Our Living Oceans

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

National Marine Fisheries Service

Our Living Oceans

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U.S. Government Printing Office: 1999—792-898.

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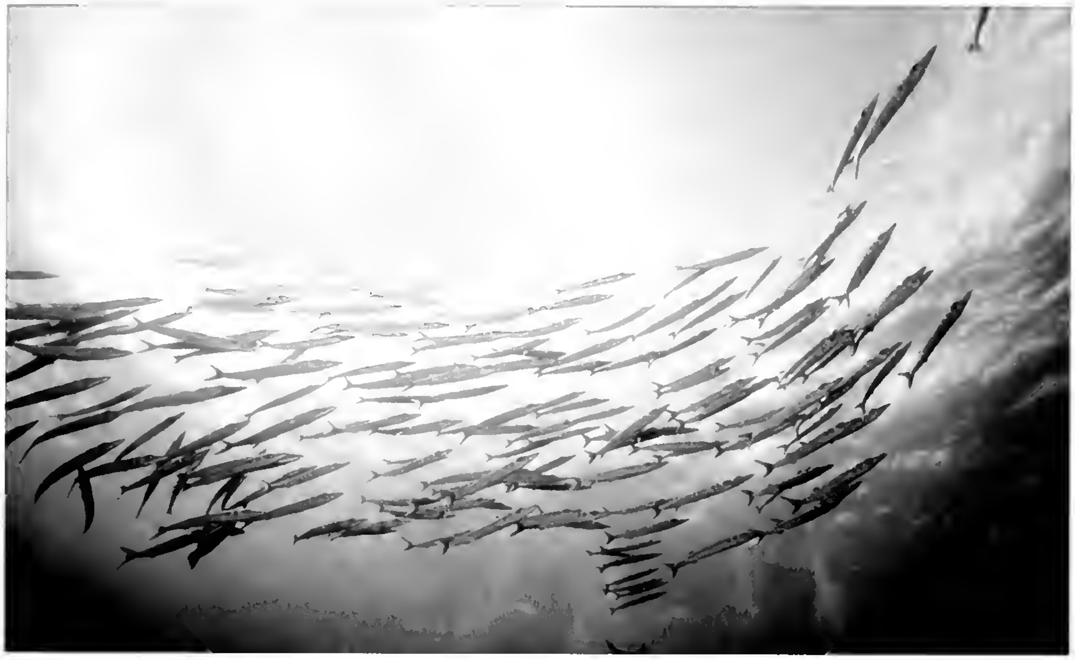

Report on the status of U.S. living marine resources, 1999

June 1999
NOAA Technical Memorandum NMFS-F/SPO-41

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This publication may be cited as:

NMFS. 1999. Our living oceans. Report on the status of U.S. living marine resources, 1999. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-41, 301 p.

Foreword

This is the fifth edition of *Our Living Oceans*, the report card on the state of the U.S. living marine resources prepared by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service. These reports are neither mandated nor intended to fulfill any legal requirement. Rather, they are written to provide an overview of and a perspective on a very complex subject for the interested reader.

The full set of *Our Living Oceans* spans a period of tremendous change in the management of living marine resources in the United States. Since 1991 when the first edition was published, there have been several profound legal and conceptual changes in the management landscape—notably, major revisions to the Marine Mammal Protection Act (1994) and the Magnuson-Stevens Fishery Conservation and Management Act (1996). Internationally, the development of the United Nations Treaty on Straddling Fish Stocks and Highly Migratory Fish Stocks and a major new emphasis on the use of a precautionary approach to fishery management have refocused efforts on dealing with the problems of overfishing. These national and international legal changes direct fishery management authorities to implement programs that end overfishing quickly and rebuild overfished resources in a timely manner.

Our marine resource legislation is among the strongest in the world. The Magnuson-Stevens Fishery Conservation and Management Act requires strict deadlines for the development of fishery management plans, very conservative management targets, tight timeframes for rebuilding stocks, and consideration of a broader scope of resource issues, ranging from habitat impacts to bycatch, and to impacts on fishing communities. For Federally protected species, similarly strict mandates to rebuild depleted stocks are now in place.

Our Living Oceans 1999 reflects the beginning of implementation of many new management imperatives. Biological populations often respond slowly to management changes. The fishing communities which depend on marine life for food and commerce also need time to adjust to changes in management practices, though in many cases efforts to address overfishing have been underway for many years. Furthermore, as this report clearly shows, the majority of our marine stocks are healthy or at least improving.

Ultimately, it is not just the passage of new laws that will improve the condition of our living marine resources; it is changes on the water that matter most. This report does not tell the American public that the job is done, but that it has begun. Thus it describes our efforts to improve the conservation and management of the Nation's living marine resources so that their full and enormous benefits are available for all Americans.

Andrew A. Rosenberg, Ph.D.
Deputy Assistant Administrator for Fisheries

Silver Spring, Maryland
June 1999

Preface

When the inaugural edition of *Our Living Oceans* was released in November 1991 it was to be the first in a series of national status reviews prepared by the National Marine Fisheries Service. From the beginning its purpose has been to serve as a report card to the Nation on the biological health of U.S. living marine resources. Subsequent editions have been completed for the 3-year reporting periods ending in 1992, 1993, and 1995. Over time, this reporting effort has evolved to a multi-year cycle to better reflect the extended time period that is often required to observe and document change in the marine environment.

Building on the reception of the biological report card, *Our Living Oceans: The Economic Status of U.S. Fisheries* was released to the American public in December 1996. This companion report defined and characterized economic sustainability in the Nation's fisheries, and presented a preliminary assessment of their economic health. Work on a third report that will present the initial assessment on the status and health of marine and coastal habitats important to living marine resources is now underway. When *Our Living Oceans: The Status of Habitat for U.S. Living Marine Resources* is released in 2001, the envisioned *Our Living Oceans* series covering stock status, economics, and habitat will be in place.

Our Living Oceans 1999 is the fifth edition on the status of U.S. living marine resources. This report presents new data analyses covering the years 1995–97. On the eve of the 21st Century, it offers a progress report and discusses important issues impacting our living ocean heritage and the challenges that remain.

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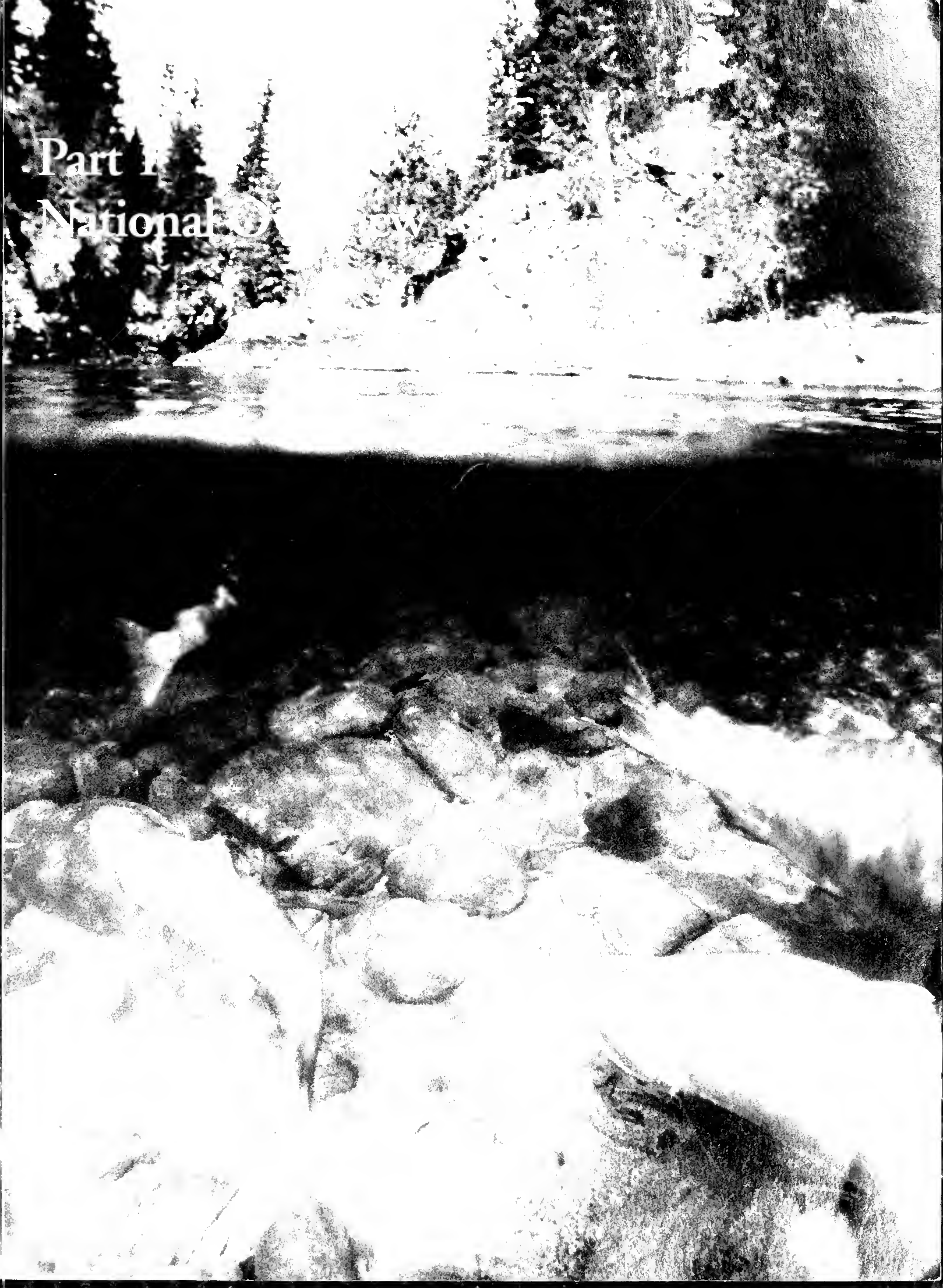

Previous page: Sockeye salmon in spawning coloration moving upriver, Pacific Northwest. © Melissa Cole

National Overview

INTRODUCTION

The conservation and management of living marine resources (LMR's) in the United States is entrusted to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS), which carries out its charge under many laws, treaties, and legislative mandates from the U.S. Congress. Most of the agency's stewardship responsibilities come from five statutes:

- The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) regulates fisheries within the U.S. Exclusive Economic Zone (EEZ),

- The Endangered Species Act (ESA) protects species that are in danger of extinction or likely to become an endangered species,

- The Marine Mammal Protection Act (MMPA) regulates the taking of marine mammals,

- The Fish and Wildlife Coordination Act (FWCA) authorizes collection of fisheries data and coordination with other agencies for environmental decisions affecting LMR's, and

- The Federal Power Act provides for concurrent responsibilities with the U.S. Fish and Wildlife Service (USFWS) in protecting aquatic habitat.

The NMFS regulates fisheries in the 3–200 nautical mile (n.mi.) Federal EEZ seaward of the 48 contiguous states, Alaska, Hawaii, and U.S.-affiliated islands (Figure 1). Within the 0–3 n.mi. territorial sea,[1] management jurisdiction belongs to the coastal states and multistate fisheries commissions. International waters outside the U.S. EEZ are regu-

[1]Territorial waters extend 9 n.mi. off the shores of Texas, the Florida Gulf Coast, and Puerto Rico.

Figure 1

Our Living Oceans 1999 divides the 200-nautical-mile U.S. Exclusive Economic Zone (EEZ) into five regions for purposes of reporting the status of U.S. living marine resources.

lated by applicable international laws and multilateral agreements among sovereign governments, and the agency plays an important role on behalf of the United States in the implementation of those international arrangements. Federal resource conservation laws require that the best scientific information be used as the basis for management actions. NMFS scientists collect and analyze much of these data. From these data bases, the agency prepares scientific reports and makes technical presentations to fishery managers, industry groups, and the public for use in formulating sound policies governing the long-term protection and sustainable use of U.S. LMR's.

Ultimately, the Secretary of Commerce has management responsibility for most marine life in U.S. waters. Fishery resources are managed largely through fishery management plans (FMP's). These plans are generally developed by fishery management councils (FMC's) through extensive consultations with state and other Federal agencies, affected industry sectors, public interest groups, and, in pertinent cases, international science and management organizations.

FMP's for EEZ stocks originate through the MSFCMA, which established eight regional FMC's (Appendix 2). The FMC's represent diverse interests through their members, who are nominated by state governors in each region and appointed by the Secretary of Commerce. For most marine fisheries and for Federally protected marine mammals and sea turtles, FMP's and protected species recovery plans may be developed by NMFS with input from the public and by direction of the FMC's.

Our Living Oceans 1999 (*OLO '99*) covers the majority of LMR's that are of interest for commercial, recreational, subsistence, and aesthetic or intrinsic reasons to the United States. The biological status of U.S. fishery resources is reported. Current and potential harvest levels are presented, along with information on the degree of utilization of each resource by its fishery and a discussion of significant management issues. Selected nearshore species, largely the responsibility of the coastal states, are also discussed, and the status of U.S. stocks of marine mammals and sea turtles are summarized.

Information in this report has been collected from many sources. Ideally, the latest peer-reviewed stock-assessment reports and publications, which serve as the scientific basis for management, are used. For some species, stock assessments may not be complete, due to lack of data, but they may still be adequate for fishery scientists to exercise professional judgments as to stock status and the magnitude of potential fishery yield. When information is inadequate, the stock or fishery status is classified as unknown. In such cases, potential yield is estimated from the most recent catch statistics. More detailed information can be obtained from regional reports produced by NMFS fisheries science centers around the country (Appendix 3) and from state natural resource agencies.

CONTENTS

Part 1 contains the national overview of significant LMR's and their fisheries. It includes this introduction, a brief review of common terms, LMR summaries and trends, issues of national concern, and a discussion of near-term outlook.

Part 2 includes three feature articles—an examination of the precautionary approach in U.S. marine fisheries management, an essay on the management history of the Northeast groundfish fishery, and a review of the Gulf of Mexico's king mackerel fishery.

Part 3 presents in greater detail the biological status of LMR's in 25 separate units. These unit synopses describe important species or species groups that are linked geographically, ecologically, or by characteristics of their fisheries.

Part 4 includes appendices for acknowledgments, regional FMC's and FMP's, principal NMFS facilities around the country, stock assessment principles and terms, a detailed (but not exhaustive) listing of the scientific and common names of species covered in this report, and acronyms and abbreviations.

Midwater trawl catch of Pacific whiting, Oregon coast.

COMMON TERMS

Most of the technical terms or phrases used in this report are defined in Appendix 4; the most important are reviewed here.

Stock ideally refers to a biologically distinct group of organisms that are genetically related or reproductively isolated from other segments of a larger population. Since stocks intermix in the marine ecosystem, it may be necessary to consider all of the individuals of a species, or several co-occurring species within a geographical area, as one fishery stock when it is impractical to differentiate between them. Thus, a stock unit defined for fishery management purposes may not necessarily correspond to a discrete genetic unit.

Recent average yield (RAY) is equivalent to the recent catch history. RAY is the reported fishery landings averaged for the most recent 3-year period of workable data, usually 1995–97, unless otherwise indicated.

Current potential yield (CPY) is the potential catch that can be taken depending on the current stock abundance and prevailing ecosystem considerations.[2] This term is analogous to acceptable biological catch (ABC) that is specified in some FMP's.

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[2]For many stocks, LTPY or CPY may be unknown. For the purpose of reporting total LTPY and CPY across resources within the various fishery units and for the Nation as a whole, if CPY was unknown RAY was substituted when calculating a unit, regional, or national total CPY. If LTPY was unknown CPY was substituted, or, failing that, RAY was substituted in calculating totals.

Long-term potential yield (LTPY) is the maximum long-term average catch that can be achieved from the resource.[2] This term is analogous to the concept of maximum sustainable yield (MSY) in fisheries science.

Stock level relative to LTPY is a measure of a stock's biological status. The current abundance level of the stock is compared to the level of abundance that, on average, would support the LTPY. This level is expressed as below, near, above, or unknown relative to the abundance level that would produce LTPY.[3]

Alaska snow crab.

Status of resource utilization describes the degree to which a stock is utilized by its fishery (i.e. underutilized, fully utilized, overutilized, or unknown). It shows how the existing fishing effort compares with levels necessary to achieve LTPY from the resource.

Threatened or **endangered** are terms specifically defined under the ESA. A species is considered endangered if it is in danger of extinction throughout a significant portion of its range; it is threatened if it is likely to become an endangered species within the foreseeable future.

Potential biological removal (PBR) is a concept that establishes a quantitative process for setting levels of take such that marine mammal stocks will equilibrate within their optimal population size. PBR (calculated in numbers of animals) is the sustainable removal level defined by the MMPA 1994 Amendments. Stocks for which bycatch levels exceed PBR are classified as **strategic** (stocks listed as **depleted** under the MMPA, or **threatened** or **endangered** under the ESA, are also considered strategic regardless of the level of take).

PRODUCTIVITY OF STOCKS

The United States is ranked fifth in the world for fisheries landings as reported by the Food and Agriculture Organization (FAO) of the United Nations for 1996, its latest survey

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[3]Since 1997, NMFS has been required to produce an annual "Report to Congress on the Status of Fisheries of the United States," which classifies stocks as overfished, not overfished, or approaching an overfished condition. As explained in Appendix 4, there is not a one-to-one correspondence between the status classifications in *Our Living Oceans* and those in the Report to Congress.

Unit number and fishery	Total productivity (t) over the entire range of stock: Total recent average yield (RAY)	Total current potential yield (CPY)	Total long-term potential yield (LTPY)	Prorated productivity (t) within the U.S. EEZ: U.S. RAY	U.S. LTPY
1 Northeast demersal	159,875	134,475	317,500	142,215	253,555
2 Northeast pelagic	158,500	711,550	701,700	121,300	462,000
3 Atlantic anadromous	9,408	9,208	9,208	9,408	9,208
4 Northeast invertebrate	130,500	109,300	138,000	127,200	133,900
5 Atlantic highly migratory pelagic	352,800	315,470	348,300	18,300	18,100
6 Atlantic shark	7,393	6,430	6,430	7,393	6,430
7 Atlantic coastal migratory pelagic	15,454	20,339	26,448	15,454	26,448
8 Atlantic, Gulf of Mexico, and Caribbean reef fish	25,737	24,641	37,136	25,737	37,136
9 Southeast drum and croaker	33,623	31,420	78,835	33,623	78,835
10 Southeast menhaden	860,000	860,000	1,140,000	860,000	1,140,000
11 Southeast and Caribbean invertebrate	119,376	116,575	120,953	119,376	120,953
12 Pacific Coast salmon	17,304	33,312	33,312	17,304	33,312
13 Alaska salmon	376,100	310,600	310,600	376,100	310,600
14 Pacific Coast and Alaska pelagic	153,500	334,200	455,200	112,500	348,400
15 Pacific Coast groundfish	353,264	395,958	462,800	268,085	391,796
16 Western Pacific invertebrate	109	160	222	109	222
17 Western Pacific bottomfish and armorhead	492	470	2,802	492	2,802
18 Pacific highly migratory pelagic	2,049,418	3,439,825	3,435,031	253,606	253,116
19 Alaska groundfish (total)	2,033,982	3,100,410	3,983,420	2,026,272	3,963,290
Eastern Bering Sea and Aleutian Islands	1,775,600	2,499,900	3,478,700	1,775,600	3,478,700
Gulf of Alaska	211,922	548,770	452,980	211,922	452,980
Pacific halibut	46,460	51,740	51,740	38,750	31,610
20 Alaska shellfish	52,131	52,131	113,218	52,131	113,218
21 Nearshore	312,700	312,700	312,700	312,700	312,700
Total	7,221,666	10,319,174	12,033,815	4,899,305	8,016,021

Table 1
Productivity in metric tons (t) of fisheries resources utilized by the United States.

year (FAO, 1997). The U.S. catch was 4.5% of the world's total catch (121 million metric tons (t)) of marine and freshwater fisheries products. The FAO also ranked the United States second in value for world imports (12.5% of the $56.9 billion world total), and third (5.6%) in the $52.9 billion international trade in world exports of fish and fishery products, including aquaculture, in 1996 (FAO, 1997).

The productivity (Table 1) and status of fishery resources utilized by the United States are summarized in Units 1–21. LMR productivity is represented by RAY, CPY, and LTPY.

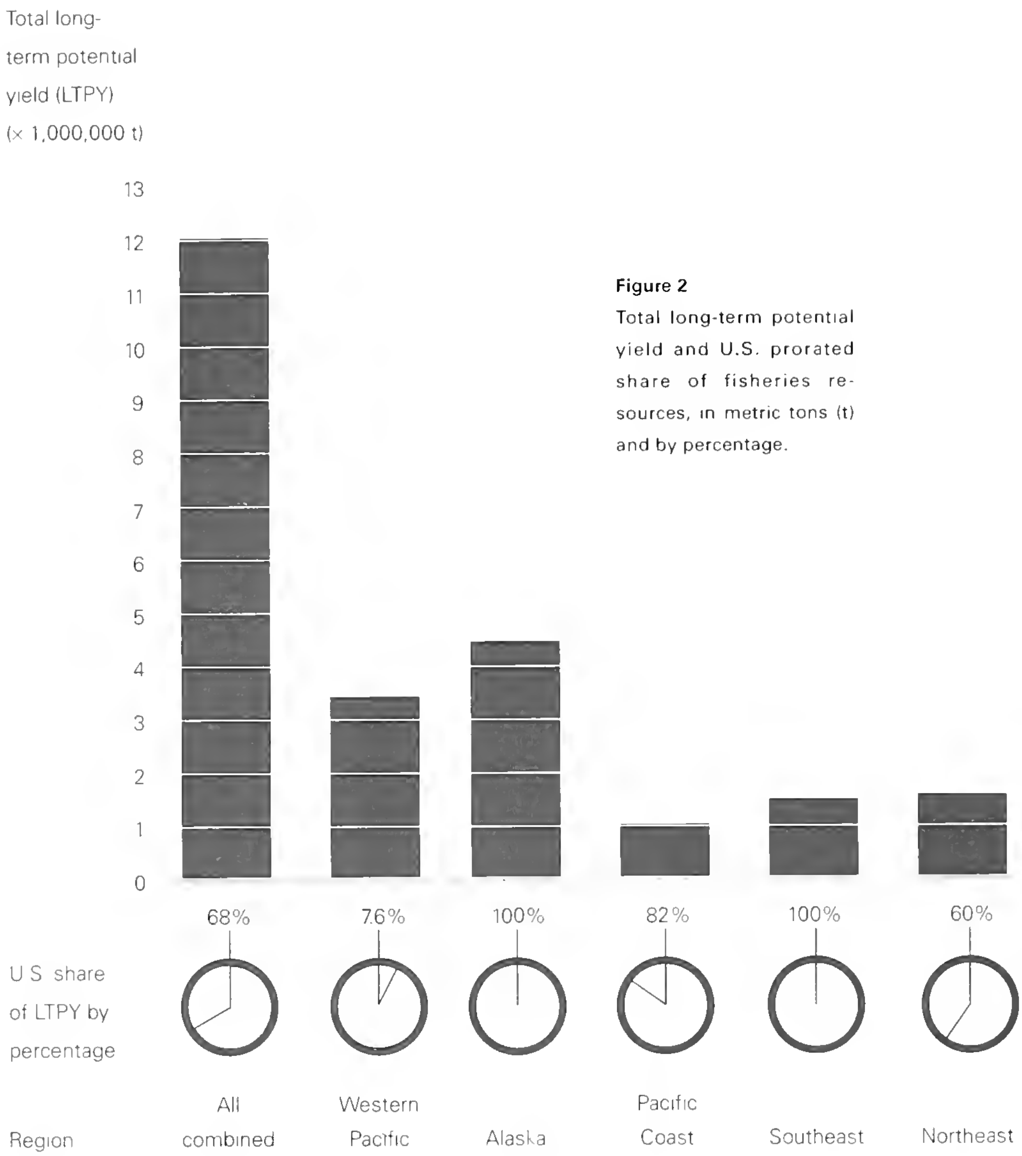


Figure 2
Total long-term potential yield and U.S. prorated share of fisheries resources, in metric tons (t) and by percentage.

For some stocks, the United States shares productivity with other fishing nations because these stocks range beyond the U.S. EEZ. For the purposes of this report, the productivity of transboundary species is compiled for the entire stock and sometimes provided for the prorated portion of the stock within the U.S. EEZ. *OLO '99* reports both total productivity and the prorated U.S. share of the stocks based on the ratio of the U.S. RAY to total RAY. The U.S. RAY is taken primarily within the U.S. EEZ.

Table 2
Regional productivity in metric tons (t) of fisheries resources utilized by the United States.

Region	Total productivity (t) over the entire range of stock: Total recent average yield (RAY)	Total current potential yield (CPY)	Total long-term potential yield (LTPY)	Prorated productivity (t) within the U.S. EEZ: U.S. RAY	U.S. LTPY
Northeast	885,533	1,354,453	1,589,158	492,873	951,213
Southeast	1,155,123	1,152,945	1,503,342	1,155,123	1,503,342
Alaska	2,509,633	3,519,656	4,472,638	2,509,633	4,472,638
Pacific Coast	619,938	850,245	1,038,087	486,049	852,263
Western Pacific	2,051,439	3,441,875	3,439,475	255,627	257,560
Total	7,221,666	10,319,174	12,042,700	4,899,305	8,037,016

The total LTPY of all U.S. fishery resources, across their entire range, is estimated to be 12,033,815 metric tons (t) (Table 1). Total CPY is 10,319,174 t, indicating that the present productivity of the stocks is 14% below the long-term potential. Total RAY is 7,221,666 t, or 40% below the long-term potential.

When only the U.S. prorated share of the resources is considered, the U.S. LTPY is 8,016,021 t or 33% below total LTPY (Figure 2). By region, the percentage distribution of U.S. LTPY's is 55% for Alaska, 19% for the Southeast, 12% for the Northeast, 11% for the Pacific Coast, and 3% for the Western Pacific Region (Table 2, Figure 3).

The U.S. RAY is 4,899,305 t or 39% below U.S. LTPY. The missing 39% potential yield was not realized because some of the stocks were underutilized while some have been overexploited and therefore were not producing at their full long-term potential. By region, the percentage distribution of U.S. RAY is 51% Alaska, 24% Southeast, 10% Northeast, 10% Pacific Coast, and 5% Western Pacific (Table 2, Figure 4).

STATUS OF STOCKS

The status of stocks is classified according to the current level of abundance relative to the level that would produce LTPY. Table 3 summarizes the classifications for the 283 stock groups addressed in this report as being 31% below, 31% near, 8% above, and 30% unknown relative to the levels that would produce LTPY. This summary includes 80 stock

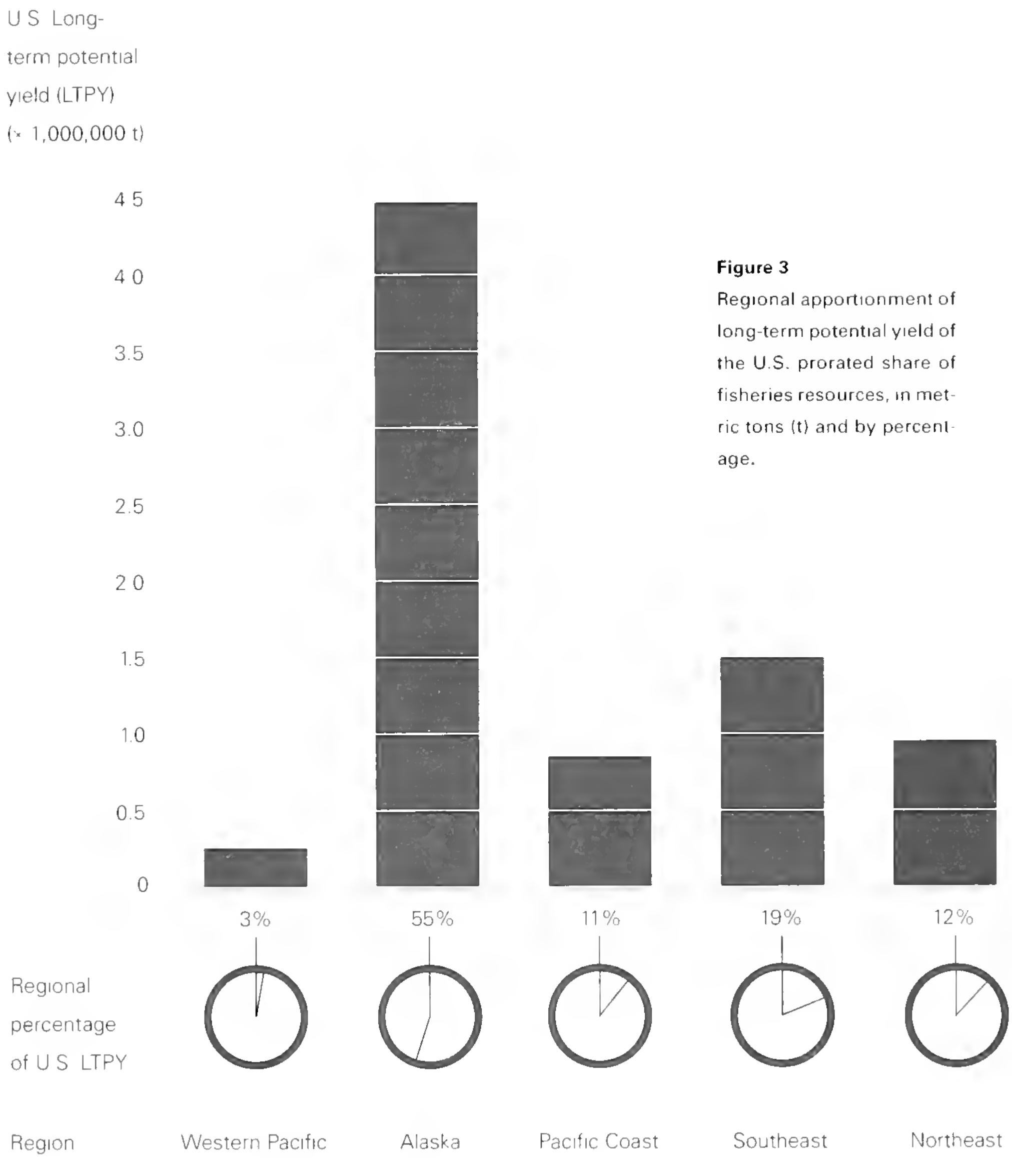


Figure 3
Regional apportionment of long-term potential yield of the U.S. prorated share of fisheries resources, in metric tons (t) and by percentage.

groups of nearshore resources that are under the purview of coastal states. The 85 stocks classified as unknown contributed 6.6% of U.S. RAY.

Excluding nearshore resources, the remaining 203 stock groups that are under Federal jurisdiction have been classified as being 36% below, 31% near, 11% above, and 22% unknown relative to the abundance levels that would produce U.S. LTPY (Figure 5). The 22% unknown category comprises 45 out of 203 stock groups. These 45 stock groups are generally of low abundance and contributed only 2.5% of U.S. RAY.

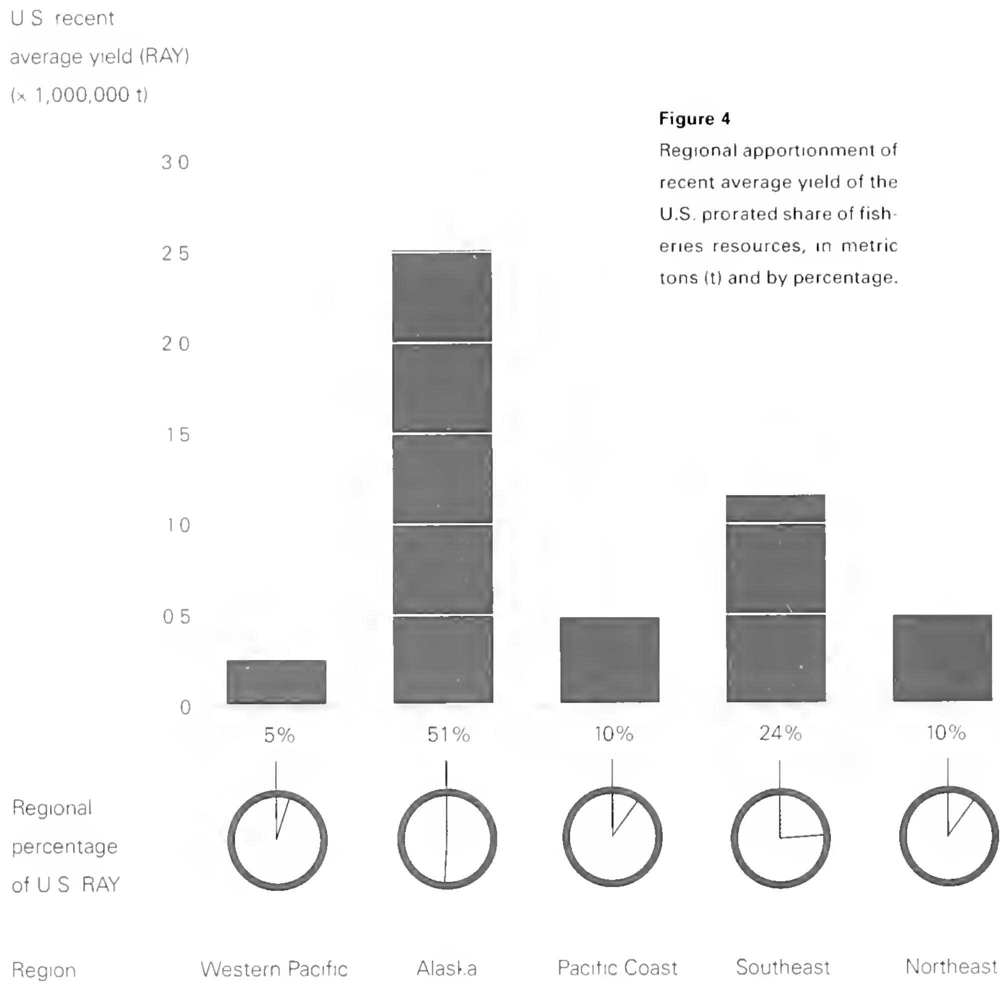


Figure 4
Regional apportionment of recent average yield of the U.S. prorated share of fisheries resources, in metric tons (t) and by percentage.

There are 158 stock groups whose status is "known" that fall under NMFS purview (Units 1–20 in Table 3). In this category, a high percentage of stock groups (46%, or 73 out of 158 groups with known status) are below levels that would produce LTPY. The majority of these low abundance cases occurred in Unit 1 (21 stocks of Northeast demersal species), Unit 8 (nine stocks of Atlantic and Gulf of Mexico reef fish), and Unit 15 (eight stocks of Pacific Coast groundfish). Less pronounced cases of low abundance can be found in all regions. The remaining stocks (85 out of 158 known-stock status) have been classified as 39% near and 15% above the levels that would produce LTPY. Assuming that stocks near or above levels that would produce LTPY are stocks in healthy condition, 54% of the known-status groups are at healthy abundance levels.

Table 3
Status of stock levels of U.S. fisheries resources, 1995–97.

Unit number and fishery	Current status relative to the level producing LTPY				
	Below	Near	Above	Unknown	Total
1 Northeast demersal	21	2	0	2	25
2 Northeast pelagic	1	0	3	0	4
3 Atlantic anadromous	4	0	1	0	5
4 Northeast invertebrate	1	4	1	2	8
5 Atlantic highly migratory pelagic	7	2	0	1	10
6 Atlantic shark	1	0	1	1	3
7 Atlantic coastal migratory pelagic	1	3	0	3	7
8 Atlantic, Gulf of Mexico, and Caribbean reef fish	9	3	0	16	28
9 Southeast drum and croaker	3	0	0	4	7
10 Southeast menhaden	0	2	0	0	2
11 Southeast and Caribbean invertebrate	2	7	0	5	14
12 Pacific Coast salmon	2	3	0	0	5
13 Alaska salmon	1	1	3	0	5
14 Pacific Coast and Alaska pelagic	0	6	1	0	7
15 Pacific Coast groundfish	8	4	2	5	19
16 Western Pacific invertebrate	1	0	0	0	1
17 Western Pacific bottomfish and armorhead	2	4	0	0	6
18 Pacific highly migratory pelagic	1	11	2	1	15
19 Alaska groundfish (total)	5	10	8	4	27
20 Alaska shellfish	3	0	1	1	5
21 Nearshore	14	26	0	40	80
Subtotal of Units 1–20	73	62	23	45	203
% of Subtotal	36%	31%	11%	22%	
% of 158 "known" stock groups	46%	39%	15%		
Total of Units 1–21	87	88	23	85	283
% of Total	31%	31%	8%	30%	
% of 198 "known" stock groups	44%	44%	12%		

DEGREE OF UTILIZATION

The degree of utilization describes the level of use of a fisheries resource as being underutilized, fully utilized, overutilized, or unknown. It compares existing fishing effort with the appropriate levels necessary to achieve LTPY.

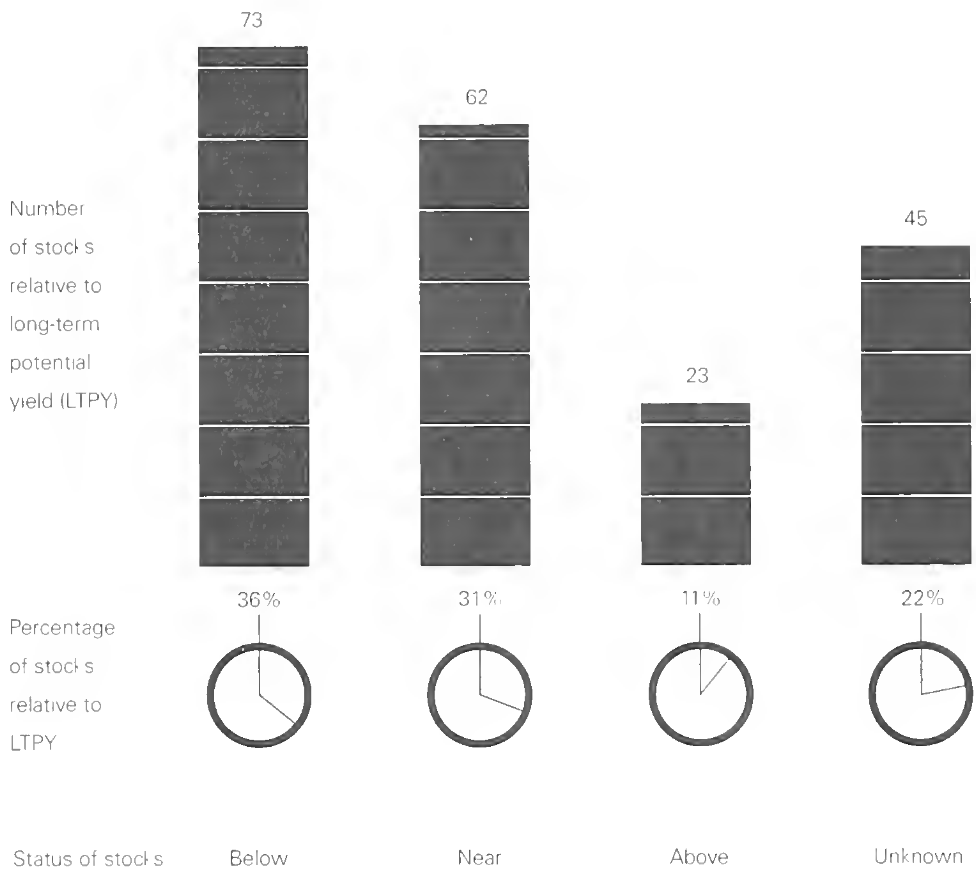


Figure 5
The number and percentage of stocks under NMFS purview that are above, near, or below the population level that would produce long-term potential yield

Table 4 summarizes the classifications for the 283 stock groups addressed in this report as being 13% underutilized, 39% fully utilized, 22% overutilized, and 27% unknown. This grouping includes 80 stock groups of nearshore resources that are under the purview of coastal states. Excluding nearshore resources, the remaining 203 stock groups that are under NMFS purview have been classified as 15% underutilized, 37% fully utilized, 27% overutilized, and 21% unknown (Figure 6).

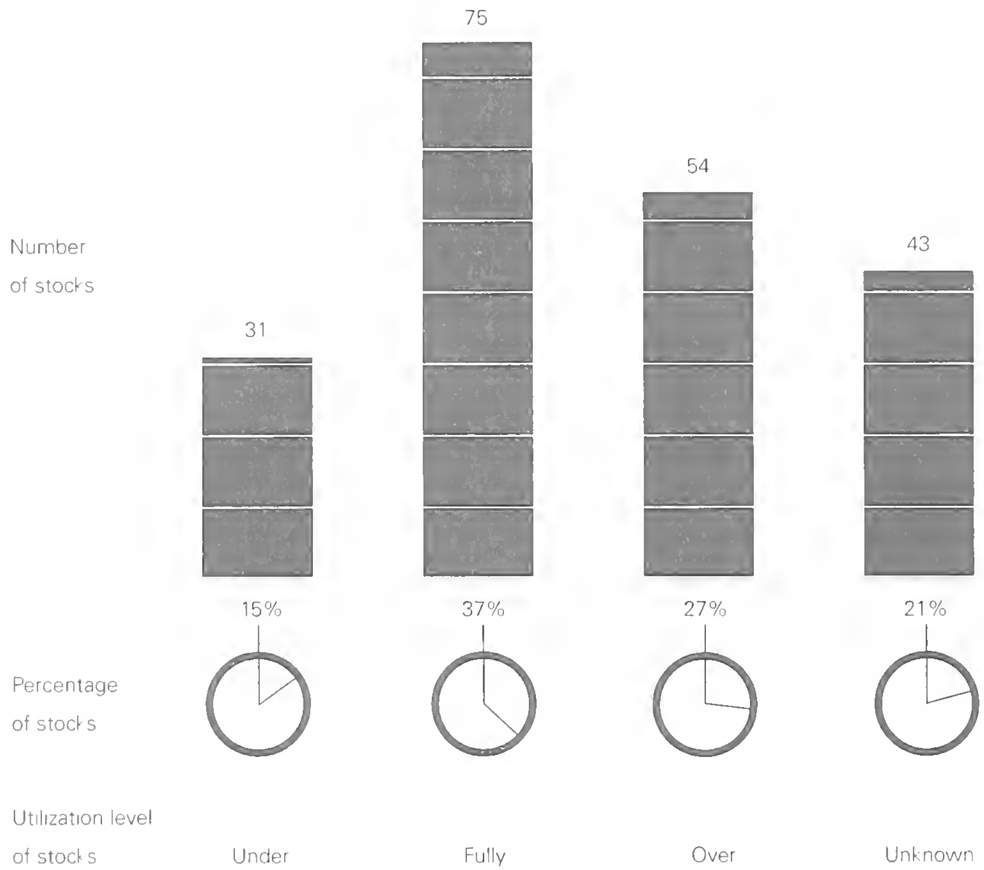
There is still a high percentage of stocks, 21% (involving 43 out of 203 stock groups), whose degree of utilization is unknown. The majority of these 43 unknown stock groups are found in the Southeast Region, where assessments of coastal migratory species, reef fishes, and invertebrates are complex and incomplete because of the huge diversity of species and fisheries. This category also includes 7 stock groups from Unit 18 in the Western Pacific Region, where the highly migratory species of tunas move long distances across many national jurisdictions, making assessment of stock utilization difficult.

Table 4
Status of utilization levels of U.S. fisheries resources, 1995–97.

Unit number and fishery	Degree of fisheries utilization of the resource: Under	Full	Over	Unknown	Total
1 Northeast demersal	0	7	16	2	25
2 Northeast pelagic	3	0	1	0	4
3 Atlantic anadromous	0	1	4	0	5
4 Northeast invertebrate	1	3	2	2	8
5 Atlantic highly migratory pelagic	0	2	7	1	10
6 Atlantic shark	0	1	1	1	3
7 Atlantic coastal migratory pelagic	1	2	1	3	7
8 Atlantic, Gulf of Mexico, and Caribbean reef fish	1	3	10	14	28
9 Southeast drum and croaker	0	0	3	4	7
10 Southeast menhaden	0	2	0	0	2
11 Southeast and Caribbean invertebrate	0	7	2	5	14
12 Pacific Coast salmon	0	3	2	0	5
13 Alaska salmon	0	5	0	0	5
14 Pacific Coast and Alaska pelagic	2	5	0	0	7
15 Pacific Coast groundfish	5	10	2	2	19
16 Western Pacific invertebrate	0	1	0	0	1
17 Western Pacific bottomfish and armorhead	3	1	2	0	6
18 Pacific highly migratory pelagic	5	2	1	7	15
19 Alaska groundfish (total)	9	16	0	2	27
20 Alaska shellfish	1	4	0	0	5
21 Nearshore	5	34	8	33	80
Subtotal of Units 1–20	31	75	54	43	203
% of Subtotal	15%	37%	27%	21%	
% of 160 "known" stock groups	19%	47%	34%		
Total of Units 1–21	36	109	62	76	[illegible]
% of Total	13%	39%	22%	27%	
% of 207 "known" stock groups	17%	53%	30%		

There are 160 stock groups classified as being of known status that are under NMFS purview (Units 1–20 in Table 4). Of these, 34% (54 out of 160 known-status groups) are overutilized. The majority of these overutilized cases occurred in Unit 1 (16 stocks from the Northeast demersal unit) and Unit 8 (10 stocks of Atlantic and Gulf of Mexico reef fish). The remaining stocks have been classified as 19% underutilized and 47% fully utilized, for a combined total of 66% not overutilized.

Figure 6
Number and percentage of stock groups classified by their status of utilization for stocks under NMFS purview.



REGIONAL AND SPECIES-GROUP SYNOPSES

Northeast Region

The Northeast Region's finfish and invertebrates are grouped under demersal, pelagic, anadromous, invertebrate, highly migratory pelagic, and nearshore resources. Their combined northeastern U.S. LTPY is 951,213 t (Table 5) out of a total (U.S. and Canada) LTPY of 1,589,158 t for the region. The lower U.S. LTPY reflects the sharing of transboundary resources with Canada. The U.S. RAY totaled only 492,873 t, or 52% of the U.S. LTPY, because 29 species, principally groundfish, are overutilized and below the stock levels necessary to produce LTPY. The RAY of 492,873 t excluded 300,000 t of menhaden that were taken in the Northeast. That amount has been added to the Southeast menhaden data (Unit 10) as it is an integral part of the South Atlantic menhaden stock.

Unit number and fishery	Total productivity (t) over the entire range of stock (U.S. and Canada): Total recent average yield (RAY)	Total current potential yield (CPY)	Total long-term potential yield (LTPY)	Prorated productivity (t) within the U.S. EEZ: U.S. RAY	U.S. LTPY
1 Northeast demersal	159,875	134,475	317,500	142,215	253,555
2 Northeast pelagic	158,500	711,550	701,700	121,300	462,000
3 Atlantic anadromous	9,408	9,208	9,208	9,408	9,208
4 Northeast invertebrate	130,500	109,300	138,000	127,200	133,900
5 Atlantic highly migratory pelagic	352,800	315,470	348,300	18,300	18,100
21 Northeast nearshore resources	74,450	74,450	74,450	74,450	74,450
Total	885,533	1,354,453	1,589,158	492,873	951,213

Table 5
Productivity in metric tons (t) of fisheries resources of the Northeast Region, 1995–97.

The mixed-species groundfish fishery has traditionally been the most valuable, followed by American lobster and Atlantic sea scallop. Recreational fisheries for species such as Atlantic cod, winter flounder, Atlantic mackerel, striped bass, bluefish, and bluefin tuna are also important to the region's economy.

Principal groundfish and flounders in the Northeast, particularly cod, haddock, and yellowtail flounder, have been severely overfished, reaching record low levels in spawning-stock biomass in 1993–94, but they have since begun to rebuild.[4] Dogfish and skates, which increased in abundance beginning in the 1970's as groundfish and flounders declined, currently comprise a substantial fraction of the total fish biomass on Georges Bank and have supported larger catches in recent years. Since 1990, however, their abundances have also begun to decrease. Catches of other groundfish have become more important in recent years as the preferred species continued to decline in number. In 1994, the U.S. catch of goosefish exceeded the catch of Atlantic cod for the first time.

Five species, mainly pelagic fishes, are presently underutilized, and the CPY of the two most abundant of these, Atlantic mackerel and herring, is about 555,500 t higher than their combined RAY. The anadromous striped bass, driven to very low levels of abundance

[4]The haddock population started to rebuild around 1994–95, and has been improving steadily.

in the early 1980's and subjected to severe catch restrictions beginning in the mid 1980's, was declared fully restored in early 1995. The region's valuable crustaceans and bivalve mollusks, both offshore (e.g. American lobster, sea scallop, surfclam, and ocean quahog) and inshore (e.g. blue crab, oyster, blue mussel, and hard and softshell clam) are nearly all fully or overexploited.

Headboat, Belmar, New Jersey

Most Northeast Region fisheries are governed by FMP's that are either in place or under development. Despite the goals of FMP's, overexploitation of their respective species has occurred in many cases, and efforts to rebuild have generally not yet succeeded in fully restoring depleted stocks. Striped bass (managed since 1981 by an Atlantic States Marine Fisheries Commission (ASMFC) FMP), herring, mackerel, short-finned squid, and surfclams (managed by Federal FMP's) are the only species to have fully recovered from overutilization. Both summer flounder and weakfish have experienced marked increases in abundance and reductions in fishing mortality as a result of regulatory constraints imposed by FMP's, although target levels have not yet been fully achieved. Amendment 5 to the Northeast Multispecies FMP, approved in March 1994, was intended to limit commercial fishing effort on groundfish in New England and bring recovery within 5–10 years. However, scientific advice issued in August 1994, indicating that the Georges Bank stocks of cod, haddock, and yellowtail flounder had collapsed or were in danger of collapsing, led to the Secretary of Commerce approving, in December 1994, an emergency closure of portions of Georges Bank and severely restricting fishing for haddock. In addition, the New England Fishery Management Council (NEFMC) developed and implemented Amendment 7 to the Multispecies FMP to further reduce fishing mortality on these stocks by means of even stricter restrictions on fishing. As a result, some rebuilding has occurred for stocks on Georges Bank, but additional restrictions are in the process of being implemented to achieve management objectives for the cod stock in the Gulf of Maine. Concurrently, Canada has tightened controls on its groundfish fishery on the eastern part of Georges Bank to promote stock rebuilding, and these measures have resulted in improved abundance in those waters.

Amendment 4 to the Sea Scallop FMP, implemented in 1994, was intended to control fishing effort by limiting the days at sea for each vessel, placing a moratorium on new entrants, and imposing a larger mesh-ring size for dredges. Since fishing mortality on sea scallops has remained well above the overfishing level, further measures for reducing effort and protecting undersized scallops (closed areas in the Mid-Atlantic area) are being developed. Some protection of scallops has been achieved by the closure, since December 1994, of portions of Georges Bank to all fishing for the protection of groundfish. Amendment 3 to the ASMFC American Lobster FMP, approved in December 1997, introduced effort control and various other measures aimed at reducing the currently high fishing mortality on lobsters.

The highly migratory pelagic species (Unit 5) are important components of domestic fisheries in the Northeast and Southeast Regions, and for international fisheries elsewhere in the Atlantic Ocean. For the purpose of summarizing the information, they have been included in the Northeast Region. U.S. RAY is 5.2% of the total RAY for these stocks over the range of their distribution. The western Atlantic bluefin tuna is well below historic population levels. Marlins (blue and white) and sailfish are below as well. Swordfish in the North Atlantic is also below the level that would produce maximum long-term yield. Yellowfin tuna, which accounts for 39% of the total RAY for these stocks, is presently fully exploited and near its maximum long-term yield. Bigeye tuna exploitation has recently increased, but current yields are not expected to be maintained because they are about 20% above LTPY.

Southeast Region

The Southeast Region covers the Gulf of Mexico, the Southeast Atlantic, and the Caribbean Sea. Its important resources are Atlantic sharks, Atlantic and Gulf of Mexico coastal migratory pelagics, Atlantic and Gulf of Mexico reef fish, drum and croaker, menhaden, Southeast Atlantic and Caribbean invertebrates, highly migratory pelagic fishes (see the Northeast Region summary), and nearshore resources. A conservative estimate of the total LTPY of fisheries resources is 1,503,342 t, and virtually all are available to the United States (Table 6). The Southeast RAY is 1,155,123 t or 77% of the estimated Southeast LTPY.

Menhaden comprise about 74% of both the U.S. LTPY and U.S. RAY in this region. Menhaden are considered fully utilized in both the Gulf of Mexico and Atlantic Ocean, with some growth overfishing occurring in the Atlantic.

Shrimp led the region's fisheries in value, although they are only 10% of the total Southeast LTPY and RAY. The three major species (brown, white, and pink) are considered

William B. Folsom NMFS

Shrimp trawlers, Tarpon Springs, Florida.

Unit number and fishery	Total productivity (t) over the entire range of stock			Prorated productivity (t) within the U S EEZ	
	Total recent average yield (RAY)	Total current potential yield (CPY)	Total long-term potential yield (LTPY)	U S RAY	U S LTPY
6 Atlantic shark	7,393	6,430	6,430	7,393	6,430
7 Atlantic coastal migratory pelagic	15,454	20,339	26,448	15,454	26,448
8 Atlantic, Gulf of Mexico and Caribbean reef fish	25,737	24,641	37,136	25,737	37,136
9 Southeast drum and croaker	33,623	31,420	78,835	33,623	78,835
10 Southeast menhaden	860,000	860,000	1,140,000	860,000	1,140,000
11 Southeast and Caribbean invertebrate	119,376	116,575	120,953	119,376	120,953
21 Southeast nearshore species	93,540	93,540	93,540	93,540	93,540
Total	1,155,123	1,152,945	1,503,342	1,155,123	1,503,342

Table 6

Productivity in metric tons (t) of fisheries resources of the Southeast Region, 1995–97.

fully utilized in both the Gulf of Mexico and Atlantic. Yields are not now closely tied to shrimping effort—about half the current effort in the Gulf could produce about the same long-term average yield.

Information is incomplete on the status of invertebrates other than shrimp. Spiny lobster off the southeastern U.S. coast is apparently overutilized and below the LTPY level. The recreational catch of spiny lobster is unknown but thought to be significant. The Caribbean spiny lobster status is uncertain, but that species is possibly overutilized and experiencing growth overfishing. Stone crab appears to be fully utilized. Queen conch off the southeastern U.S. coast has been below the LTPY level for some time, despite a joint state-Federal protection program.

Yellowtail snapper, Frenchtown Harbor, U S Virgin Islands.

RAY for Atlantic sharks is less than 1% of the total for the Southeast Region. However, sharks are a very important component of the ecosystem. Because of their low reproductive capacity, sharks are considered to be particularly vulnerable to overfishing. Large coastal sharks (as a group consisting of 17 species) may be overutilized, but the status of each species is presently unknown. When managed in aggregate, it is likely that some stocks will be overfished while others will go underutilized. Improvements in data collection are necessary before these stocks can be assessed more adequately on an individual basis.

Coastal migratory pelagic fishes account for 1.3% of the Southeast RAY (Table 6). Spanish mackerel appear to be fully utilized in both the Gulf of Mexico and Atlantic. King mackerel are below the LTPY level in the Gulf, where a stringent rebuilding program has been in place for the last several years. In the Atlantic, king mackerel are underutilized and have the potential to produce additional yield. The status of other coastal migratory pelagic species in the region is unknown.

Reef fish in the Southeast Region include over 200 stocks of more than 100 species currently contributing 25,737 t in fishery yield. The degree of utilization and status relative to LTPY are unknown for many of these stocks, but several of the major species have been assessed. In the Gulf of Mexico, red snapper are overfished, and a rebuilding plan has begun. RAY is about 40% greater than CPY, which may slow or impede stock recovery. The success of this rebuilding program hinges primarily on the reduction of bycatch of juvenile red snapper in the Gulf shrimp fishery. Red grouper appears to be fully utilized in the Gulf of Mexico. In the Atlantic, many of the key species are considered overutilized (e.g. vermilion and other snappers, red porgy, several groupers, amberjacks, and jewfish). In the Caribbean, Nassau grouper and jewfish are considered overutilized; the status of other species is unknown.

Ian K. Workman NMFS

Mixed bycatch from a shrimp trawl net, including juvenile red snapper and blue crab, Gulf of Mexico.

The status of drum, spot, croaker, seatrouts, and kingfish stocks, which contribute about 3% of the Southeast RAY, is largely unknown. These species constitute the bulk of a bycatch that averaged 175,000 t during the 1980's, when billions of juveniles were discarded annually. Bycatch has become a major management issue, and efforts are underway to reduce bycatch through new gear designs. Red drum harvests in the U.S. EEZ of the Gulf of Mexico and South Atlantic have been prohibited, and harvests in state waters have been reduced for several years due to low spawning levels. All indications are that recruitment is increasing, and recovery is expected, although not necessarily in the immediate future.

As noted above, the highly migratory pelagic species (Unit 5) are important components of domestic fisheries in the Southeast and Northeast Regions, and for international fisheries elsewhere in the Atlantic. In particular, the Southeast Region includes major components of the fisheries for swordfish, marlins, sailfish and yellowfin. However, for purposes of summarizing the information, these have been included in the Northeast Region and were discussed in that section.

Unit number and fishery	Total productivity (t) over the entire range of stock: Total recent average yield (RAY)	Total current potential yield (CPY)	Total long-term potential yield LTPY)	Prorated productivity (t) within the U S EEZ: U S RAY	U S LTPY
13 Alaska salmon	376,100	310,600	310,600	376,100	310,600
14 Alaska herring	45,500	55,200	55,200	45,500	55,200
19 Alaska groundfish					
Eastern Bering Sea and Aleutian Islands	1,775,600	2,499,900	3,478,700	1,775,600	3,478,700
Gulf of Alaska	211,922	548,770	452,980	211,922	452,980
Halibut (Alaska)	38,180	42,855	51,740	38,180	51,740
20 Alaska shellfish	52,131	52,131	113,218	52,131	113,218
21 Alaska nearshore species	10,200	10,200	10,200	10,200	10,200
Total	2,509,633	3,519,656	4,472,638	2,509,633	4,472,638

Table 7
Productivity in metric tons (t) of fisheries resources of the Alaska Region, 1995–97.

Pursing a salmon seine, Dutch Harbor, Alaska.

Alaska Region

The Alaska Region dominates in the tonnage of fisheries resources that could be obtained in the long term for the United States. Its major resources are Pacific salmon, groundfish, Pacific halibut, shellfish, and herring. Their combined U.S. LTPY is 4,472,638 t (Table 7). The resources are generally healthy, with regional CPY 22% below LTPY. The U.S. RAY has been steady at about 2,510,000 t, or 44% below LTPY. Catches are substantially below the long-term potential because many of the resources, particularly flatfish species, are underutilized.

Alaska's salmon stocks have generally produced bumper harvests in recent years, although some stocks have been down. The RAY of 376,100 t is actually 21% above LTPY, because returning salmon runs have been particularly successful. Five species of Pacific salmon (chinook, coho, sockeye, pink, and chum) contribute to the catch.

The development of domestic groundfish fisheries off Alaska has been a great success under the MSFCMA. Until its implementation in 1977, Alaska's groundfish fisheries, except for Pacific halibut, were dominated by foreign fishing. Then, within a few years under the new management regime, the U.S. fishery largely replaced the foreign fishing fleets.

Unit number and fishery	Total productivity (t) over the entire range of stock: Total recent average yield (RAY)	Total current potential yield (CPY)	Total long-term potential yield (LTPY)	Prorated productivity (t) within the U S EEZ: U S RAY	U S LTPY
12 Pacific Coast salmon	17,304	33,312	33,312	17,304	33,312
14 Pacific Coast pelagic	108,000	279,000	400,000	67,000	293,200
15 Pacific Coast groundfish	353,264	395,958	462,800	268,085	391,796
19 Halibut (Can , Wash , Oreg , and Calif)	8,280	8,885	8,885	570	865
21 Pacific Coast nearshore species	133,090	133,090	133,090	133,090	133,090
Total	619,938	850,245	1 038,087	486,049	852,263

Table 8
Productivity in metric tons (t) of fisheries resources of the Pacific Coast Region, 1995–97

For the Eastern Bering Sea and Aleutian Islands groundfish, RAY is 1,775,600 t (Table 7), 49% below LTPY. The major species groups harvested are walleye pollock, Pacific cod, flatfishes, Atka mackerel, rockfish, and sablefish. Greenland turbot and sablefish are below LTPY levels. All flatfish species are high in abundance and in excellent condition. Walleye pollock and Pacific cod abundances are much lower than their recent high levels, but are still close to the levels that would produce LTPY.

For Gulf of Alaska groundfish, RAY is 211,922 t, 53% below LTPY. The major species groups harvested include walleye pollock, Pacific cod, sablefish, flatfishes, and slope rockfish. Walleye pollock, sablefish and slope rockfish are below their respective LTPY levels. Pacific cod and thornyhead rockfish are high in abundance, and the status of the remaining groundfish stocks is unknown.

In addition to the general groundfish complex, Pacific halibut is a groundfish species that has supported an important traditional fishery for both the United States and Canada. This resource is fully utilized and managed by the International Pacific Halibut Commission. Abundance has been stable since 1993.

Pacific herring stocks are producing about 45,500 t, perhaps slightly below their LTPY's. Three shellfish resources, Tanner crab, king crab, and shrimp are below their LTPY levels, with a combined RAY 84% below their long-term potential. Snow crab stocks are in good condition, but the RAY has decreased substantially since the early 1990's.

Pacific Coast Region

Commercial trollers off Pt. Año Nuevo, California

Pacific Coast fisheries resources have a prorated U.S. LTPY of 852,263 t (Table 8). The major species are Pacific salmon, coastal pelagic fishes, groundfish, Pacific halibut, and nearshore resources. The total U.S. RAY is 619,938 t or 73% of LTPY. The lower RAY is due mainly to underutilization of some species and to low abundance of some stocks. Most stocks are either fully utilized or overutilized.

All five salmon species are fully or overutilized. The RAY of 17,304 t is 52% of its LTPY. Depressed production is partly due to generally unfavorable ocean conditions for salmon off the Pacific Coast since the late 1970's and other factors such as habitat degradation. Some stocks are depleted and have triggered ESA designations and status reviews.

Coastal pelagic fishes typically fluctuate widely in abundance, and most stocks are low in abundance relative to historical levels and are fully utilized. The total RAY of 108,000 t is only 27% of LTPY. The Pacific sardine population has been increasing after decades of low abundance levels and now accounts for 52% of the U.S. RAY for coastal pelagic fishes. Jack mackerel and northern anchovy are underutilized.

The groundfish fishery harvests a vast array of bottom-dwelling species from Washington to California. The total RAY of 353,264 t is 76% of LTPY. The difference between RAY and LTPY is due to a variety of factors, including the diversity of this fishery complex. Some species are overexploited, some have experienced periods of low recruitment, and some are underutilized. Despite being below LTPY, Pacific whiting dominates the commercial U.S. RAY, accounting for 78% of the west coast groundfish catch. Rockfishes and lingcod also support popular recreational fisheries. Certain stocks, such as Pacific ocean perch, need to be rebuilt following overutilization and a period of poor recruitment. Shortbelly rockfish is underutilized because of a lack of market.

Pacific Coast shellfish resources are diverse and important both commercially and recreationally. Shrimp, crab, clam, and abalone fisheries are relatively small in terms of

Unit number and fishery	Total productivity (t) over the entire range of stock: Total recent average yield (RAY)	Total current potential yield (CPY)	Total long-term potential yield (LTPY)	Prorated productivity (t) within the U.S. EEZ: U.S. RAY	U.S. LTPY
16 Western Pacific invertebrate	109	160	222	109	222
17 Western Pacific bottomfish and armorhead	492	470	2,802	492	2,802
18 Pacific highly migratory pelagic	2,049,418	3,439,825	3,435,031	253,606	253,116
21 Western Pacific nearshore species	1,420	1,420	1,420	1,420	1,420
Total	2,051,439	3,441,875	3,439,475	255,627	257,560

Table 9
Productivity in metric tons (t) of fisheries resources of the Western Pacific Region, 1995–97.

tonnage landed, but they contribute substantially to the value of the fisheries, due to the high prices they command. Most shellfish species are fully utilized.

Recreational fisheries are important along the Pacific Coast and especially so in southern California. A wide variety of species is taken, and the recreational catch of some greatly exceeds the commercial catch. Many are nearshore resources. Gamefishes such as albacore, billfishes, rockfish, and salmon are highly prized. Recreational crabbing, clam digging, and abalone diving activities are also significant.

Western Pacific Region

The vast area that encompass this region stretches across the central and western Pacific and includes the Hawaiian Islands and the U.S.-affiliated islands of American Samoa, Guam, and the Northern Marianas (Figure 1). These are tropical and subtropical island waters with a large diversity of species but relatively low sustainable yields due to limited ocean nutrients. Though the magnitude of the fisheries may be relatively small (U.S. RAY and U.S. LTPY are only slightly above 250,000 t: Table 9) when compared to certain larger mainland fisheries, they are valued highly and are important culturally and socially in Hawaii and the Pacific islands. Additionally, certain transboundary fisheries hold considerable international interest, with high collective importance and value to Pacific Rim nations and U.S. fleets fishing within and beyond the U.S. EEZ. Fishery resources include highly migratory pelagic fishes, bottomfishes, nearshore reef fishes, and

USFWS

Fish survey, Rose Atoll, American Samoa

invertebrates. The region also supports protected species such as the Hawaiian monk seal, sea turtles, whales, and dolphins.

Bigscale soldierfish, Point Panie Pipe, Oahu, Hawaii.

The highly migratory stocks (tunas, billfishes, swordfish, sharks, and others) range the high seas, often beyond U.S. fisheries management jurisdiction. Tunas are the major catch component and migrate across multiple jurisdictions in the Pacific. The combined LTPY of these stocks throughout their migratory range is 3,435,031 t, while the prorated U.S. LTPY is only about 7.5% of that. Of the 15 stock groups of highly migratory pelagic fishes, 11 stocks are near the levels that would produce their LTPY's, 1 is below LTPY (blue marlin), 2 are above (yellowfin and skipjack in the central-western Pacific), and 1 (pelagic sharks) is of unknown status. Together, these stocks account for 99% of the region's RAY in tonnage and support some of the most valuable fisheries in the world.

Western Pacific bottomfishes (snappers, jacks, grouper, emperors) are harvested from a variety of rock and coral habitats around Hawaii and western Pacific islands. About 90% of the catch is taken in the Main Hawaiian Islands, where stock assessments indicate some important species are only at 10–30% of original stock levels in some areas. But when the resources are considered across the region, the U.S. RAY of 492 t is only 18% of LTPY, mainly because stocks in the Northwestern Hawaiian Islands, American Samoa, and the Mariana Islands are underutilized.

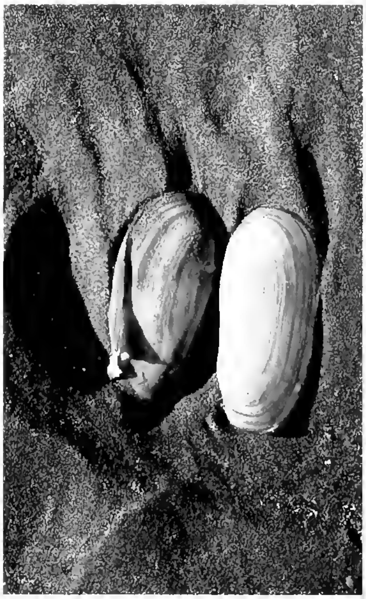
Pelagic armorhead was harvested from 1968 to the late 1980's or early 1990's by foreign fleets on the summits and slopes of submerged seamounts along the southern Emperor-northern Hawaiian Ridge. Of these undersea mountains, the only group under U.S. jurisdiction is the Hancock Seamounts (representing less than 5% of the total fishing grounds). Fishing there has been prohibited since 1984, to allow the stock to recover after foreign catch rates declined to low levels. The United States has never fished pelagic armorhead, but because of its fishery potential, the resource is regulated under a Seamount Groundfish FMP.

The most important invertebrate fisheries in the Western Pacific Region are for spiny and slipper lobsters. They are primarily fished in the Northwestern Hawaiian Islands. This fishery began in 1977 and reached its peak during the mid 1980's, but it has since declined. The primary cause of the decline is thought to be a general reduction in lobster productivity and recruitment since 1989, stemming from mesoscale oceanographic changes. Since

1991, a limited entry and harvest guideline regulatory regime has been implemented, which has allowed some recovery in the fishery. The lobster total RAY of 109 t is 49% of LTPY.

Nearshore Resources

In this report, nearshore fishery resources are those coastal and estuarine species under the control of coastal states and for which NMFS does not have direct responsibility. Many of these species provide the basis for locally important commercial and recreational fisheries. They vary widely in species diversity and abundance. Many are highly prized gamefish. Others are small fishes used for bait, food, and industrial products. Those of greatest interest include invertebrate species like crabs, shrimps, abalones, clams, scallops, and oysters.



Razor clam shell, Pacific Coast.

Because it is difficult to assess the condition of many of the Nation's nearshore resources, a high percentage are of unknown status. No firm estimates exist for LTPY or CPY. Thus, the RAY of 312,700 t (Table 1) has been used to indicate minimum amounts for CPY and LTPY. The RAY itself may have been underestimated due to incomplete landings information, and it excludes landings of large-scale nearshore fisheries like anchovy, sardine, herring, and invertebrate resources, which are reported in other units.

Because the composition of nearshore resources is diverse and management is spread out among the many coastal states and other local authorities, a comprehensive treatment of them has not been attempted in this report. Unit 21 presents information on the more significant species and their general status.

Marine Mammals

The Marine Mammal Protection Act Amendments of 1994 (Public Law 103-238) require the Secretary of Commerce and the Secretary of Interior to develop stock assessment reports (SAR's) for all marine mammal stocks that are found within U.S. waters. NMFS is responsible for assessing and managing stocks of whales, dolphins, porpoises, seals, sea lions, and fur seals. USFWS has authority over stocks of Pacific walrus, Alaska polar bear, Alaska and Pacific Coast sea otter, and West Indian manatee.

Table 10
Status and trends of marine mammals and sea turtles, 1995–97.

Unit number, area, and species	Number of stocks	Strategic	Endangered	Threatened	Depleted
22 Alaska marine mammals	33	10	7	1	1
23 Pacific Coast and Hawaii marine mammals	55	11	9	1	0
24 Atlantic Coast and Gulf of Mexico marine mammals	57	26	7	0	1
Total	145	47	23	2	2
25 Atlantic and Pacific sea turtles	13		6	7	

Mike Spindle USFWS

Bearded seal, Alaska.

The 1994 Amendments require NMFS to include, among other things, information on how a stock is defined, a minimum abundance estimate, the stock's current and maximum net productivity rate, current population trend, a calculation of potential biological removal (PBR), assessment of whether incidental fishery takes are "insignificant and approaching zero mortality and serious injury rate," and an assessment of whether the level of human-caused mortality and serious injury is likely to reduce the stock to below optimum sustainable population (OSP) or whether the stock should be classified as a strategic stock. Strategic stocks are those that are listed as endangered or threatened under the ESA or declining and likely to be listed in the foreseeable future, those designated as depleted under the MMPA (i.e. below OSP), and those for which human-caused mortality exceeds the PBR. SAR's are to be reviewed annually for strategic stocks and for stocks for which new information is available, and at least once every 3 years for all other stocks. The 1994 Amendments also require that take reduction teams involving user groups and environmental groups be formed for each strategic stock and charges them with developing plans to reduce takes to below the PBR's.

NMFS SAR's are produced for three regions and more than 145 stocks—Alaska (33); the Pacific Ocean, including Hawaii (55); and the Atlantic Ocean, including the Gulf of Mexico (57). Currently, 47 marine mammal stocks are classified as strategic (Table 10). These include stocks that are considered depleted (2) under the MMPA, listed as threatened (2) and endangered (23) under the ESA, 15 stocks for which the total annual mortality equals or exceeds PBR, and 46 stocks for which population status or fisheries related mortality is uncertain. Although explicitly excluded from U.S. management under the PBR section of the MMPA, 2 of 10 stocks of eastern tropical Pacific dolphins are listed as depleted.

There are sufficient long-term population data to assign trends for only 18 stocks (12%), with the remaining stocks undetermined. Where reliable information is available, 3 are declining, 6 are stable, and 9 are increasing. Alaska has 13 of 33 stocks that are of known status. The Atlantic Ocean and Gulf of Mexico have only 6 stocks of known status—the harbor, gray, harp, and hooded seals, harbor porpoise, and the western North Atlantic coastal stock of bottlenose dolphin. Upwards of 33 putative stocks of bottlenose dolphins in Gulf of Mexico estuaries, bays, and sounds are of indeterminate status. There are insufficient data to assign an abundance trend to any Pacific Ocean or Hawaiian marine mammal stock.

Sea Turtles

Six species of sea turtles regularly spend all or part of their lives off the U.S. Atlantic and Pacific Coasts and in U.S. territorial waters of the Caribbean Sea and western Pacific Ocean. All sea turtles are listed either as endangered or threatened under the ESA (Table 10). The Kemp's ridley, hawksbill, and leatherback are listed as endangered throughout their range. The loggerhead and olive ridley are listed as threatened throughout their U.S. range, as is the green turtle, except the Florida nesting population, which is listed as endangered.


Donna Dewhurst, USFWS

Loggerhead hatchling.

The large Pacific green turtle population at French Frigate Shoals in the Hawaiian Islands is thought to be increasing, but there is continuing concern about fibropapilloma, a tumor-associated disease. Leatherbacks are seriously declining on their major nesting beaches throughout the Pacific. The collapse of these nesting populations is due to the incidental mortality from fishing and direct harvest of adults and eggs.

Several distinct loggerhead populations have been identified for the Atlantic and Gulf of Mexico. The southern Florida nesting population appears to be increasing; in contrast, the population that nests north of Cape Canaveral through North Carolina is declining. In the western North Atlantic and Gulf of Mexico, the Kemp's ridley population appears to be in the earliest stages of recovery. This can be attributed to the full protection of nesting turtles and their nests in Mexico and the requirement to use turtle excluder devices in shrimp trawls.

Although much progress has been made towards eliminating the killing of sea turtles in shrimp and summer flounder trawl gear, there continues to be a problem from longlines, driftnets, and gillnets from other fisheries.

RECENT TRENDS

Menhaden.

Successive editions of *Our Living Oceans* have sought to maintain consistency in the way stocks are classified and in the way data are reported, and therefore to provide a basis for examining overall trends in the degree of utilization of fishery resources. An examination of recent trends is presented here by comparing the data reported in *OLO '92* and *OLO '99*. Since these editions generally pertain to stock status averaged over 1988–90 and 1995–97, respectively, the comparisons provide an idea of trends over a 7- to 9-year time frame. Readers wishing to obtain more detailed accounting of interannual changes for stocks of interest should refer to the reference sources listed at the end of each unit.

Stock Level Status and Degree of Utilization

The degree of fishery utilization (underutilized, fully utilized, or overutilized) shows how the level of fishing effort exerted on the resource compares to the level necessary to achieve LTPY. In general, management actions[5] should seek to prevent changes that would cause the utilization level to worsen (go from underutilized or fully utilized to overutilized), and should encourage changes that would reverse overutilization (go from overutilized to fully utilized or underutilized). By 1999 (not counting nearshore resources for which NMFS does not have primary monitoring responsibilities), the status of 17 stocks improved, changing from overutilized to fully utilized (+16) or underutilized (+1) (Table 11). Those improving were pollock, yellowtail flounder, haddock, and redfish in the Northeast Region; Spanish mackerel in the Gulf of Mexico and Atlantic (2 stocks); Atlantic menhaden; pink, brown and white shrimp in the Gulf of Mexico and Atlantic (6 stocks); pink, sockeye, and chum salmon off the Pacific Coast; and albacore in the North Pacific. Nine stocks experienced changes in the opposite direction, from under- or fully utilized to overutilized: red hake, spiny dogfish, silver hake, windowpane flounder, black sea bass, and

[5] The actual management actions taken by the regional fishery management councils are linked to their own technical definitions of overfishing and overfished status, which do not always correspond to the fishery utilization and stock level status used in *Our Living Oceans*.

Table 11
Change in degree of fishery utilization (above) and in stock level status relative to LTPY (below) between *OLO '92* and *OLO '99* (Units 1–20).

Degree of fishery utilization (1992)	Total number of stocks by degree of fishery utilization in *OLO '92*: Total	Number of stocks by degree of fishery utilization in *OLO '99*: Over (and change)	Full (and change)	Under (and change)	Unknown (and change)
Over	59	42 (-17)	16 (+16)	1 (+1)	0 (0)
Full	56	6 (+6)	41 (-15)	7 (+7)	2 (+2)
Under	26	3 (+3)	4 (+4)	18 (-8)	1 (+1)
Unknown	47	3 (+3)	8 (+8)	3 (+3)	33 (-14)
Total	188	54 (-5)	69 (+13)	29 (+3)	36 (-11)

Stock-level status (1992)	Total number of stocks by stock-level status relative to LTPY in *OLO '92*: Total	Number of stocks by stock-level status relative to LTPY in *OLO '99*: Below (and change)	Near (and change)	Above (and change)	Unknown (and change)
Below	56	49 (-7)	5 (+5)	2 (+2)	0 (0)
Near	64	14 (+14)	42 (-22)	7 (+7)	1 (+1)
Above	25	4 (+4)	5 (+5)	14 (-11)	2 (+2)
Unknown	43	4 (+4)	5 (+5)	1 (+1)	33 (-10)
Total	188	71 (+15)	57 (-7)	24 (-1)	36 (-7)

Table shows the number of stocks in each *OLO '92* category (over, full, under, below, near, above, and unknown) that have stayed in the same category or shifted to a different category in *OLO '99*. These comparisons can be interpreted as changes between the late 1980's and the mid 1990's. Stocks not appearing in both *OLO '92* and *OLO '99* are not included in this summary. Entries of "variable by river" from *OLO '92* for alewife, American shad, and sturgeons (Unit 3) have been interpreted as overutilized and below LTPY in *OLO '99*.

bluefish in the Northeast Region; and albacore, blue marlin, and bigeye tuna in the Northeast and Southeast Regions. In aggregate, then, the changes in utilization levels were positive during this time period, resulting in a net reduction in the number of overutilized stocks. In terms of scientific understanding, the utilization level became known for 14 stocks that were previously classified as unknown. This is in contrast to only 3 stocks whose utilization level was reclassified as unknown.

Shortspine thornyhead rockfish, Newport, Oregon.

The stock level relative to LTPY shows how the stock size compares to the level of abundance which on average would support the LTPY harvest. In general, management actions should prevent stocks from falling below LTPY, or rebuild them (i.e. to change from below LTPY to near or above LTPY). In terms of stock level relative to LTPY, 7 stocks changed status from below LTPY to near or above LTPY: pollock in the Northeast Region, Atlantic menhaden, Gulf of Mexico pink shrimp, Pacific sardine, North Pacific albacore, thornyhead rockfish in the Gulf of Alaska, and western Pacific spiny and slipper lobsters. In contrast, 18 stocks changed status from near or above LTPY to below LTPY: Atlantic cod, windowpane flounder, spiny dogfish, red hake, white hake, bluefish, sea scallop, albacore, and bigeye tuna in the Northeast Region; coho salmon, Pacific whiting, sablefish, widow rockfish, canary rockfish, and yellowtail rockfish off the Pacific Coast (Oregon-Vancouver Island); Tanner crabs off Alaska; and sablefish in the Eastern Bering Sea and Aleutian Islands and Gulf of Alaska (2 stocks). The status of 10 stocks was reclassified as known, compared to 3 stocks that were reclassified as unknown.

Changes in the degree of utilization by the fishery can occur more rapidly than changes in stock status relative to LTPY. For example, a fishery can be regulated such that the stock's classification changes from overutilized to underutilized in a single year by restricting the number of days-at-sea of fishing vessels, by closing large areas to fishing, or by other regulatory measures. In contrast, allowing a stock to rebuild from below to above LTPY can take many years, depending on the stock's intrinsic natural capacity to grow, on its initial level of depletion, and on the regulatory measures put in place during the rebuilding program. Similarly, deterioration in stock status from, for example, near to below LTPY is a process that cannot always be halted instantaneously.

In addition, changes in how stocks are classified in terms of population status and utilization by the fishery can be due to improved scientific understanding of their long-term potential and of how fishing affects stock abundance over time. Even though NMFS has intended to use terms like LTPY in a consistent manner in every edition of *Our Living Oceans*, our ability to quantify LTPY improves as we accumulate more biological and fishery information, which can result in substantive changes. For example, the two stocks that experienced the largest positive and negative changes in estimates of LTPY between *OLO*

Table 12
Comparison of U.S. recent average yield (RAY) in metric tons (t) reported by *OLO '92* and *OLO '99*

Unit number and fishery[1]	U.S. RAY *OLO '92*	U.S. RAY *OLO '99*	Change (t)	Change (%)
1 Northeast demersal	170,221	142,215	-28,006	-16%
2 Northeast pelagic	101,100	121,300	20,200	20%
3 Atlantic anadromous	3,773	9,408	5,635	149%
4 Northeast invertebrate[2]	129,400	126,200	-3,200	-2%
5 Atlantic highly migratory pelagic	16,512	18,300	1,788	11%
6 Atlantic sharks	9,530	7,393	-2,137	-22%
7 Atlantic coastal migratory pelagic	15,838	15,454	-384	-2%
8 Atlantic, Gulf of Mexico, and Caribbean reef fish	35,186	25,737	-9,449	-27%
9 Southeast drum and croaker	25,808	33,623	7,815	30%
10 Southeast menhaden[2]	920,000	860,000	-60,000	-7%
11 Southeast and Caribbean invertebrate	126,960	119,376	-7,584	-6%
12 Pacific Coast salmon	43,360	17,304	-26,056	-60%
13 Alaska salmon	318,104	376,100	57,996	18%
14 Pacific Coast and Alaska pelagic	120,400	106,500	-13,900	-12%
15 Pacific Coast groundfish	288,538	268,085	-20,453	-7%
16 Western Pacific invertebrate	395	109	-286	-72%
17 Western Pacific bottomfish and armorhead	558	492	-66	-12%
18 Pacific highly migratory pelagic	430,061	253,606	-176,455	-41%
19 Alaska groundfish (total)	1,903,324	2,026,272	122,948	6%
Eastern Bering Sea and Aleutian Islands	1,661,766	1,775,600	113,834	7%
Gulf of Alaska[2]	202,308	211,049	8,741	4%
Pacific halibut (less Canada)	39,250	38,750	-500	-1%
20 Alaska shellfish	123,821	52,131	-71,690	-58%
21 Nearshore	225,185	312,700	87,515	39%
Total	5,008,074	4,891,432	-116,642	-2%

[1]Some stocks were listed under different units in 1992. Unit groupings correspond to *OLO '99*.

[2]Some stocks were not listed in both reports. For comparability, these RAY totals exclude the following: red crab, Unit 4, 1999; butterfish, Unit 10, 1992; Pacific herring, Unit 14, 1999; Atka mackerel, Unit 19 (Gulf of Alaska), 1999.

'92 and *OLO '99* were rock sole in the Eastern Bering Sea (a 285,000 t increase) and Pacific cod in the Gulf of Alaska (a 321,000 t decrease). In some cases, changes in estimates of LTPY coincide with changes in status classification. An example is windowpane flounder in the Northeast Region, for which an initial LTPY value of 5,000 t for *OLO '92* and *OLO '93* was provisional, based on historical landings. In *OLO '95*, LTPY was estimated to be much lower (2,100 t), and at the same time the stock status classification changed from near LTPY to below LTPY.

Stock	Region	Unit number	U S recent average yield (RAY) *OLO '92*	U S recent average yield (RAY) *OLO '99*	Change (t)	Change (%)	Status relative to long-term potential yield (LTPY)
Tanner (including snow) crabs	Alaska	20	109,910	41 910	-68,000	-62%	Below
Atlantic cod	Northeast	1	58,600	15,200	-43,400	-74%	Below
Bluefish	Northeast	2	25,100	11,200	-13,900	-55%	Below
Sea scallop	Northeast	4	16,100	7,100	-9,000	-56%	Below
Yellowtail flounder	Northeast	1	9,200	2,400	-6,800	-74%	Below
Jack mackerel	Pacific Coast	14	8,766	2,000	-6,766	-77%	Above
Coho salmon	Pacific Coast	12	7,944	1,421	-6,523	-82%	Below
Pollock	Northeast	1	9,300	3,800	-5,500	-59%	Near
Scup	Northeast	1	7,400	3,300	-4 100	-55%	Below
Northern anchovy	Pacific Coast	14	7,997	4,000	-3,997	-50%	Near
Porgies (Gulf of Mexico)	Southeast	8	3,798	125	-3 673	-97%	Unknown
Sockeye salmon	Pacific Coast	12	5,097	1,740	-3,357	-66%	Near
Sablefish (Bering Sea and Aleutian Islands)	Alaska	19	4,100	1,600	-2,500	-61%	Below
Small coastal sharks	Southeast	6	3,000	685	-2,315	-77%	Above
Windowpane flounder	Northeast	1	2,700	800	-1,900	-70%	Below
Ocean pout	Northeast	1	1,300	60	-1,240	-95%	Near
Pacific cod	Pacific Coast	15	1,687	515	-1,172	-69%	Unknown
Haddock	Northeast	1	2,000	900	-1,100	-55%	Below
Other porgies (Atlantic)	Southeast	8	844	67	-777	-92%	Unknown
Wreckfish (Atlantic)	Southeast	8	1,100	349	-751	-68%	Near
Alewife/blueback	Northeast	3	1,200	500	-700	-58%	Below
Cusk	Western Pacific	1	1,200	600	-600	-50%	Below
Spiny and slipper lobsters	Western Pacific	16	395	109	-286	-72%	Above
Nassau grouper and jewfish (Gulf of Mexico)	Southeast	8	73	2	-71	-97%	Below
Sturgeons	Northeast	3	73	7	-66	-90%	Below
Nassau grouper and jewfish (Atlantic)	Southeast	8	7	1	-6	-86%	Below
Total			288,892	100,391	-188,501	-65%	

Table 13

Comparison of recent average yield (RAY, U S share only) in metric tons (t), except for highly migratory stocks (Units 5 and 18, which have a very high percentage of non-U S landings) between *OLO '92* and *OLO '99* Only stocks with RAY changes greater than 50% are listed Nearshore resources are not included

Therefore, the summary picture of recent trends presented in Table 11 should be interpreted with care. It is evident that most stock status classifications in *OLO '99* remained the same as in *OLO '92*. Nevertheless, it appears that more stocks have improved in utilization level (17 stocks) than have worsened (9 stocks). At the same time, more stocks have worsened in stock-level status (18) than have improved (7). Overall, this implies some net progress in bringing excessive fishing mortality rates under control, but it does not appear that there has been an overall net improvement in stock status. In fact, this summary serves to confirm that a transition to eliminate overfishing and rebuild overfished stocks has begun, but it does not reflect the very real and substantive management measures that have been enacted in recent years nor the improved scientific understanding of resource dynamics and potential. A case in point is that of Northeast demersal fisheries, which have recently (since 1996–97) been subjected to very substantial reductions in fishing mortality in order to begin rebuilding programs that are designed to meet specific long-term targets (see Feature Article 2). Strengthened management measures designed to reduce overfishing and initiate rebuilding are also currently being implemented in many other fisheries, and this should result in an acceleration in the rate of improvement of stock status and degree of fishery utilization in the near future.

Recent Yields

Overall, average yields (U.S. share) of the fishery resources reported in Units 1–21 declined by 2% between the time periods considered by *OLO '92* and *OLO '99*. This corresponds to a decrease of more than 116,600 t (Table 12). The largest declines occurred for Pacific highly migratory fish stocks (–176,455 t), Alaska shellfish (–71,690 t), and Southeast menhaden (–60,000 t). The largest gains were for Eastern Bering Sea groundfish (113,834 t), Alaska salmon (57,996 t), and Northeast pelagic fisheries (20,200 t).

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Tagged bluefin tuna released off Ocean City, Maryland.

Table 13 lists the individual stocks or stock groups for which RAY decreased by 50% or more between *OLO '92* and *OLO '99*. In terms of tonnage, the largest reduction in RAY was for Tanner crabs in Alaska, after an all-time high in the early 1990's (Tanner crab landings, including snow crab, declined from 109,910 t in 1991 to 41,910 t in 1996). RAY for Atlantic cod in the Northeast Region also declined substantially during this time period, due to the low stock abundance caused by overfishing and to current fishing restrictions aimed at rebuilding the stock. For the same reasons, many of the stocks that experienced large percentage declines in RAY are from the Northeast (Table 13). Some stocks experienced large percentage declines in RAY, although the absolute magnitude of the landings is small. Examples are Nassau grouper and jewfish in the Gulf of Mexico and Atlantic, severely depleted stocks for which management aims to eliminate catches until rebuilding is achieved. Overall, 26 stock groups experienced a decrease in RAY of 50% or more, accounting for a 188,501 t decrease between *OLO '92* and this report.

Stock	Region	Unit number	U.S. recent average yield (RAY) *OLO '92*	U.S. recent average yield (RAY) *OLO '99*	Change (t)	Change (%)	Status relative to long-term potential yield (LTPY)
Atka mackerel (Bering Sea, Aleutians)	Alaska	19	21,100	83,800	62,700	297%	Near
Atlantic herring	Northeast	2	46,800	92,700	45,900	98%	Above
Chum salmon	Alaska	13	28,694	70,800	42,106	147%	Above
Bigeye tuna (Atlantic)	Northeast	5	63,233	100,700	37,467	59%	Below
Pacific sardine	Pacific Coast	14	3,511	35,000	31,489	897%	Near
Rock sole (Bering Sea, Aleutians)	Alaska	19	31,600	56,500	24,900	79%	Above
Flatfish (Gulf of Alaska)	Alaska	19	13,548	36,294	22,746	168%	Unknown
Other fish (Bering Sea, Aleutians)	Alaska	19	4,200	24,000	19,800	471%	Above
Other flatfish (Bering Sea, Aleutians)	Alaska	19	18,400	38,100	19,700	107%	Above
Pacific herring (Bering Sea)	Alaska	14	15,715	34,000	18,285	116%	Near
Goosefish	Northeast	1	11,700	27,600	15,900	136%	Below
Spiny dogfish	Northeast	1	10,600	23,900	13,300	125%	Below
Striped bass	Northeast	3	1,400	8,300	6,900	493%	Above
Pacific halibut (Bering Sea)	Alaska	19	3,200	8,930	5,730	179%	Near
Arrowtooth flounder (Bering Sea, Aleutians)	Alaska	19	5,600	11,300	5,700	102%	Above
Pink shrimp (Gulf of Mexico)	Southeast	11	5,454	11,009	5,555	102%	Near
Other rockfish (Bering Sea, Aleutians)	Alaska	19	800	5,800	5,000	625%	Above
Seatrouts	Southeast	9	6,250	10,820	4,570	73%	Variable
Northern shrimp	Northeast	4	3,800	7,600	3,800	100%	Unknown
Blue marlin (Atlantic)	Northeast	5	1,086	4,100	3,014	278%	Below
Rock shrimp	Southeast	11	3,419	6,240	2,821	83%	Unknown
Atlantic croaker	Southeast	9	4,946	7,657	2,711	55%	Below
Red drum (Gulf of Mexico)	Southeast	9	2,828	5,031	2,203	78%	Below
Stone crab	Southeast	11	1,264	2,961	1,697	134%	Near
Seabob shrimp	Southeast	11	2,269	3,947	1,678	74%	Unknown
Red snapper (Gulf of Mexico)	Southeast	8	2,228	3,815	1,587	71%	Below
Pelagic shelf rockfish (Gulf of Alaska)	Alaska	19	1,179	2,605	1,426	121%	Unknown
Shrimp	Alaska	20	340	1,637	1,297	381%	Below
White marlin (Atlantic)	Northeast	5	262	1,600	1,338	511%	Below
[illegible]	Northeast	1	1,500	2,500	1,000	67%	Unknown
Tilefish	Northeast	1	800	1,200	400	50%	Below
Pacific halibut (Wash., Ore., Calif.)	Pacific Coast	19	250	570	320	128%	Near
Snappers (Caribbean)	Southeast	8	224	422	198	88%	Unknown
Royal red shrimp	Southeast	11	143	250	107	75%	Unknown
Bottomfish (NW Hawaiian Islands)	Western Pacific	17	98	184	86	88%	Near
[illegible]	Southeast	[illegible]	55	91	[illegible]	65%	Below
[illegible]	Western Pacific	18	101	160	59	58%	Near
[illegible]			[illegible]	[illegible]	[illegible]	146%	
[illegible]			318,597	[illegible]	413,526	130%	

Table 14 lists the individual stock groups for which RAY increased by 50% or more during the same time period. Many of these stocks are from the Alaska Region, where overfishing has not been widespread in the past. Examples of Alaska stocks with large gains in RAY include Atka mackerel, chum salmon, rock sole, and various other flatfishes (Table 14). In the Northeast Region, RAY increased for striped bass after an aggressive rebuilding program and a series of good recruitments. Other Northeast stocks that experienced large gains in RAY are often less traditional species like spiny dogfish, which replaced the more traditional stocks when they became depleted. In the Southeast Region, large relative gains in RAY were observed for shrimps and, despite low population sizes, for stocks such as red snapper and red drum in the Gulf of Mexico. Environmental conditions often modulate long-term trends in stock abundance. The increased levels of RAY for coastal pelagic fishes like herrings and sardine are partly due to more favorable environmental conditions. The overall gain in RAY for the 37 stocks in Table 14 amounts to 413,500 t. However, part of that total includes catches of tuna and tuna-like species made by other countries. The total gain excluding these stocks amounts to nearly 372,000 t.

Allen Shimada NMFS

Stacking a salmon purse seine, Dutch Harbor, Alaska.

It is evident from Table 13 that many of the stocks that experienced declines in landings are below the level that supports LTPY (65% of the stocks of known status in Table 13 are below LTPY). That is, the landings for many of these stocks decreased because their population sizes can no longer support historical levels of catch, or because of restrictive management regulations aimed at rebuilding the stocks, or both. In contrast, many of the stocks that had very large increases in landings had population sizes that could support LTPY (62% of the stocks of known status in Table 14 are near or above LTPY).

Protected Resources

Table 14 (facing page)
Comparison of recent average yield (RAY, U.S. share only, in metric tons (t) except for highly migratory stocks from Units 5 and 18, which have a very high percentage of non-U.S. landings) between *OLO '92* and *OLO '99*. Only stocks with RAY changes greater than +50% are listed. Nearshore resources are not included.

Perhaps the most positive development over the period since enactment of the 1994 MMPA Amendments has been the increase in quality of NMFS stock assessment information covering a greater number of separate stocks. *OLO '92* reported on 82 stocks of marine mammals and sea turtles from the Atlantic and Pacific Regions, but with fully 74% having unknown status. In this report, about twice that number of marine mammal and sea turtle stocks (158) are enumerated. Still problematic is that trends can only be assigned to 12% of marine mammal stocks, and that no trend characterizations, other than for sea turtles, can be made in the Pacific Ocean. The designation of strategic stock confers special status which requires NMFS to prepare recovery plans for impacted stocks and closer scrutiny through annual status assessments.

Hawaiian monk seal, National Wildlife Refuge, Northwestern Hawaiian Islands.

Marine Mammals Off the Atlantic Coast, only the northeastern U.S. bottlenose dolphin stock changed from unknown to stable trend status. Because the total annual mortality estimate was higher than PBR, this stock was listed as depleted in 1998. Minimum population estimates, as compared to 1992, are equivocal for fin, humpback, pilot, and northern right whales, and trends cannot be assigned. Northwest Atlantic harbor porpoise and harbor seals are the only species with increasing abundance over 1992 levels. In the Gulf of Mexico, abundance estimates are available for six stocks of bottlenose dolphins, but there are more than 33 individual groups found in bays, estuaries, and sounds that are of unknown status.

The Hawaiian monk seal remains critically endangered throughout its range, with no discernible improvement in stock size since last reported in *OLO '95*. Three Pacific Coast stocks of harbor seal are increasing, but little else can be said about the remaining species. In the eastern tropical Pacific, several dolphin stocks are thought to have stabilized, largely from significant reductions in bycatch mortality associated with the tuna purse-seine fishery.

Steller sea lions hauled out in Southeast Alaska

Recent stock assessments in Alaska show continued incremental improvement for bowhead whales, gray whales, and Southeast Alaska harbor seals. Although the threatened eastern Pacific stock of Steller sea lions (east of long. 144°W) has shown some improvement, the western U.S. Pacific stock (west of long. 144°W) continues to decline precipitously and has been placed in endangered status. In late 1998, NMFS issued a biological opinion finding the western U.S. Pacific stock to be in jeopardy and implemented emergency rules prior to the January opening of the 1999 walleye pollock fishery. Continuing their declining trend are harbor seals in the Gulf of Alaska and Bering Sea. The northern fur seal population remains stable, but retains its depleted status under the MMPA. The eastern stock of North Pacific gray whale has the distinction of being the first marine mammal to be removed from ESA listing. This species has fully recovered and is at or above its initial unexploited stock size.

Sea Turtles ESA status for all species of sea turtles remains unchanged from their initial listings in the 1970's, but progress has been made in developing new trend data and separation of populations. Improvements over 1992 include estimates of nesting females now available for the Atlantic populations of leatherback, and for several nesting populations in the Pacific of the leatherback, loggerhead, and olive ridley. Recent work in genetic stock identification has identified three loggerhead populations in the southeastern United States and a fourth off Mexico's Yucatán Coast.

Recent assessments suggest improving conditions in several stocks. Green turtles continue to increase from 1992 levels throughout their U.S. range. Increases were also observed for central-southwest Florida loggerhead (from stable in 1992), and for olive ridley in the Pacific (from unknown in 1992). Conservation efforts for the Atlantic Kemp's ridley has reversed an estimated 3% annual rate of decline (since 1978) to a sustained increase in the number of nests beginning in the early 1990's. The leatherback has gone from unknown status throughout its U.S. range to stable in the Atlantic but declining in the Pacific. The Pacific stocks of loggerhead and hawksbill are now considered stable relative to unknown status in 1992. Less promising circumstances are noted for two loggerhead stocks (northern Florida-North Carolina and Florida Panhandle) and the Atlantic hawksbill as they are in declining or unknown status.

ISSUES OF NATIONAL CONCERN

The management of living marine resources is complex and involves many biological, economic, social, and political factors. Each region and fishery discussed in this report, even those fisheries that are currently well managed and yielding near their long-term potential for the national benefit, must continually adjust and adapt to ever-changing conditions. To increase long-term benefits from currently overutilized and depleted fishery resources, the difficult issues and practices, which have resulted in overutilization and resource depletion must be confronted. In all 25 units, major issues affecting the resources and their management are raised. Although each resource unit has unique features, common themes are significant to many, if not all of them; they are discussed below.

Resource Conservation and Utilization by the Fishery

The primary concern of fishery management is conservation—the protection and wise use of the Nation's living marine resources. Management strategies must consider which stocks are overutilized and too low to produce LTPY. Table 3 indicates that 46% of the stocks under NMFS purview, whose status is known (73 out of 158 stock groups), are below the abundance levels that would produce LTPY. Similar compilations indicate that 34% of the stocks (54 out of 160 stock groups) are overutilized (Table 4).

China rockfish, North Pacific Ocean.

The list of stocks that are overutilized or below the levels required to produce LTPY includes some of our most valuable fishery resources, such as New England groundfish, Atlantic sea scallops, several pelagic highly migratory fish stocks (including Atlantic bluefin tuna and swordfish), some Pacific salmon stocks, some rockfish off Alaska, and Alaska king crab. Many nearshore stocks (including several oyster populations, bay scallops, abalones, and Pacific striped bass) are also overutilized.

The Northeast Region presents the worst case of overutilized stocks (Tables 3 and 4). Cod, haddock, and yellowtail flounder, historically the most important groundfish species on Georges Bank off New England, are presently among the most depleted stocks in U.S. waters. By 1994, the Georges Bank haddock and yellowtail flounder stocks had collapsed, and Georges Bank cod was in danger of collapse. Restrictive controls on fishing effort, and closure of large areas on Georges Bank, have been implemented to reduce fishing mortality, and haddock and yellowtail flounder stocks are now improving.[5]

Examples of resource overutilization can also be found in all other regions. In some cases, like Pacific salmon, the main causes for their decline appear to be changing ocean conditions and habitat alterations, although intense fishing pressure from competing user groups has exacerbated the problem. Other stocks are disproportionately impacted by fishing owing to their low numbers in relation to more abundant target species.

On Georges Bank, the spawning-stock biomass of haddock is currently about one-fourth to one-third of the historical average. The spawning-stock biomass of yellowtail flounder has rebounded to its highest level since 1973.

In recent years, there has been growing awareness of Federal actions to mitigate overutilized situations. Throughout the early and mid 1990's, Federal FMP's were amended to specify numerical definitions of overfishing levels according to sound population dynamics principles (see Appendix 4). The fisheries managed by those FMP's need to maintain fishing mortality at levels lower than the definition of overfishing, which can be accomplished by a number of controls such as limiting catches. As the previous section on recent trends indicates, it is still too early to realize the full benefits of related conservation actions that have been taken in all regions. More recently, concurrent with the writing of this report, all FMP's are being amended again to revise the overfishing definitions, if necessary, to comply with changes made to the MSFCMA when it was reauthorized in October 1996. The amended Act has been interpreted by NMFS as being consistent with the precautionary approach, a framework for ensuring that conservation objectives take precedence over short-term economic considerations (see Feature Article 1). The Act, for example, dictates that management needs to maintain the abundance of stocks at levels capable of producing LTPY (or MSY). As a result, it is expected that management measures designed to eliminate overfishing will be strengthened in the near future.

In the case of stocks that are below LTPY, the amended MSFCMA requires plans to rebuild the stocks as quickly as possible. The benefits of rebuilding are not trivial. A very conservative estimate of the potential gain in yield from restoring overutilized stocks (those below LTPY) is 138,700 t, or a 39% increase of their combined RAY (Table 15). Many of these stocks are extremely valuable, not only commercially and to recreational anglers, but also as important components of the ecosystems that they are a part of, such that the true benefits to the Nation are difficult to quantify.

It is important to recognize that the benefits of rebuilding depleted stocks cannot be realized immediately after the rebuilding plans become operational. The amount of time required to rebuild a stock depends on the species' longevity and growth potential, on environmental influences, and on the management controls put in place. For example, a stock of long-lived rockfish that has been overfished for decades cannot be rebuilt in 10 years under average environmental conditions, even under a complete moratorium on fishing. Where fisheries are overcapitalized and performing poorly in economic terms, as many U.S. fisheries are, short-term economic concerns have tended to receive undue weight relative to the steps needed to cut back harvests–sometimes for many years–and achieve long-term biological and economic goals. The reauthorized MSFCMA effectively limits the weight

Stocks	Region	Recent average yield (RAY)	Long-term potential yield (LTPY)	Change (t)	Change (%)
American plaice	Northeast	4,300	7,200	2,900	67%
Atlantic cod	Northeast	15,200	40,000	24,800	163%
Atlantic halibut	Northeast	15	300	285	1,900%
Black sea bass	Northeast	3,500	Unknown	Unknown	Unknown
Cusk	Northeast	600	Unknown	Unknown	Unknown
Goosefish	Northeast	27,600	Unknown	Unknown	Unknown
Red hake	Northeast	1,400	Unknown	Unknown	Unknown
Scup	Northeast	3,300	Unknown	Unknown	Unknown
Silver hake	Northeast	15,500	Unknown	Unknown	Unknown
Spiny dogfish	Northeast	23,900	Unknown	Unknown	Unknown
Summer flounder	Northeast	9,700	24,500	14,800	153%
Tilefish	Northeast	1,200	1,200	0	0%
Windowpane flounder	Northeast	800	1,900	1,100	138%
Winter flounder	Northeast	5,500	12,900	7,400	135%
Witch flounder	Northeast	2,000	2,900	900	45%
Wolffish	Northeast	400	Unknown	Unknown	Unknown
Bluefish	Northeast	11,200	42,700	31,500	281%
Alewife/blueback	Northeast	500	Unknown	Unknown	Unknown
American shad	Northeast	600	Unknown	Unknown	Unknown
Atlantic salmon	Northeast	1	Unknown	Unknown	Unknown
Sturgeons	Northeast	7	Unknown	Unknown	Unknown
Sea scallop	Northeast	7,100	9,310	2,210	31%
Bigeye tuna	Northeast	100,700	80,000	-20,700	-21%
Albacore (North Atlantic)	Northeast	31,900	32,000	100	0%
Blue marlin (Atlantic)	Northeast	4,100	4,500	400	10%
Bluefin tuna (West Atlantic)	Northeast	2,300	5,250	2,950	128%
Sailfish (West Atlantic)	Northeast	900	700	-200	-22%
Swordfish (North Atlantic)	Northeast	14,800	13,000	-1,800	12%
White Marlin (North Atlantic)	Northeast	1,600	2,200	600	38%

Table 15

Potential gains in yield in metric tons (t) from rebuilding overutilized stocks that are currently below LTPY. RAY and LTPY are U.S. share only, except for tunas and billfishes The total is a conservative estimate, assuming that LTPY equals RAY when RAY is unknown

Table continued on the next page

that can be given to short-term economic concerns when a stock's LTPY is in jeopardy. As a result, management measures designed to achieve rebuilding should also be strengthened over the near future.

A few abundant resources, such as some pelagic stocks of Atlantic mackerel and herring in the Northeast Region (Unit 2), jack mackerel off California (Unit 14), flatfishes off

Stocks	Region	Recent average yield (RAY)	Long-term potential yield (LTPY)	Change (t)	Change (%)
Large coastal sharks	Southeast	5,216	Unknown	Unknown	Unknown
King mackerel (Gulf of Mexico)	Southeast	3,307	9,750	6,443	195%
Nassau grouper and jewfish (Gulf of Mexico)	Southeast	2	Unknown	Unknown	Unknown
Red snapper (Gulf of Mexico)	Southeast	3,815	15,000	11,185	293%
Nassau grouper and jewfish (Atlantic)	Southeast	1	Unknown	Unknown	Unknown
Other groupers (Atlantic)	Southeast	1,150	Unknown	Unknown	Unknown
Other snappers (Atlantic)	Southeast	652	Unknown	Unknown	Unknown
Red porgy (Atlantic)	Southeast	236	450	214	91%
Red snapper (Atlantic)	Southeast	155	Unknown	Unknown	Unknown
Vermilion snapper (Atlantic)	Southeast	564	Unknown	Unknown	Unknown
Nassau grouper and jewfish (Caribbean)	Southeast	4	Unknown	Unknown	Unknown
Atlantic croaker	Southeast	7,657	50,000	42,343	553%
Red drum (Atlantic)	Southeast	800	Unknown	Unknown	Unknown
Red drum (Gulf of Mexico)	Southeast	5,031	7,900	2,869	57%
Queen conch	Southeast	91	Unknown	Unknown	Unknown
Spiny lobster (southeast United States)	Southeast	3,325	3,565	240	7%
Chinook salmon	Pacific Coast	7,444	11,460	4,016	54%
Coho salmon	Pacific Coast	1,421	5,300	3,879	273%
Lingcod	Pacific Coast	1,966	1,943	-23	-1%
Pacific ocean perch	Pacific Coast	800	1,100	300	38%
Bottomfish (Main Hawaiian Islands)	Western Pacific	249	254	5	2%
Pelagic armorhead	Western Pacific	0	2,123	2,123	N/A
Blue marlin	Western Pacific	23,278	23,278	Unknown	Unknown
Subtotal for "known" LTPY		271,844	410,560	138,716	51%
Subtotal for "known" LTPY excluding tuna and billfish		115,544	272,910	157,366	136%
Total		357,787	496,503	138,716	39%

Table 15
Continued from previous page.

Alaska (Unit 19), and tunas in the central-western Pacific, are currently underutilized. A much larger fishery yield can potentially be obtained from these stocks, perhaps as high as an extra 1,270,000 t (excluding tunas, Table 16). However, market conditions or bycatch limitations have kept the harvest for many of these stocks at low levels. Shifting fishing pressure from overutilized to underutilized stocks may relieve pressure on stressed stocks and aid in the rebuilding of depleted stocks. However, the habitats of the stocks often overlap and effective harvesting strategies must be developed to fish one stock while not jeopardizing others.

Stocks	Region	Recent average yield (RAY)	Long-term potential yield (LTPY)	Change (t)	Change (%)
Atlantic herring	Northeast	92,700	266,000	173,300	187%
Atlantic mackerel	Northeast	14,600	140,000	125,400	859%
Butterfish	Northeast	2,800	16,000	13,200	471%
Jack mackerel	Pacific Coast	2,000	100,000	98,000	4,900%
English sole	Pacific Coast	1,263	3,100	1,837	145%
Shortbelly rockfish	Pacific Coast	38	23,500	23,462	61,742%
Skipjack tuna (central-western Pacific)	Western Pacific	950,527	2,000,000	1,049,473	110%
Yellowfin tuna (central-western Pacific)	Western Pacific	335,451	600,000	264,549	79%
Arrowtooth flounder	Alaska	11,300	230,000	218,700	1,935%
Other fish	Alaska	24,000	27,800	3,800	16%
Other flatfish	Alaska	38,100	253,000	214,900	564%
Other rockfish	Alaska	5,800	8,300	2,500	43%
Rock sole	Alaska	56,500	449,000	392,500	695%
Subtotal without tunas		249,101	1,516,700	1,267,599	509%
Total		1,535,079	4,116,700	2,581,621	168%

Table 16

Potential gains in yield in metric tons (t) from fully utilizing underutilized stocks that are currently above LTPY. RAY and LTPY are U.S. share only, except for tunas.

In addition to requirements for preventing overfishing, ending overfishing of currently depressed stocks, and rebuilding depleted stocks, the reauthorized MSFCMA also contains provisions for reducing bycatch and minimizing the mortality of unavoidable bycatch, designating and conserving essential habitat, reforming the approval process for fishery management plans and regulations, reducing conflicts of interest on regional fishery management councils, and establishing user fees. The original 1976 Magnuson Fishery Conservation and Management Act contained seven national standards dealing with overfishing and optimum yield, best available science, management units, allocation of fishing privileges, economic efficiency, accounting for variation in stocks and fisheries, and minimizing management costs. There are now an additional three new national standards on fishing communities, bycatch, and safety at sea. Since the MSFCMA was reauthorized, NMFS and the fishery management councils have succeeded in implementing many of its requirements, including the development of new guidelines on most of the national standards and definitions of essential habitat, FMP amendments, formation of several special committees and advisory panels, and preparation of numerous studies and reports.

Almost all major U.S. fisheries now have some form of limited access in recognition of pervasive problems of overcapacity and overcapitalization and their effects on overfishing. Four U.S. fisheries (Alaska halibut and sablefish, wreckfish, and surfclams-ocean quahogs) have individual fishing quotas (IFQ's), a mechanism considered to be effective at matching fishing effort to resource productivity, but often perceived to result in other problems. In 1996, the U.S. Congress established a moratorium on new IFQ programs pending review by a National Academy of Sciences committee. That review was recently (December 1998) completed and is generally favorable towards IFQ's, although recognizing that this system of management is not a panacea and may not be applicable for all fisheries (NRC, 1999a). The United States has also been involved in several FAO-sponsored initiatives concerned with the issue of excess fishing capacity.

Sablefish subsample, Aleutian Islands bottom trawl assessment survey.

Transboundary Jurisdiction

Many living marine resources often cross political or geographic boundaries, complicating their assessment and management. The boundaries can be between states, between adjacent countries, or even between distant countries in international waters. Sometimes boundaries are crossed by juvenile or adult fish during migrations, and sometimes the boundaries are crossed by larvae drifting with ocean currents. In all cases, these movements complicate even rhe most comprehensive fisheries assessment and management regimes. Effective oversight of these species requires coordination, cooperation, and agreement among all interested parties.

Stocks located primarily within Federal waters are managed under FMP's prepared by regional FMC's and implemented and enforced by NMFS. Stocks whose distribution overlaps the jurisdiction of more than one regional FMC require the participation of multiple FMC's. Most stocks that extend beyond the U.S. EEZ are managed wholly or in part under international conventions.

Stocks located largely within the waters of more than one state are, to an increasing extent, managed by interstate mechanisms. One example of successful interstate management is the recovery of Atlantic striped bass under a rebuilding plan developed by the Atlantic States Marine Fisheries Commission; striped bass were considered to be fully restored in 1995. Examples of other resources that require interstate coordination of management are menhaden and mackerels in the Atlantic and Gulf of Mexico.

The United States shares important resources with its continental neighbors. Several groundfish stocks in the Northeast Region are shared with Canada. Although there is no formal mechanism to manage these stocks jointly, there is considerable interaction between the two countries in terms of sharing knowledge and information and in conducting joint assessments and reviews. In addition, the two countries share a similar objective of maintaining fishing mortality levels below the same threshold. Pacific halibut represent an example of a formal arrangement to assess and manage stocks shared by the U.S. and Canada jointly through the International Pacific Halibut Commission.

Spotted spiny lobster, Caribbean Sea.

To the south, other valuable resources are shared with Mexico: Gulf of Mexico migratory pelagics (mackerels) and Pacific Coast pelagics (mackerels, sardine, and anchovy), as well as highly migratory stocks of tunas, swordfish, and sharks. No bilateral agreements are yet in place for the assessment and management of these stocks, although the foundations for these joint and multilateral agreements are being developed through MEXUS-Gulf and MEXUS-Pacific bilateral discussions, as well as through Mexico's developing interest in joining the International Commission for the Conservation of Atlantic Tunas (ICCAT).

In the Atlantic, highly migratory bluefin tuna and swordfish fall under the jurisdiction of ICCAT. Regulation of these particular species is difficult, since international consensus on catch levels for these high-valued fish is not always reached or agreed on. Further, enacted measures must always be successfully enforced by all nations to be effective. Highly migratory tuna and billfish also cross international borders in the Pacific, and some range across the Pacific. While international exchange of scientific information has been historically good, progress on joint management has been slow. In the absence of cooperative international management regimes, most stocks are regulated by individual coastal nations.

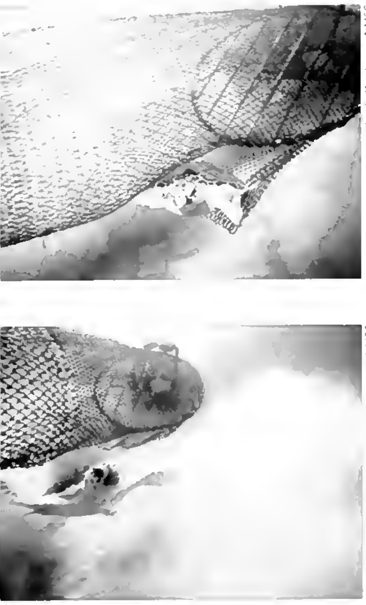
In some cases, foreign fisheries targeting migrating U.S.-origin stocks outside the U.S. EEZ can undermine Federal management of those stocks. Salmon on both the Atlantic and Pacific Coast begin life in freshwater and migrate to the open ocean to feed and mature before returning to their natal streams to spawn. During this period, salmon are subject to fishing pressure outside U.S. waters. Heavy exploitation of U.S.-origin Atlantic salmon in the commercial fisheries off Newfoundland and Greenland has recently been reduced through a Canadian closure of the Newfoundland fishery and through measures implemented by the North Atlantic Salmon Conservation Organization. Off the Pacific Coast, some U.S.-origin salmon are intercepted by Canadian fishermen while migrating through Canadian waters, and some sockeye and pink salmon originating in Canada's Fraser River are caught by U.S. fishermen while transiting U.S. waters. The ever contentious allocation of expected catches from stocks originating from each country to fishermen of both nations is handled by the U.S.-Canada Pacific Salmon Commission. Some U.S. pollock from the Eastern Bering Sea migrate into the Russian zone in the northwestern Bering Sea where they are subject to exploitation by Russian fisheries. While there is scientific exchange on this issue between Russia and the United States, a joint management scheme has not yet been formulated.

Other stocks migrate over international borders through larval drift. Caribbean spiny lobsters, distributed from Brazil to Bermuda, produce larvae that can live from 4 to 9 months in the plankton, thus having the potential to move long distances. As yet, there is no international mechanism for the routine analysis and compilation of data that would facilitate Caribbean-wide management schemes for lobsters. A similar situation results in the need for international plans to manage pelagic armorhead fisheries off seamounts in the Western Pacific Region.

Bycatch

Bycatch, the incidental take of nontarget species or sizes in fishing operations, is a worldwide problem that results in 17,900,000–39,500,000 t of the world's commercial fish catch being discarded (Alverson et al., 1994). Bycatch not only creates waste but also makes it nearly impossible to meet management objectives simultaneously for the mix of species caught and, in many cases, bycatch results in the overutilization of stocks.

Bycatch is a ubiquitous problem, as can be appreciated from many units in Part 2 of this report. In all regions, bycatch results in overutilization or underutilization of resources, conflicts of allocation between competing user groups, or unwanted interactions with protected resources like marine mammals, birds, and sea turtles. Groundfish fisheries have notoriously visible bycatch problems. The fisheries, whether conducted with trawl gear, longlines, or pot gear, catch and discard large volumes of animals that are of the wrong size, wrong species, wrong maturity stage, or are otherwise unwanted. For instance, as much as 60–80% of the rock sole caught in recent years in the Eastern Bering Sea were discarded because they are not the valuable roe-bearing female fish. Several Alaska groundfish stocks are underutilized because their fisheries also catch other depleted stocks or stocks that are under strict quota management, such as halibut or king and Tanner crabs. The bycatch of juvenile red snapper in the Gulf of Mexico shrimp fisheries restricts the speed at which the snapper stock can be rebuilt. Tuna and swordfish fisheries often catch marlins and sailfish, prized targets for recreational anglers. There are many other examples.



Loggerhead escaping out a turtle excluder device, Gulf of Mexico.

Mitigation of bycatch problems is complex. The problem is partly biological and partly technological. Some technological innovations can work to reduce bycatch, such as the use of turtle excluder devices to minimize impacts on sea turtles in the shrimp fisheries of the Gulf of Mexico or fish excluder devices to reduce bycatch of groundfish in the northern shrimp fishery of the Northeast Region. Research by NMFS, industry, and academia continues to develop fishing gears that are more species-selective. In some cases, however, new technologies cannot resolve the problem adequately and it may be necessary to use closed-area and closed-season controls on fishing. In the Northeast Region, for instance, scalloping is prohibited in some areas to aid in the rebuilding of Atlantic cod and yellowtail flounder. Time-area closures are also being used to reduce salmon bycatch in Alaska groundfish fisheries. Time-area closures may require continuous adjustments when the dynamics and abundance of the species of concern change in time and space and therefore require routine scientific monitoring.

Habitat

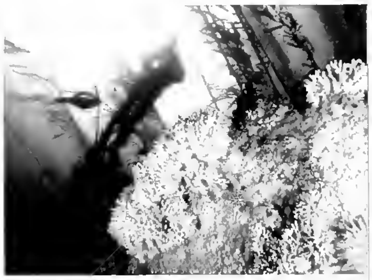
The requirement to identify essential fish habitat (EFH) was one of the most substantive changes in the 1996 reauthorization of the MSFCMA. With the EFH and related provisions, the amended Act gives heightened consideration to fish habitat in resource management decisions, and provides significant new tools to assist resource managers to conserve the habitats of marine, estuarine, and anadromous fish and shellfish resources.

EFH is identified as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." The MSFCMA requires that fishery management plans identify and describe EFH for all life stages of each species Federally managed within the U.S. EEZ, using the best scientific information available. Within areas identified as EFH, fishery management councils must minimize to the extent practicable adverse effects on the habitat caused by fishing practices. They must also identify adverse impacts from nonfishing activities and consider conservation and enhancement measures to mitigate those impacts. Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with the Secretary of Commerce, through NMFS, regarding the effects of their actions on the habitat and on the associated fisheries. NMFS can provide conservation and enhancement recommendations where appropriate, designed to minimize adverse impacts to EFH. These new policies incorporate the precautionary approach into the management of fish habitats.

Coastal zones contain the most productive marine ecosystems, providing habitats and essential spawning and nursery areas for most of the major commercial and recreational fishery species. The habitats of the coastal zone also provide a number of critical services that maintain the health and stability of the coastal ecosystems benefiting the organisms that depend on the system and man. Coastal and riparian wetlands serve as efficient filters for contaminants derived from land-based runoff, moderate the effects of flooding, and, along with coral reefs, buffer storm surges and help retard coastal erosion. Coastal habitats (mangrove swamps, estuarine oyster beds, salt marsh wetlands, seagrass beds, coral reefs, etc.), although highly productive, are fragile, and susceptible to degradation through human activities. It is here, where the shore meets the sea, and where people are most inclined to build, manufacture, and recreate, that the most susceptible and diverse aspects of marine life exist.

Sockeye salmon in spawning river, Pacific Northwest.

As the world's most biologically diverse marine ecosystems, coral reefs are home to one-third of all marine fish species and tens of thousands of other species. Coral reef areas under U.S. jurisdiction cover approximately 16,879 square kilometers. In the United States, coral reefs appear threatened wherever they are close to large concentrations of people; however, data are available to monitor the status and trends of U.S. coral reefs in only a few sites. The International Year of the Reef, 1997, and the 1998 Executive Order on Coral Reef Protection are providing impetus to new reef monitoring programs that should greatly increase our understanding of the status and outlook for coral reefs worldwide.



Diver amid kelp and coral off California coast.

If coral reefs represent the most diverse marine communities, coastal wetlands and estuaries rank among the most productive ecosystems. These systems, including salt marshes, seagrass beds, and mangroves, are associated with some of the world's greatest fisheries, and provide habitat for migrating shorebirds and waterfowl. They also provide critical ecological functions supplying nutrients for nearshore production, filtering land runoff, and stabilizing coastal lands. Approximately 75 percent, by weight, of the Nation's commercial fish catch is composed of fish and shellfish that depend on estuaries at some critical stage in their life cycle.

Mangrove roots, Florida Keys, Florida

Until quite recently, the United States was losing wetlands at a rapid rate. The Clean Water Act and other Federal environmental laws have been instrumental in decreasing wetland losses since that time. During 1982–92, the losses totaled 31,000 acres of wetland per year, down from 157,000 acres per year in 1974–83, and down further from the 398,000 acres per year in 1954–74. However, despite regulatory programs and natural resource management plans, human population growth and development continue to result in a net loss of habitat acreage and function.

In addition to the coastal and estuarine habitats, fishery managers must also extend their concern to the riverine and riparian ecosystems of anadromous species and to the deeper offshore ecosystems that support migratory and pelagic species. Although many fish stocks are stable in Alaska, many other west coast salmon stocks are so diminished that they are now listed, proposed for listing, or under consideration for listing under the ESA. Declines in abundance have been attributed to habitat loss and degradation from the cumulative impacts of human activities, including hydropower dams, irrigation diversions, logging, mining, grazing, urbanization, etc. Loss of these species from their traditional river reaches has devastating effects on the biological integrity of those ecosystems.

Although pelagic fishes usually are not correlated with the types of areas commonly thought of as fish habitat (e.g. wetlands and bottom substrate), physiographic and hydrographic structures with which migratory pelagic fishes are often associated (e.g. seamounts, current boundaries, temperature discontinuities) can be characterized as habitat. In spite of the distance from shore, these habitats are susceptible to adverse effects from both inshore and offshore activities due to the transport of materials to these locations, and to damage (e.g. to seamounts) caused by certain types of fishing gears.

Many changes in the environment are not directly caused by human activities. For example, the decline in ocean survival for coho and chinook salmon in the Pacific during the last 2 decades coincides with a change in the oceanographic regime off the west coast. As another example, the abundance of some species, notably sardine and anchovies, typically oscillates in cycles that last for decades. In all cases, however, human actions can accelerate the declines in population either from other changes to the habitat (e.g. for salmon in the rivers of the Pacific Coast), or from overfishing (e.g. for Pacific sardine in the 1970's), and may prolong the period of low abundance.

Marine Mammals and Protected Species

Many protected marine mammal stocks and all U.S. sea turtles are listed as either endangered or threatened under the ESA. Developing and implementing management strategies to minimize the adverse impact of human activities on these animals and aiding their recovery, while not unnecessarily restricting commercial and recreational fisheries, is a major challenge.

Significant progress has been made towards the recovery of turtle stocks during the last decade. Management strategies are being strengthened in order to ensure that these stocks continue on the path to recovery. In 1998, NMFS and the USFWS published recovery plans for five species of Pacific turtles and for one distinct turtle nesting population. Efforts are also underway to revise some of the existing recovery plans for Atlantic populations.

Much progress has also been made towards the protection and recovery of marine mammal stocks. The 1994 reauthorization of the MMPA strengthened requirements for classification of stocks in terms of the magnitude of levels of bycatch compared to population size and productivity. Efforts at reducing human-induced mortality, especially bycatch, are being focused on those stocks where the problem is more severe. Bycatch mitigation efforts have been focused through take reduction teams, and take reduction plans are in preparation or have been adopted for several stocks and fisheries.

The main issues for several selected high profile marine mammal species are summarized here.

Southeastern U.S. bottlenose dolphins Our understanding of the status of bottlenose dolphins in the southeastern United States has improved greatly through use of photographic identification, radiotracking, and biomolecular analyses. In the Atlantic, two distinct ecotypes have been identified, a coastal form occurring in shallow warm waters and an offshore form occurring in deep colder water. The coastal form is considered to be a strategic stock because it is classified as depleted under the MMPA due to an earlier epizootic, and because current levels of bycatch slightly exceed the proper PBR level. In the Gulf of Mexico, 33 stocks of bottlenose dolphins have been identified in bay, sound, and estuarine areas, which are mostly quite small. Five additional stocks have been identified from the coastal and offshore areas. Estimates of direct human-induced annual mortalities are only a small fraction of the abundances for these five stocks, so none are classified as strategic. Three anomalous mortality events have been documented for bottlenose dolphins, suggesting that these stocks may be physiologically stressed.

Atlantic harbor porpoise A harbor porpoise take reduction plan for the Northeast Region's sink gillnet and Mid-Atlantic coastal gillnet fisheries was implemented in December 1998. The bycatch of the Gulf of Maine-Bay of Fundy harbor porpoise in gillnets has exceeded the PBR since first estimated in 1990. The fishery has been subject to seasonal and spatial regulation in the Gulf of Maine, and this may be part of the reason that it has intensified in the Mid-Atlantic Region in recent years. The take reduction plan defines specific areas and seasons that are closed to fishing or where either acoustic deterrents or net modifications are required to be used. The success of the plan at reducing bycatch below PBR's will be closely monitored using observer programs and other at-sea research.

David Rugh NMFS

Steller sea lion, Gulf of Alaska.

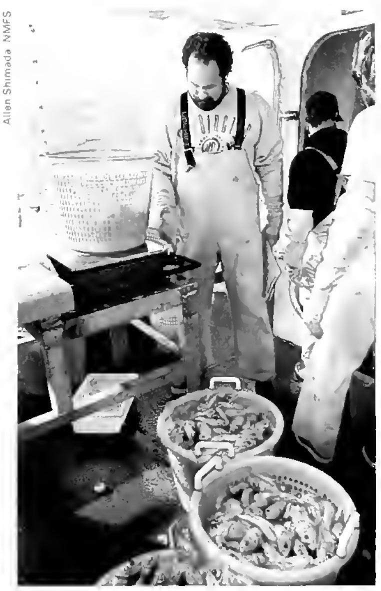
Steller sea lions Improved estimates of Steller sea lion abundance were obtained for 1998. The western U.S. Pacific stock has continued to decline, while the eastern Pacific stock appears to be either stable or increasing slightly. The human-caused mortality exceeded PBR for the western U.S. Pacific stock, but not for the eastern Pacific stock. Newly instituted management actions (in early 1999) include a no-entry zone around rookeries, a prohibition of groundfish trawling within 10–20 n.mi. of most Alaskan rookeries and important haulout sites, and spatial and temporal allocation of Eastern Bering Sea and Gulf of Alaska Atka mackerel and walleye pollock catches.

Eastern tropical Pacific dolphins The 1997 International Dolphin Conservation Program Act mandated new research to determine whether or not encirclement of dolphins during tuna purse-seine fishing in the eastern tropical Pacific has an adverse affect on the animals. The status of several eastern tropical Pacific dolphin stocks continues to be of concern, especially for two stocks classified as depleted because of incidental mortality that has occurred in the fishery since the early 1960's, even though incidental mortality of dolphins has been substantially reduced since the early 1990's. Research is underway to clarify the status of these stocks and to determine the effects of chase and recapture.

Adequacy of Scientific Information and Assessments

One of the most important national issues is the quality and quantity of data on which stock assessments and management decisions are based. Stock assessments and other scientific information are the foundation for the rational and sustainable utilization of renewable resources. Stock assessments require data on the biology of the species, catches, abundance trends, and stock characteristics such as age composition, which are put together to estimate the current status of the stock and its past history. This understanding aids managers in the selection of fishing targets to be achieved and thresholds or limits to be avoided.

Allen Shimada NMFS

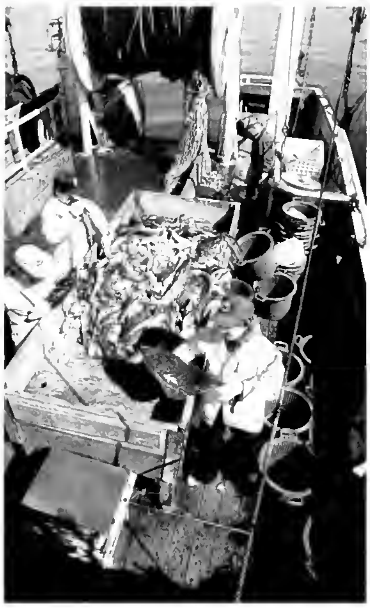


Weighing a subsample of longspine thornyhead rockfish, west coast upper continental slope assessment survey.

Basic information is still lacking to construct adequate assessments for many U.S. LMR's. This is the main reason why 21% of the stocks reported in Units 1–20 have unknown utilization levels (Tables 3 and 4). These stocks of unknown status account for less than 3% of the U.S. RAY, but include important species, such as sharks and many reef fish, for which not even the catch is recorded on a species-by-species basis. Progress has been made during the last few years, as 14 stock groups whose utilization level was unknown in *OLO '92* are now of known status (Table 11). But sound, scientifically based fisheries management requires more than the ability to classify the status of stocks. Relatively precise estimates of actual abundance, fishing mortality, and potential yield (e.g. CPY and LTPY) are more desirable. To improve on these estimates, more comprehensive data and research are needed.

The recent study of stock assessment methods conducted by the National Academy of Sciences (NRC, 1998) suggests that one of the key pieces of information required to assess a stock is an adequate index of relative abundance. Abundance indices can be obtained from analyses of catch rates in the fishery, or from scientifically designed research surveys. The former type is often problematic because fishing operations tend to occur in areas of high fish density, thus introducing potential biases of serious consequence. For instance, an increasing trend in the efficiency of fishing operations over time could mask a decline in abundance. Research surveys do not suffer from the same problem, but they tend to be more imprecise and survey data are more expensive to collect.

The Northeast Region has the longest history of surveys, which have been conducted since the 1960's for groundfish, and more recently also for pelagic and invertebrate resources. All regions have fishery-independent surveys for some of their more important resources, and efforts are underway to improve NMFS' ability to obtain abundance indices through a data acquisition plan involving the deployment of new replacement fisheries research vessels and increases in the use of charter vessels. The new vessels are urgently needed because existing NOAA fisheries research vessels average 34 years old, are technologically obsolete, and are approaching the end of their useful service life. To ensure the continuity and scientific integrity of NMFS' survey time-series, each replacement vessel must be calibrated with its older counterpart, while it is still operational.



Sampling table and mixed catch on chartered commercial trawler, triennial west coast groundfish assessment survey.

Many of the issues discussed in the previous sections end up, in one way or another, affecting the allocation of fishery resources. Allocation can be between countries, between states, between several commercial sectors, commercial-recreational, inshore-offshore, tribal-nontribal, and combinations of these. Allocation decisions require precise and accurate knowledge of user-specific harvest levels in addition to an understanding of the spatial segregation of the resource. Recreational fisheries have increased considerably in importance and are now the main source of fishing mortality for many stocks, particularly in coastal waters (Unit 21). But, because of their dispersed nature, recreational fishing impacts are difficult to quantify. The main source of data for recreational fisheries is the NMFS marine recreational fisheries statistics surveys (MRFSS[6]) which now constitutes a 20-year continuous time series. In recent years, there have been several efforts to increase levels of sampling (e.g. for king mackerel in the Southeast Region) and to conduct region-wide surveys to collect data on the demographics and economics of recreational fisheries (in the Northeast Region in 1994 and 1998, the Southeast Region in 1997, and the Pacific Coast Region in 1998). Cooperative programs to improve the collection of data on charter boat operations have also recently been initiated in Maine, New Hampshire, North Carolina, and the Gulf of Mexico. Data on recreational fisheries are now available to the public on the World Wide Web.[7]

MRFSS (Marine Recreational Fisheries Statistics Survey). NMFS Office of Science and Technology, Fisheries Statistics and Economics Division, Silver Spring, MD 20910.

http://www.st.nmfs.gov/st1/recreational/database/index.html

New insight into the biology of some species is reshaping their stock assessments. For example, an improved understanding of the population structure of several Atlantic tunas is being obtained from genetic studies and from research using biological markers and new tagging technologies. New technologies may also play an important role in enhancing NMFS' capacity to provide more efficient and accurate fish surveys through, for example, the development of advanced, integrated acoustic and laser-based systems and sensor platforms. In most cases, the acoustic and laser-based optical technologies are complementary, addressing specific components of an overall assessment problem. For example, an integrated light detection and ranging (LIDAR) system could potentially be developed to survey midwater species, for which the LIDAR system could be used to estimate fish size or identify species, and the integrated acoustic sensor could be used to provide abundance estimates from greater water volumes than could be obtained using LIDAR alone.

In addition to uncertainties in the status of stocks and abundance estimates or trends, there are critical gaps in our knowledge about ecosystem effects on LMR's. These gaps include the effects of environmental variability and changes caused by climate, functional habitat alteration, and long-term environmental degradation. Also included are gaps in knowledge about multispecies interactions. Several recent studies have stressed the need to incorporate ecosystem considerations and multispecies interactions into fish stock assessments and management advice. The National Academy of Sciences indicates that in order to restore fish populations and protect ecosystems, it will probably be necessary to substantially reduce fishing mortalities on most species (NRC, 1999b).

Outlook

Issues of National concern have not changed substantially since *Our Living Oceans* was first published in 1991. Indeed, it could be said that they have not changed much during the past 2 decades and that they are found in all corners of the world: concerns about overcapacity, overfishing, and the ability to rebuild overfished stocks; bycatch; allocation between user groups; management of stocks that straddle different jurisdictions; habitat degradation; fishing interactions with protected species; and the adequacy of scientific information in a complex environment.

Substantial advances have been made, and continue to be made, on all issues. But because each stock has its own characteristics, each fishery has its own peculiarities, and each set of available data is unique in some way, the progress made towards resolving these problems on the whole seems slow.

Not only is each situation unique, but the forces giving rise to the problems also seem to grow over time. Ever intensifying fishing effort and deployment of more powerful and sophisticated fishing gear and electronic fish-finding equipment have resulted in gross overcapacity and overfishing of resources that were previously considered to be at near-optimal exploitation. The increasing demand for fishery products or for the fishing experience increases the pressure on LMR's constantly. Urbanization of coastal zones and population growth also put continuously increasing pressure on the nearshore habitats that many species depend on as nursery areas. Long-term impacts from causes such as global warming and biophysical changes to ecosystems will likely also affect many LMR's in ways that are difficult to forecast.

Pacific sand lance, Pacific Northwest.

The available scientific information and the ability to implement and enforce effective management regulations have been, in many cases, insufficient to manage LMR's at their maximum potential without incurring significant conservation risks. In the face of such uncertainty, fishing should be allowed to proceed conservatively, setting aside part of the resource potential as insurance against unknown risks. But the many increasing pressures acting upon LMR's have given rise to unduly favoring short-term economic gain at the expense of long-term sustainable utilization. In fact, in the face of uncertainty, fishing has generally proceeded less conservatively.

This situation began to be reversed in the early 1990's, when FMP's were required to contain measurable definitions of overfishing, a conservation threshold or limit to be avoided irrespective of any short-term considerations. Today, FMP's are required to make the definitions of overfishing consistent with avoiding fishing levels higher than those that support MSY. If adequately implemented, the new requirements should result in immediate actions to eliminate overfishing, rebuild depleted stocks, and prevent other stocks from becoming overfished. However, it is important to realize that stock rebuilding will be slow in many cases, perhaps of the order of a generation or more for some species.

Parallel to strengthened management measures, there is a need for strengthened science: If more is known about a stock and the effects of fishing upon it, then it becomes possible to fine-tune its management and protect the stock with less need for conservatism.

There are many scientific elements that can be strengthened, and some may be unique to each situation. A common one to most situations is to set up permanent monitoring programs to measure relative abundance from fishery-independent data. Such efforts should improve the quality of many stock assessments and would also serve as an improved basis for the understanding of population dynamics.

The outlook for the Nation's living marine resources depends in good part on the management actions that are being taken at present. The decline in the abundance of many stocks in all U.S. regions during the past few decades was primarily the result of overfishing (sometimes compounded by environmental changes). The strengthened management measures, designed to reduce overfishing and begin rebuilding, that are being implemented should result in an acceleration in the rate of improvement of stock status and fishery utilization levels. Their success depends on how effectively they can be implemented over the foreseeable future. Short-term losses in yield are expected as an immediate cost of rebuilding overfished stocks. However, judging from the remarkable ability of many stocks to recover from overfishing, the outlook is very positive over the long term, and should result in the potential for higher sustainable yields with reduced risk to the resources.

William B. Folsom, NMFS

Edwin S. Taylor fishing pier, Folly Beach, South Carolina.

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Previous page: Blacksmith in giant kelp forest off southern California coast. William B. Folsom, NMFS.

The Precautionary Approach: A New Paradigm or Business as Usual?

Feature Article 1

pre•cau•tion \'pri-'ko-shen\ n [F *précaution*, fr. LL *praecaution-*, *praecautio*, fr. L praecautus, pp. of *praecavere* to guard against, fr. *prae-* + *cavere* to be on one's guard—more at HEAR] **1** : care taken in advance : FORESIGHT <warned of the need for ~> **2** : a measure taken beforehand to prevent harm or secure good : SAFEGUARD—**pre•cau•tion•ary** \-she-,ner-e\ *adj*

approach n **1 a** : an act or instance of approaching <the ~ of summer> **b** : APPROXIMATION <in this book he makes his closest ~ to greatness> **2 a** : the taking of preliminary steps toward a particular purpose <experimenting with new lines of ~> **b** : a particular manner of taking such steps <a highly individual ~ to language> **3** : a means of access : AVENUE[1]

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INTRODUCTION

The term Precautionary Approach has been receiving considerable attention in fisheries. It is a principal focus of recent scientific documents and technical guidelines for fishery management agreements, and it continues to be a focus of many workshops being held throughout the world. As explained below, the Precautionary Approach is a protocol for ensuring that resource conservation takes precedence over other—usually short-term—objectives. But the need for conservation measures in the use of renewable resources like fisheries is nothing new. Hence the question asked by many people, including fishermen, managers, and scientists, is this: Are these simply buzzwords that will come and go, or does the Precautionary Approach represent something new that is needed now? In this feature, we explain what the Precautionary Approach is about and how it relates to contemporary fishery management needs in the United States and elsewhere.

[1] The first definition of precaution, and the second definition of approach. By permission, from Merriam-Webster's Collegiate® Dictionary, Tenth Edition ©1998 by Merriam-Webster, Incorporated.

Allen Shimada NMFS

Bering Sea crab boats and shoreside processors in Dutch Harbor-Unalaska, Alaska, the Nation's leading fishing port by landed catch and value.

THE CONSERVATION RECORD

It has long been recognized that fishery resources are not inexhaustible, and that management measures are needed to ensure that they are harvested in a sustainable manner. The concept of overfishing, and the need to avoid it or reverse its effects, achieved foremost prominence in the 1976 law that regulates marine fisheries in the U.S. Exclusive Economic Zone — the Magnuson Fishery Conservation and Management Act (MFCMA[2]). That Act's principal purpose is "to take immediate action to conserve and manage the fishery resources found off the coasts of the United States ..."

When the legislation became effective, several fishery resources were considered to be overfished, having declined "to the point where their survival is threatened," and the MFCMA sought to reverse this situation for those stocks, while preventing it in other stocks by managing all resources for optimal long-term use. To accomplish this, the MFCMA established eight regional fishery management councils and entrusted them with preparing fishery management plans that "will achieve and maintain, on a continuing basis, the optimum yield from each fishery." In addition, the MFCMA sought to encourage the development of the U.S. fishing industry by phasing out foreign fishing which was then perceived to be the main cause of overfishing.

Over 20 years have elapsed since the MFCMA came into effect, but many stocks remain overfished. Operational definitions of overfishing and rebuilding plans for overfished stocks have been formally required in Federal fishery management plans since 1989, but it is only in the last few years that stock recoveries have begun to materialize. In a 1998 report to Congress on the status of U.S. fisheries (NMFS, 1998), NOAA's National Marine Fisheries Service (NMFS) categorized 90 stocks as being overfished, 10 as approaching an overfished condition, 200 as not overfished, and 544 as having unknown status relative to overfishing (although the stocks of unknown status represent less than 3% of U.S. landings). Thus, of the

[2] The MFCMA has been amended many times, most recently during reauthorization by Congress in October 1996 through the Sustainable Fisheries Act. It is currently referred to as the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

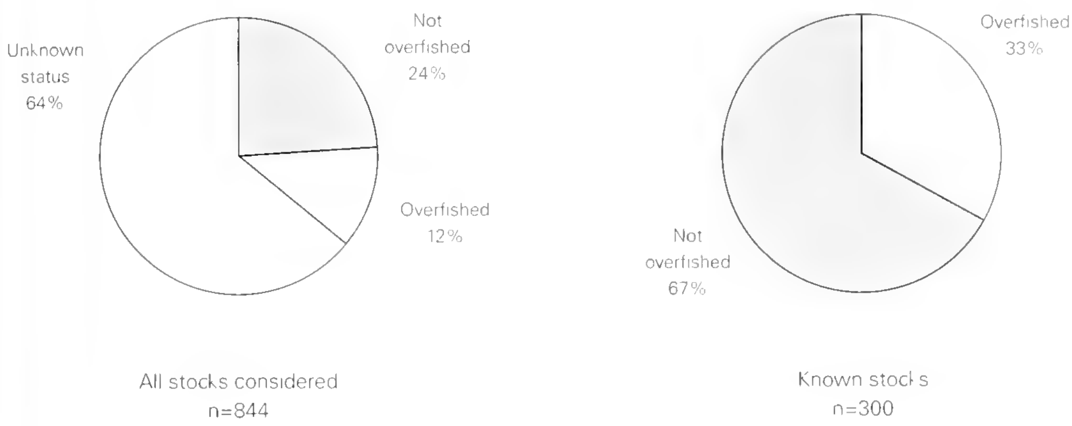

Figure 1
Status of fisheries of the United States reported to Congress (NMFS, 1998).

300 stocks whose status was known, 33% were either overfished or approaching an overfished condition (Figure 1). Many of the unknown stocks may be overfished as well, and NMFS expects that the percentage of overfished stocks will increase with planned amendments to almost all fishery management plans currently in progress.

The United States is not alone in having a significant portion of its stocks in an overfished state. Based on data up to 1992, the Food and Agriculture Organization (FAO) of the United Nations (UN) estimated that of those stocks for which formal assessments were available, 44% were considered intensively to fully exploited, and 25% were considered overexploited, depleted, or recovering. Using a different classification system and considering the top 200 of the world's fisheries in 1994, FAO estimated that about 60% can be considered "mature" or "senescent."[3]

WHAT IS THE PRECAUTIONARY APPROACH?

The Precautionary Approach has been proposed as a way of thinking about fisheries and making management decisions that can help prevent overfishing and rebuild depleted stocks. The Precautionary Approach is adapted from the Precautionary Principle. The latter aims to prevent irreversible damage to the environment by implementing strict conservation measures, even in the absence of scientific evidence that environmental degradation is being caused by human intervention. The Principle is rather rigid and implies an extreme form of reversal of the burden of proof (in its extreme, human actions would be considered harmful unless proven otherwise). If strictly applied to fisheries, the Principle would only allow fishing in cases where it could be proven that fishing activities would not harm fishery resources or their ecosystems. The Precautionary Approach is a relaxation of the Principle, developed to deal with systems that are slowly reversible but often difficult to control, not well understood, and may be subject to changing environment and human values. Thus, the Precautionary Approach is particularly advocated for renewable resources like fisheries.

As with the Principle, the reversal of the burden of proof still pertains in applying the Precautionary Approach. As such, it is recognized that: 1) all fishing activities have environmental impacts, and it is not appropriate to assume that these are negligible until proven otherwise, 2) although some fishing impacts may be potentially detrimental, this does not imply that all fishing should cease until all potential impacts have been evaluated and determined to be negligible, and 3) in cases where the likely impacts of fishing activities are uncertain, priority should be given to conserving the productive capacity of the fishery resources. According to FAO (1995a), the standard of proof to be used in decisions regarding authorization of fishing activities should be commensurate with the potential risk to the resource, while also taking into account the expected benefits of the activities.

[3]FAO reports and press releases can be found on the World Wide Web at http://www.fao.org

The collapse of fish stocks in the United States and elsewhere has often been precipitated by the inability to implement timely conservation measures without irrefutable scientific proof of overfishing. That is, managers have frequently delayed, postponed, or failed to implement corrective management actions when scientific information on the status of stocks and the impacts of exploitation was not beyond doubt. A shift in the burden of proof is a natural remedy to reverse the situation.

As discussed below, it is difficult to define the Precautionary Approach succinctly, because it has so many components. However, the following sentence represents one attempt to do so:

> In fisheries, the Precautionary Approach is about applying judicious and responsible fisheries management practices, based on sound scientific research and analysis, proactively (to avoid or reverse overexploitation) rather than reactively (once all doubt has been removed and the resource is severely overexploited), to ensure the sustainability of fishery resources and associated ecosystems for the benefit of future as well as current generations.

INTERNATIONAL EVOLUTION

The United Nations Convention on the Law of the Sea of 1982 provided several mechanisms to promote responsible management of marine fisheries. However, not until the 1990's did work begin on developing a precautionary approach to fisheries management. In 1991, the FAO's Committee on Fisheries (COFI) requested the FAO to develop an International Code of Conduct for Fisheries. Subsequently, FAO and the Government of Mexico sponsored an International Conference on Responsible Fishing, held in Cancun in May 1992. Resolutions formulated in Cancun were presented at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, in June 1992. The Rio meeting highlighted the importance of the Precautionary Approach in the Rio Declaration and Agenda 21. For example, Principle 15 of the Rio Declaration states that

> "In order to protect the environment, the Precautionary Approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Several binding and nonbinding agreements embodying the Precautionary Approach were developed and concluded during 1991–96. The most comprehensive of these is the FAO International Code of Conduct, completed in late 1995 (FAO, 1995b). The Code of Conduct addresses six key themes: 1) fisheries management, 2) fishing operations, 3) aquaculture development, 4) integration of fisheries into coastal area management, 5) post-harvest practices and trade, and 6) fisheries research. In total, there are 19 general principles and 210 standards in the Code. While the Precautionary Approach is integral to all themes, it is applied particularly to fisheries management:

> "States should apply the Precautionary Approach widely to conservation, management, and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment."

The Code of Conduct also emphasizes that

> "The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures."

The Code of Conduct is a voluntary, nonbinding agreement. However, it contains sections that are similar to those in two recently concluded binding agreements: 1) the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (the Compliance Agreement), and 2) the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (officially abbreviated as the UN Implementing Agreement or UNIA, but commonly referred to as the Straddling Stocks Agreement) (UN, 1995).

The Compliance Agreement was adopted by FAO Conference in November 1993. It specifies the obligations of Parties whose vessels fish on the high seas, including the obligation to ensure that such vessels do not undermine international fishery conservation and management measures. The Compliance Agreement is considered to be an integral part of the Code of Conduct. The United States implemented the Compliance Agreement through the High Seas Fishing Vessel Compliance Act of 1995 (16 U.S.C. 5550 et. seq.).

The Straddling Stocks Agreement, negotiated over a similar period as the FAO Code of Conduct and now in the process of being ratified, contains nearly identical language as the Code on many issues, including the Precautionary Approach and General Principles for the conservation and management of living marine resources. Although the Straddling Stocks Agreement is strictly applicable to straddling fish stocks and highly migratory fish stocks, much of it is also relevant to fishery resources within national exclusive economic zones. Indeed, the Straddling Stocks Agreement is being used as the basis for developing precautionary approaches to fisheries management in many individual countries, as well as in several intergovernmental organizations such as the Northwest Atlantic Fisheries Organization (NAFO) and the International Council for the Exploration of the Sea (ICES).

SCOPE OF THE PRECAUTIONARY APPROACH

The Precautionary Approach to fisheries management is multifaceted and broad in scope. As stated by FAO (1995a), it applies at all levels of fisheries systems: development planning, management, research, technology development and transfer, legal and institutional frameworks, fish capture and processing, fisheries enhancement, and aquaculture. FAO's Technical Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions (FAO, 1995a) groups the elements of the Precautionary Approach into three categories: 1) fisheries management, 2) fisheries research, and 3) fisheries technology. The Precautionary Approach to fisheries management requires avoidance of overfishing, restoration of already overfished stocks, explicit specification of management objectives including operational targets and constraints (e.g. target and limit reference points), taking account of uncertainty by being more conservative, avoidance of excess harvest capacity, establishment of rules for controlling access, data reporting requirements, development of sound management planning processes involving extensive consultation, and effective systems for monitoring and enforcement. Research in support of precautionary management should be designed to provide accurate and complete data and analyses of relevance to fisheries management, to develop operational targets and constraints, to provide scientific evaluation of the consequences of management actions, to incorporate uncertainty into assessments and management, and to promote multidisciplinary (biological, economic, and social) research. In terms of fisheries technology, the Precautionary Approach primarily involves the promotion of research to evaluate and improve existing technologies and encourage development of appropriate new technologies, particularly those that will prevent damage to the environment, improve economic and social benefits, and improve safety.

KEY ELEMENTS OF PRECAUTIONARY MANAGEMENT STRATEGIES

Following completion of the Code of Conduct and FAO's technical guidelines on the Precautionary Approach, the facets of the Precautionary Approach that have received by far the most attention are: 1) definitions of overfishing incorporating target and limit reference points, 2) formulation of decision rules that stipulate in advance what actions will be taken to prevent overfishing and promote stock rebuilding, and 3) incorporation of uncertainty by using a risk-averse approach to calculate targets, constrain fishing mortality, and rebuild stock biomass. These facets have been the focus of numerous workshops conducted by intergovernmental organizations (e.g. ICES, NAFO, North Atlantic Salmon Conservation Organization (NASCO), and the International Commission for the Conservation of Atlantic Tunas) as well as national governments, including the United States. They will also be the focus of the remainder of this article.

LIMIT AND TARGET REFERENCE POINTS

Limit and target reference points are signposts, usually expressed in terms of fishing mortality rates or stock biomass, that provide benchmarks with which to compare the state of the stock and status of exploitation and which can be used to guide fisheries management. Limit reference points set boundaries that are designed to constrain exploitation within safe biological limits so that stocks retain the ability to produce maximum sustainable yield. Target reference points identify desired outcomes for the fishery and are therefore intended to meet management goals and objectives. The basic idea of using reference points in a Precautionary Approach to fisheries management is that targets should be set sufficiently below limits so that the limits will be avoided with high probability and targets will be attained on average.

The United States had already made substantial progress in addressing overfishing prior to the development of the Precautionary Approach. In 1989, NMFS published guidelines (§50 CFR Part 602, Guidelines for the preparation of fishery management plans under the MFCMA) (commonly referred to as the 602 Guidelines) interpreting National Standard 1 of the MFCMA with respect to overfishing. The 602 Guidelines provided a formal definition of overfishing:

> "Overfishing is a level or rate of fishing mortality that jeopardizes the long-term capacity of a stock or stock complex to produce [maximum sustainable yield] on a continuing basis."

The 602 Guidelines required that all fishery management plans (FMP's) be amended to include measurable definitions of overfishing for each stock or stock complex covered by that FMP. In most FMP's, this directive was interpreted as a requirement for defining recruitment overfishing which was generally specified in terms of a limit fishing mortality. A review by Rosenberg et al. (1994) of more than 100 such definitions concluded that most definitions were biologically sensible and at least neutrally conservative in protecting against recruitment overfishing, although there was room for improvement especially in terms of the linkage to management actions. The most common definitions of recruitment overfishing were fishing mortality rates associated with either 20% or 30% of the maximum spawning biomass per recruit (i.e. $F_{20\%}$ and $F_{30\%}$, see Appendix 4).

Once overfishing definitions were developed and accepted, fishery management councils were required to develop and implement rebuilding plans for overfished stocks. Many of these plans were well underway, and some stocks had even been proclaimed "rebuilt" when the Act (MSFCMA) was reauthorized in 1996 (Sustainable Fisheries Act, Public Law 104–297). The MSFCMA introduced several new requirements for specifying objective and measurable criteria for determining overfishing and also introduced new or revised definitions for a number of terms related to limits and targets. Most notably, the MSFCMA redefined optimum yield to be no greater than maximum sustainable yield (Table 1). The new definition of optimum yield also included the protection of marine ecosystems as a national benefit to be considered in setting targets. In addition, the MSFCMA incorporated the definition of overfishing first presented in the 1989 Guidelines, and mandated that specific remedial actions be taken to prevent overfishing and rebuild overfished stocks.

The treatment of MSY as a management constraint in the MSFCMA is consistent with Annex II of the U.N. Straddling Stocks Agreement (UN, 1995) which states:

> "The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points."

In May 1998, NMFS published new National Standard Guidelines (Federal Register, Vol. 63, No. 840, p. 24212–24327, May 1, 1998) that interpret the amended Act (Table 1 and the definition of overfishing) and directed that fishery management plans be amended to require "status determination criteria" that include separate parts for both the act of overfishing and the condition of being overfished:

"EACH FMP MUST SPECIFY, TO THE EXTENT POSSIBLE, OBJECTIVE AND MEASURABLE STATUS DETERMINATION CRITERIA FOR EACH STOCK OR STOCK COMPLEX COVERED BY THAT FMP AND PROVIDE AN ANALYSIS OF HOW THE STATUS DETERMINATION CRITERIA WERE CHOSEN AND HOW THEY RELATE TO REPRODUCTIVE POTENTIAL. STATUS DETERMINATION CRITERIA MUST BE EXPRESSED IN A WAY THAT ENABLES THE COUNCIL AND THE SECRETARY TO MONITOR THE STOCK OR STOCK COMPLEX AND DETERMINE ANNUALLY WHETHER OVERFISHING IS OCCURRING AND WHETHER THE STOCK OR STOCK COMPLEX IS OVERFISHED. IN ALL CASES, STATUS DETERMINATION CRITERIA MUST SPECIFY BOTH OF THE FOLLOWING: (i) A MAXIMUM FISHING MORTALITY THRESHOLD OR REASONABLE PROXY THEREOF. ... THE FISHING MORTALITY THRESHOLD MUST NOT EXCEED THE FISHING MORTALITY RATE OR LEVEL ASSOCIATED WITH THE RELEVANT MSY CONTROL RULE. EXCEEDING THE FISHING MORTALITY THRESHOLD FOR A PERIOD OF 1 YEAR OR MORE CONSTITUTES OVERFISHING. (ii) A MINIMUM STOCK SIZE THRESHOLD OR REASONABLE PROXY THEREOF. ... SHOULD THE ACTUAL SIZE OF THE STOCK OR STOCK COMPLEX IN A GIVEN YEAR FALL BELOW THIS THRESHOLD, THE STOCK OR STOCK COMPLEX IS CONSIDERED OVERFISHED."

The MSFCMA does not explicitly require that OY (the target) be set safely below MSY (the limit), which is what would be expected using a Precautionary Approach. However, the National Standard Guidelines published in May 1998 recommend that the fishery management councils "adopt a Precautionary Approach" to fisheries management characterized by:

"TARGET REFERENCE POINTS, SUCH AS OY, SHOULD BE SET SAFELY BELOW LIMIT REFERENCE POINTS [I.E., THE OVERFISHING DEFINITIONS] ..."

"A STOCK OR STOCK COMPLEX THAT IS BELOW THE SIZE THAT WOULD PRODUCE MSY SHOULD BE HARVESTED AT A LOWER RATE OR LEVEL OF FISHING MORTALITY THAN IF THE STOCK OR STOCK COMPLEX WERE ABOVE THE SIZE THAT WOULD PRODUCE MSY."

"CRITERIA USED TO SET TARGET CATCH LEVELS SHOULD BE EXPLICITLY RISK AVERSE, SO THAT THE GREATER UNCERTAINTY REGARDING THE STATUS OR REPRODUCTIVE CAPACITY OF THE STOCK OR STOCK COMPLEX CORRESPONDS TO A GREATER CAUTION IN SETTING TARGET CATCH LEVELS."

HARVEST CONTROL RULES AND REBUILDING

Harvest control rules (also called decision rules) are preagreed protocols for controlling fishing activities with respect to stock status and the limit and target reference points. For example, a harvest control rule might specify how the fishing mortality rate (or, equivalently, the allowable catches) should vary as a function of the size of the stock.

The 1996 MSFCMA definition of optimum yield instructs that target catch levels for overfished stocks need to allow for rebuilding to the MSY level (Table 1). More specifically, the MSFCMA requires the fishery management councils to take remedial action to end overfishing and rebuild overfished stocks to MSY levels very rapidly (generally in 10 years or less). The definition of optimum yield does not provide much guidance for cases in which an overfished condition is being approached from the opposite direction (i.e. from a healthy stock condition). However, both the MSFCMA and the National Standards Guidelines define overfishing as a level or rate of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis. Under a Precautionary Approach, this implies that target catch levels should decrease monotonically when a stock is below its MSY level to avoid imperiling the stock's productivity.

Figure 2 depicts an example of limit and target harvest control rules that are compatible with the National Standard Guidelines. The limit (solid line) is used to decide what level of fishing mortality indicates "overfishing," and when the stock

Table 1
Definitions of optimum yield in the Fishery Conservation and Management Act (emphasis added).

1976 MFCMA	1996 MSFCMA
" the amount of fish –	" the amount of fish which –
(A) which will provide the greatest overall benefit to the Nation, with particular reference to food production and recreational opportunities, and	(A) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems,
(B) which is prescribed as such on the basis of the maximum sustainable yield from such fishery, **as modified by** any relevant economic, social, or ecological factor "	(B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, **as reduced by** any relevant economic, social, or ecological factor, and
	(C) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery "

is in an "overfished condition." The harvest (target) control rule (dashed line) is designed to achieve OY, which in this example pertains to maintaining a balance between achieving high yields and avoiding overfishing; if the stock size is below its MSY level, the decreasing target fishing mortality allows for rebuilding back to the MSY level. Specifying limit and target harvest control rules that are compatible with the National Standard Guidelines can be a complicated exercise that should take into account the biology of the stock(s), the characteristics of the fisheries (e.g. gear selectivity), the ability to assess the stock's status and productivity, and the relative importance to be assigned to the various management objectives. Restrepo et al. (1998) provide technical guidance for defining limit and target harvest control rules that are in accordance with the Guidelines, and where, in the spirit of the Precautionary Approach, resource conservation takes precedence over other management objectives.

RISK AVERSION

The concept of risk aversion has a long theoretical tradition in fisheries, although it is not frequently applied in practice. Risk-averse management means that when there is greater uncertainty regarding the status or productive capacity of a stock, greater caution is used in setting target catch levels. In the context of the Precautionary Approach, risk-aversion is the mechanism for reversing the burden of proof.

For example, consider the case in which managers wished to define the average OY as landings close to MSY, MSY being a limit reference point (not to be exceeded with any substantial probability) and OY being the target reference point (to be achieved on average). A risk-averse Precautionary Approach would set OY below MSY as a function of uncertainty, viz: the greater the uncertainty, the greater the distance between the two. In this example, only in the case of perfect knowledge (for both MSY and stock status) and perfect compliance could OY be set exactly at MSY. In the example of Figure 2, the 25% difference between the limit and target at high stock sizes provides for a safety margin to guard against uncertainty in perceived stock status, in implementation of management controls, and in natural abundance fluctuations.

Scientific analyses underpin the Precautionary Approach in that they are the basis for determining reference points, assessing stock abundance and exploitation levels, quantifying uncertainty, and assessing the risk associated with different management options. The second National Standard in the MSFCMA states that:

"CONSERVATION AND MANAGEMENT MEASURES SHALL BE BASED UPON THE BEST SCIENTIFIC INFORMATION AVAILABLE."

To the extent that scientific research can reduce uncertainties, the distance between targets and limits can be reduced when using a Precautionary Approach to management.

CONCLUSION

Taken individually, elements of the Precautionary Approach, such as the need to be proactive, management based on reference points, and risk-averse decision making, are not novel, although all elements have seldom, if ever, been applied in combination. What the Precautionary Approach does is integrate these and other elements into a formal operational framework for decision making (or, in the dictionary definition of approach, "a particular manner of taking such steps"). The particular order in which those steps should be taken under the Precautionary Approach is that conservation constraints should be met before other objectives. At face value, this does not sound like anything new. However, the reality of the fisheries management experience in most instances to date is that short-term objectives have generally taken precedence over long-term ones.

There are two other aspects of the Precautionary Approach that, while they may not be completely novel, challenge the notion that it may be possible to equate adherence to the Precautionary Approach with business as usual. The first is the notion of MSY-based reference points as limits to be avoided, rather than targets to be achieved (or exceeded). Although this is not a rigid requirement of the Precautionary Approach, it is specifically suggested in Annex II of the Straddling Stocks Agreement (UN, 1995), and is being seriously considered by ICES, NAFO, NASCO, and the U.S. Government. It is also consistent with the MSFCMA. Second, the Precautionary Approach is an explicit and detailed attempt to articulate the need for, and means of, bringing to fruition the paradigm shift that is currently in progress. It is apparent that fisheries are in transition from a paradigm of "it is not possible to overexploit marine resources" to one of "it is not acceptable to overexploit marine resources," but that at the global level this transition is only in its infancy. Completion of this transition will require a change in business as usual by all levels of participants in fishing operations and decisionmaking; i.e. politicians, managers, scientists, fishermen, and consumers. For most players, a complete change in mind-set is needed to be proactive rather than reactive, to put conservation objectives ahead of short-term gain, to proceed with caution, to treat fishing as a privilege (with associated obligations and responsibilities) rather than a birthright, to reject the status quo when it is obvious that the status quo is not viable in the long term, and, perhaps most importantly, to realize and accept the fact that only a limited number of participants can derive a livelihood from capture fishing. Advances that are already in progress must be taken seriously; for example, 1) the specification of limit reference points that will constrain fishing within safe biological limits, 2) the establishment of management targets that are explicitly risk-averse, and 3) reversal of the burden of proof.

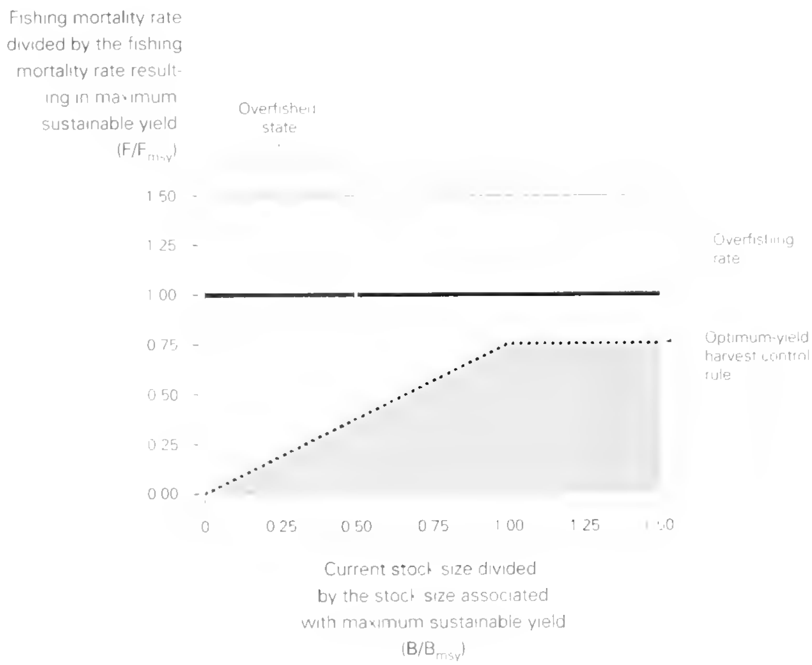

Figure 2
Hypothetical example illustrating limit and target harvest control rules. The limit (thick horizontal line) defines overfishing as any fishing mortality rate (F) higher than that which maximizes long-term yield (F_{msy}). In the example, the stock is said to be overfished when its stock size (B) falls below one-half of the MSY stock size level (1/2 B_{msy}, vertical white line). The example target (dashed line) is intended to achieve high yields while avoiding overfishing: At "healthy" stock sizes, i.e. at or above the B_{msy} level, the target fishing mortality is set 25% below the limit; if the stock is below the B_{msy} level, the target fishing mortality is reduced monotonically so as to allow for rebuilding back to B_{msy}

Allen Shimada, NMFS

Setting a bottom trawl net off Westport, Washington.

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New England Groundfish

"... there was no sound except the splash of the sinkers overside, the flapping of the cod, and the whack of muckles as the men stunned them. It was wonderful fishing."

—Rudyard Kipling
"Captains Courageous"

Feature Article 2

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INTRODUCTION

Some groundfish resources off New England are now recovering from record low stock sizes and landings observed in the early 1990's. Other stocks, however, continue to decline because of excessive fishing mortality and below-average recruitment. Declines in some stocks occurred steadily over time, while others happened more recently and abruptly. Resources more sensitive to overfishing declined and were supplanted by other target species in a sequential pattern of resource exploitation. The New England groundfish fishery is now supported by species most resilient to exploitation and others not heretofore considered marketable. Groundfish resources and their dependent fisheries are well documented by landings statistics dating back over a century, and by standardized research vessel survey efforts which began over 3 decades ago. This article reviews the history of the New England groundfish fishery, its management, and prospects for long-term recovery and sustainability.

BACKGROUND

New England has been identified economically and culturally with the harvest of groundfishes, for over 400 years. A mixture of bottom-dwelling species including Atlantic cod, haddock, redfish, hakes, and flounders constitute the groundfish resource (Table 1). The complex history of the region's groundfish resources and their exploitation can be defined into several unique stanzas since the turn of the century. Some of the important technological developments and resource conditions associated with these various stanzas are described below.

Conversion from Sail to Steam (1900–20)

In the late 19th and early 20th centuries, large fleets of sailing vessels from Gloucester, Boston, and other New England ports ranged throughout the coastal areas and offshore banks from Cape Cod to the Grand Banks off Newfoundland (Figure 1). Atlantic cod catches, primarily for salt cod, supported over 800 dory schooners and a multitude of shore-side businesses, including salt mining, ice harvesting, and an active boat-building industry, necessitated by substantial losses of both ships and men to the vagaries of the North Atlantic. The catch from distant fishing grounds was generally salted (schooners fishing with these methods were termed "salt bankers"), while catches from the Gulf of Maine and Georges Bank, by schooners called "market" or "shack" boats, were generally stored on ice and sold fresh.

At the turn of the 20th century, major technological innovations were introduced which changed how fish were caught, handled, processed,

William B. Folsom, NMFS

Skates, caught and used for lobster bait, Point Judith, Rhode Island.

Table 1

Species and stocks comprising the New England groundfish resource. Stocks that are regulated as part of the New England Fishery Management Council's Northeast Multispecies Fishery Management Plan (FMP) are indicated.

Common name	Management stocks	Part of NE FMP?
Atlantic cod	Georges Bank, South Gulf of Maine	Yes
Haddock	Georges Bank, Gulf of Maine	Yes
Ocean perch (Acadian redfish)	Gulf of Maine	Yes
Pollock	Gulf of Maine	Yes
White hake	Gulf of Maine	Yes
Red hake	Gulf of Maine and North Georges Bank, South Georges Bank and Middle Atlantic	Yes
Silver hake	Gulf of Maine and North Georges Bank, South Georges Bank and Middle Atlantic	Yes
Ocean pout	Gulf of Maine and South New England	Yes
Atlantic halibut	Gulf of Maine	Yes
Winter flounder	Georges Bank, Gulf of Maine, South New England	Yes
Witch flounder	Gulf of Maine	Yes
Yellowtail flounder	Georges Bank, South New England, Cape Cod, Middle Atlantic	Yes
American plaice	Gulf of Maine	Yes
Windowpane	Gulf of Maine and North Georges Bank, South Georges Bank and South New England	Yes
Cusk	Gulf of Maine	No
Atlantic wolffish	Gulf of Maine	No
Spiny dogfish	Northeast United States and Canada	No
Skates (seven species)	Gulf of Maine and Middle Atlantic	No
Goosefish (monkfish)	Gulf of Maine and North Georges Bank, South Georges Bank and Middle Atlantic	No
Summer flounder	Georges Bank and Middle Atlantic	No

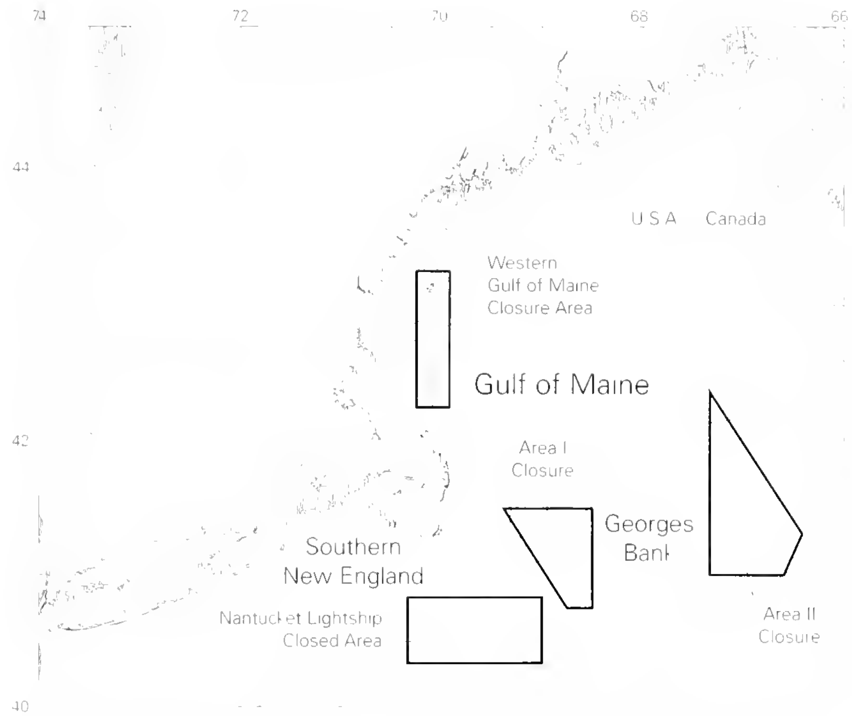
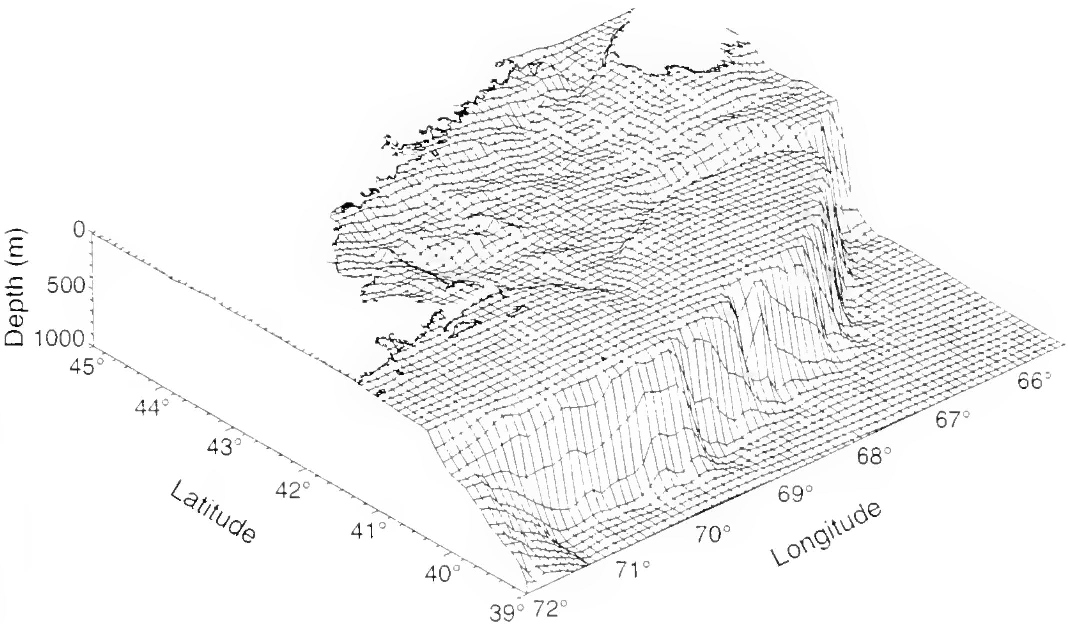


Figure 1

Geographic areas occupied by New England groundfish stocks. Four areas are outlined that are currently closed to fishing with gears capable of catching groundfish.



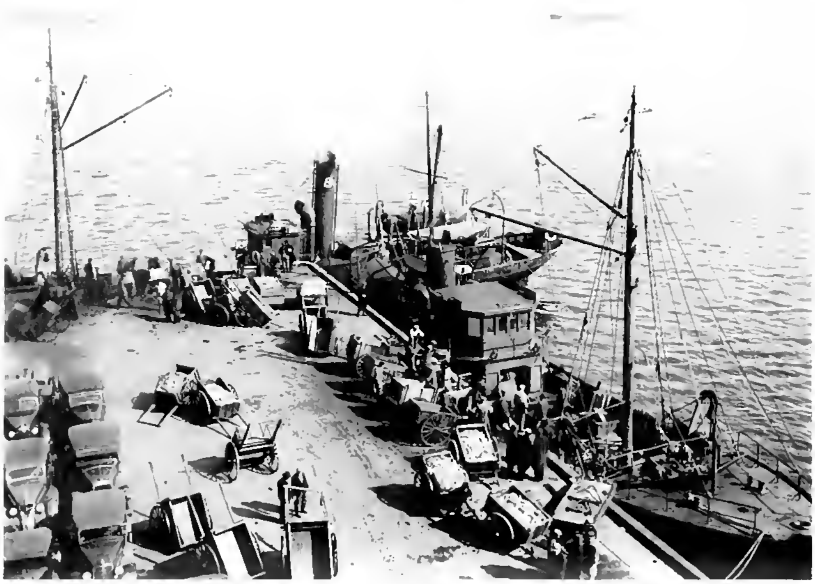


Figure 2
Otter trawl vessels at Boston Fish Pier, ca. 1931. At the end of the pier is the *Spray*, built in 1905, the first steam trawler in the New England groundfish fleet.

Figure 3
Unloading Atlantic halibut, ca. 1930, at the Boston Fish Pier. Note traditional dories nested together aboard the vessel in the foreground

distributed, and sold. The introduction of better handling (filleting and freezing) and distribution methods (train, refrigerated storage) meant that fresh and frozen fish could be sold in markets across the country, thereby reducing the dominance of salt cod as a preferred product.

Steam-powered trawl vessels, introduced to harvest flounders and haddock on smooth-bottom areas, rapidly replaced the traditional sailing schooners. The first trawler, *Spray*, was introduced in Boston in 1906 (Figure 2), and the trawler fleet quickly grew to over 300 vessels by 1930. Steam power was supplanted by diesel power after World War I. The transition to otter trawling as the dominant fishing method was, however, not without controversy. Objections to development of the otter trawl fishery centered on the potential for ecological damage to bottom-dwelling animals and plants, and economic competition with existing fixed-gear fisheries. Management recommendations resulting from scientific investigations of the "trawler problem" included delimiting areas where trawls could and could not be used; however, these recommendations were not implemented. Even before 1900, some species, especially the Atlantic halibut (Figure 3), showed signs of decline due to overfishing by hook-and-line fisheries. Halibut landings had begun to decline by the 1850's, and by the 1890's almost all of the Atlantic halibut sold in Gloucester came from Iceland. Pacific halibut were shipped to Boston via train by the turn of the century. Overfishing and resource decline would accelerate with the increased intensity of the fisheries and the expanding list of target species.

The Rise of the Trawl Fishery (1920–60)

The species composition of groundfish landings changed dramatically following the introduction of trawling, as the trawl fishery targeted haddock rather than cod (Figure 4) and then expanded to other stocks. Prior to 1900, haddock landings were relatively low (~20,000 metric tons (t)/year) since the species did not preserve well when salted. By the late 1920's, haddock landings increased to over 100,000 t (Figure 4). This level of catch, however, was not sustainable, and landings (primarily from Georges Bank) would plummet in the early 1930's.

By 1930 the groundfish fleet had grown too large relative to the natural capacity of the haddock stocks to produce increased yields. Growth overfishing was revealed by sampling of the catches by at-sea observers. In 1930, 37,000,000 haddock were landed at Boston, but an estimated 70,000,000–90,000,000 juvenile haddock were discarded dead at sea, due to the very small mesh used in the otter trawl nets. Surprisingly, mesh-size regulations to protect haddock would not be implemented until 1953.

The crash in Georges Bank haddock landings prompted a great deal of new research to investigate the causes and recommend new management measures. Modern research programs to study the population dynamics and demographics of New England groundfish date back to work begun in the 1930's by William Herrington and his colleagues at Harvard University and the U.S. Bureau of Commercial Fisheries (forerunner to the National Marine Fisheries Service). Owing partly to a shift of the fishery to resources on Browns Bank off Nova Scotia, the Georges Bank haddock resource recovered in the mid 1930's, and landings subsequently averaged about 50,000 t/year between 1935 and 1960 (Figure 4). Haddock remained the mainstay of the New England groundfish fishery until the mid 1960's. Cod landings generally remained stable throughout the 1915–40 period, as haddock, redfish, and other species were the species of primary interest to consumers (Figure 4).

The war years (World War II) were prosperous for the industry as fish was canned for military use, and protein demands and rationing necessitated increased fish consumption at home. The fleet was also reduced at this time, as many of the largest trawlers were requisitioned for war duty as mine sweepers. Development of new markets (i.e. for ocean perch (redfish), which was later marketed in the midwestern United States as a substitute for Great Lakes yellow perch) sustained a portion of the offshore fleet during the war years. Many government subsidy programs were launched after the war when demand for groundfish declined.

The redfish fishery began in the 1930's, peaked in U.S. waters by the 1940's and expanded eastward to the Scotian Shelf, growing to about 120,000 t/year during the early 1950's. This long-lived, slow-growing resource was fished down to moderate levels in the Gulf of Maine during the 1930's and 1940's, and the stock collapsed following the return of the fleet from Canadian waters in the mid 1970's. Flatfish landings were dominated by catches of winter flounder, witch flounder, and American plaice until the 1940's. Thereafter, yellowtail flounder became the most important flatfish of New England, but it declined greatly in abundance and landings through the 1940's and 1950's (Figure 4). Reasons for the yellowtail flounder decline during this period are not known, but

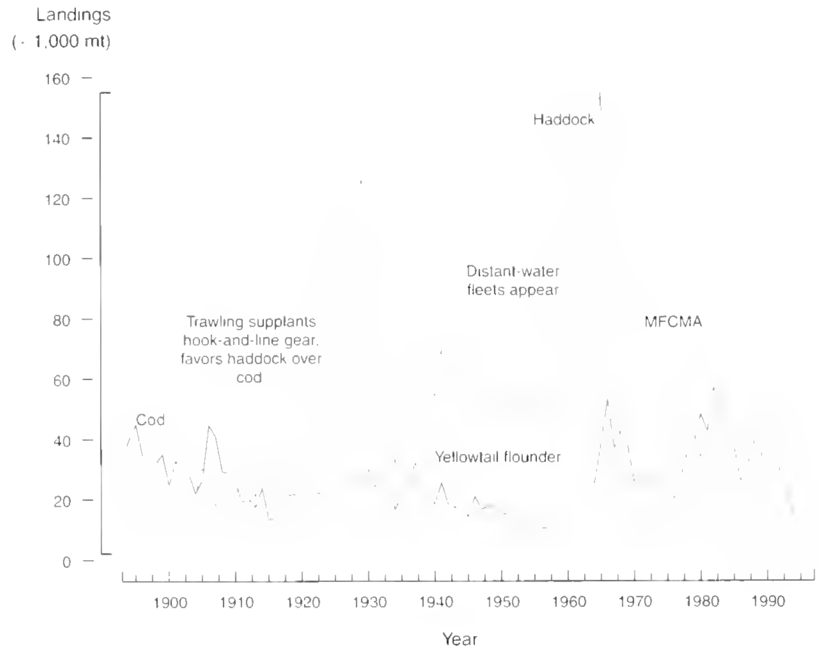


Figure 4
Total landings (· 1,000 t) of Georges Bank cod and haddock, and landings of yellowtail flounder from all New England waters, 1893–1997.

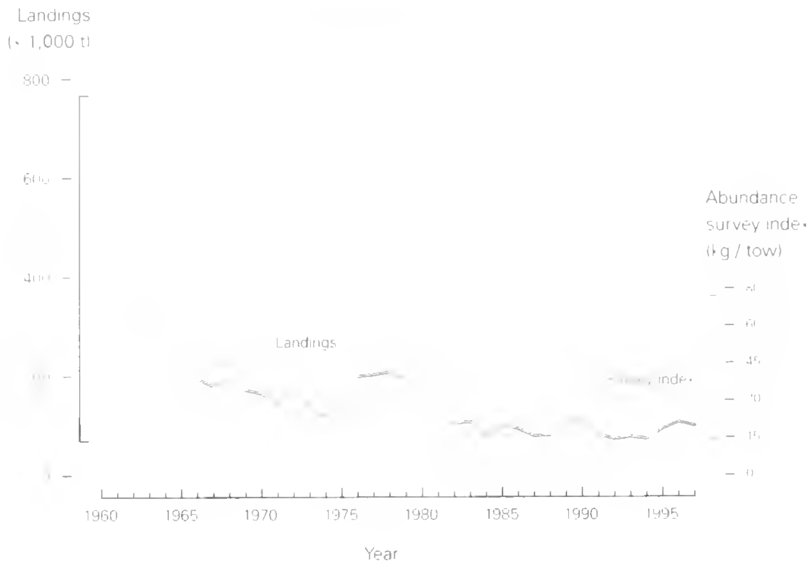


Figure 5
Landings (× 1,000 t) and relative abundance (stratified mean catch per tow in kg from NEFSC bottom trawl surveys) for principal groundfish and flounder stocks off the U.S. northeast, 1960–97.

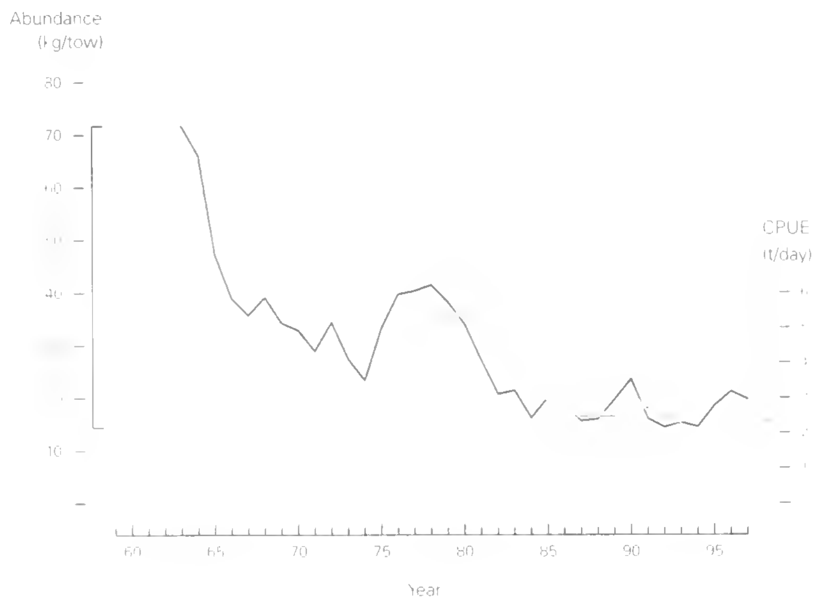


Figure 6
Relative abundance (from stratified mean catch per tow in kg from NEFSC bottom trawl surveys) and commercial trawler CPUE (catch per unit of effort, in metric tons per day fished, standardized for vessel size) for principal groundfish and flounder stocks off the U.S. northeast, 1963–97.

recruitment declined steadily during the period. Other important groundfish stocks supporting the fishery prior to the 1960's included silver hake and pollock, with small amounts of red hake, white hake, and others. Because of the modest harvest rates on most stocks, recruitment overfishing did not occur or was not persistent. When stocks declined, the fleet moved to other species, or to different stocks of the same species (e.g. off Canada).

Distant-Water Fleets (1960–76)

The growth of distant-water foreign fishing off the northeastern United States in the early 1960's included fleets of factory-based trawlers from eastern Europe, Asia, and elsewhere. Scouting vessels for the Soviet fleets first ventured into New England waters in 1961. Their initial target was Atlantic herring, and the distant-water fleet caught about 63,000 t that year. In subsequent years, herring catches increased (peaking at 225,000 t in 1963), and other species were also targeted, including silver and red hake, haddock, and Atlantic mackerel. From 1960 to 1965, total groundfish landings increased from 200,000 t to about 760,000 t (Figure 5). Haddock landings reached a record-high 154,000 t in 1965 and declined rapidly thereafter. Between 1964 and 1967 total groundfish landings were composed primarily of silver hake, haddock, red hake, flounders, and cod.

The intensified international fishery off the northeastern United States prompted the development of systematic multispecies monitoring surveys, which were initiated in the autumn of 1963. Stratified-random bottom-trawl surveys of the continental shelf waters from Nova Scotia to Hudson Canyon and later to Cape Hatteras, North Carolina, have been conducted every autumn since 1963 and every spring since 1968. Abundance, measured by these surveys, declined rapidly as various components of the demersal and pelagic systems were pulse-fished[1] (Figures 5 and 6). The parallel decline in groundfish abundance and landings was rapid and severe between 1966 and 1970 (Figure 5).

Beginning in 1970, quota-based management

[1]Intermittent, high fishing effort

was instituted for the offshore New England waters under the auspices of the International Commission for the Northwest Atlantic Fisheries (ICNAF). Quotas for each species were allocated by country, with the sum of each species equal to the total recommended removals. Additionally, second-tier quotas, less than the sum of a country's species allocations, were intended to mitigate the effects of nontarget bycatch, so that species quotas would not be exceeded. The quota system under ICNAF effectively ended directed distant-water fisheries on New England groundfish resources, as these resources were determined to have little capacity to support fisheries beyond the levels that would be taken by the United States and Canada. Quotas were progressively lowered on mackerel, herring, longfin and shortfin squids, and other species, as these resources declined as well.

In response to the declining abundance and landings of traditional New England offshore resources and elsewhere, the Magnuson Fishery Conservation and Management Act (MFCMA) was promulgated in 1976. This measure effectively ended distant-water fleet participation in New England fisheries, although some countries were allowed to harvest surpluses of squids, hake, butterfish, and mackerel for a few years following enactment.

Groundfish Fisheries Under the Magnuson Act (1976–99)

> *"No one knew exactly how many newcomers had arrived during the last four months of 1977, but according to one report, new boats entered the fishery at the astounding rate of about one every four days."*
>
> —Margaret Dewar
> "Industry in Trouble"

With the implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977, the northeast U.S. groundfish fleet, once dominated by wooden side-trawlers, was replaced relatively quickly by steel stern-trawlers equipped with more modern technology for locating, catching, and handling fish. Relatively strong year classes of cod, haddock, and some other groundfish stocks were produced in 1975, and they later resulted in improved resource conditions and increased groundfish abundance and effort in the late 1970's and early 1980's (Figures 5 and 6). As a result of the elimination of the distant-water fleets, U.S. and Canadian fishing effort off New England expanded rapidly. Between 1976 and 1984, U.S. otter-trawl fishing effort doubled. Fishery landings expanded quickly, with the Georges Bank component of the landings dominated by cod, haddock, and yellowtail flounder (Figure 7). Trends in groundfish trawler catch per unit of effort (CPUE in metric tons per day fished) paralleled the abundance indices from research vessel surveys (Figure 6). Catch rates increased rapidly

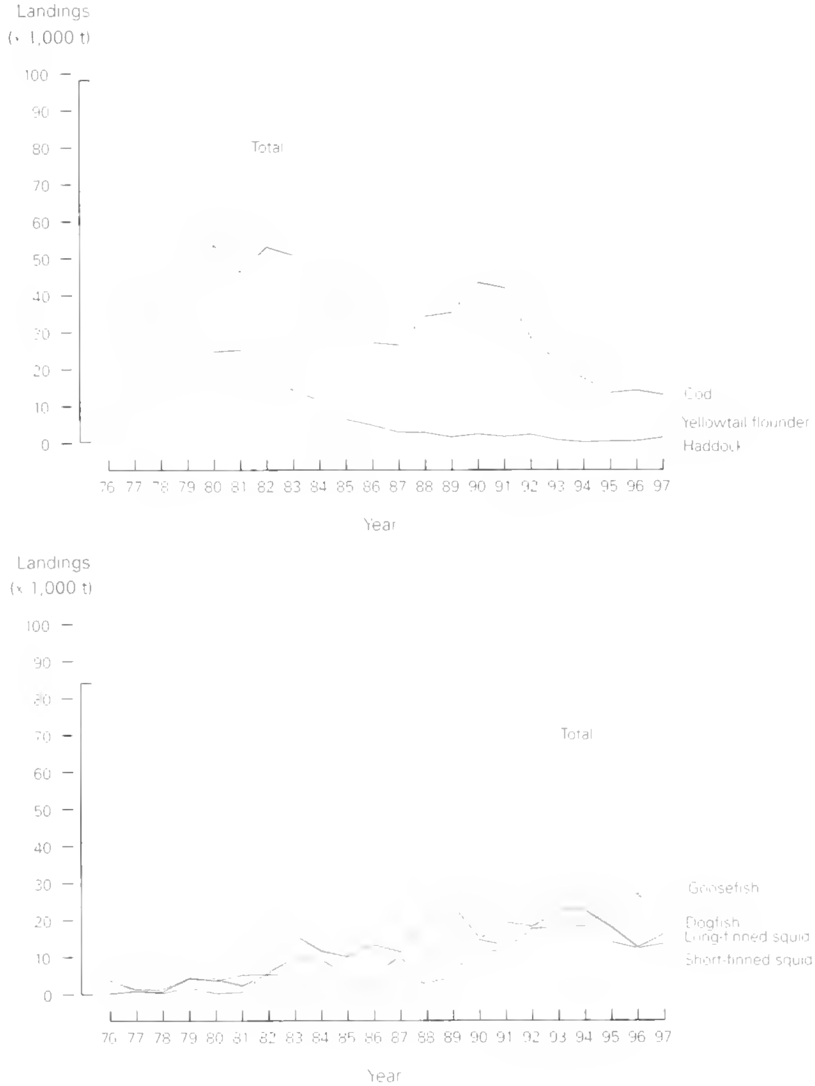


Figure 7
U.S. landings (× 1,000 t) of cod, haddock, and yellowtail flounder (top panel) and goosefish, spiny dogfish, shortfin squid and longfin squid, (bottom panel), 1976–97

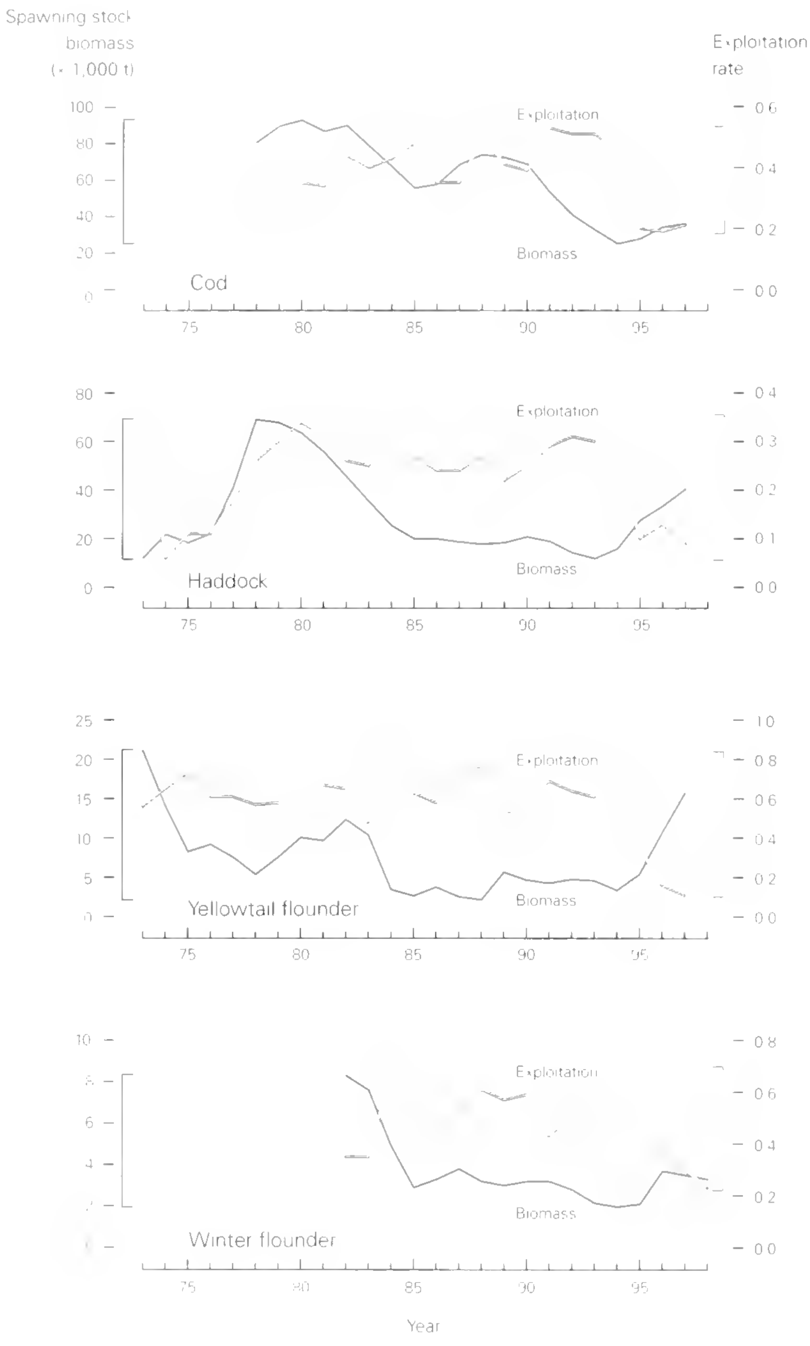


Figure 8
Spawning stock biomass (× 1,000 t) and exploitation rate for four Georges Bank groundfish stocks, 1973–98.

after 1976, but by the early 1980's they had peaked and began to decline. By the mid 1980's, commercial catch rates had dropped by half, as had the overall abundance of the resource. The collapse of the Georges Bank haddock stock, and then Georges Bank and Southern New England yellowtail flounder resources, resulted in an almost complete reliance by the fishery on cod (Figure 7).

Reduced landings of the traditional groundfish stocks, combined with strong market demand for fish, prompted the development of fisheries for alternative species such as squids, spiny dogfish, skates, and goosefish (monkfish) (Figure 7). Exploitation rates of most groundfish resources rose significantly, and spawning stock biomasses declined (Figures 8–10).

The New England Fishery Management Council initially retained the quota-based fishery management system for groundfish it inherited from the earlier management schemes adopted by ICNAF, but eventually abandoned direct controls on fishing mortality in 1982 in favor of regulations based primarily on minimum mesh and fish sizes and other indirect fishery controls.

In addition to increases in domestic fishing effort, delimitation of the maritime boundary between the United States and Canada in 1985 ended fishing by New England fleets on the eastern portion of Georges Bank and on the Scotian Shelf off Canada and resulted in even greater pressure on stocks in U.S. waters.

Exploitation rates of groundfish reached their highest levels in the early 1990's, as stock biomasses fell, in many cases, to record lows (Figures 8–10). Indirect controls had not resulted in sufficient conservation of the resources, and environmental groups sued the U.S. Department of Commerce over this failure. What emerged was a series of fishery management plan amendments, first implemented in 1994, that reduced days at sea by all fleet sectors to 50% of the pre-1994 levels. Additionally, these amendments closed over 5,000 square nautical miles of prime groundfishing areas (Figure 1), increased minimum net mesh sizes, implemented a moratorium on vessel entrants, and required mandatory vessel and dealer reporting of catches. The new regulations also implemented trip limits to reduce catches of depleted species and instituted "target" total allowable catches (TAC's) to serve as a guide to measure the effectiveness of conservation measures. Reacting to the implementation of direct controls on fishing effort, Congress instituted a buyout of fishing effort which resulted in a fleet reduction of 79 groundfishing vessels.

As a result of management measures enacted since 1994, exploitation rates, particularly on

Georges Bank groundfish stocks, have declined to levels not seen in several decades (Figure 8). Modest increases in spawning stock biomass for Georges Bank cod and haddock have occurred. Georges Bank yellowtail flounder biomass has rebounded the fastest to levels not seen since the early 1970's. Continued rebuilding of these stocks is contingent on improved recruitment, which has occurred for Georges Bank yellowtail flounder and, apparently, in 1998 for haddock, but continues to be poor for most other groundfish stocks.

In the Gulf of Maine, exploitation rates have remained high, while spawning biomasses of cod, American plaice, and white hake have declined to near record lows (Figure 9). The lack of success in reducing exploitation for Gulf of Maine groundfish is due to several factors. Overall, groundfish effort has declined substantially; however, the large closed areas on Georges Bank (Figure 2), combined with days-at-sea regulations, have resulted in displacement of fishing effort to inshore areas and a concentrations of trawl, gillnet and hook activity in the nearshore fishing grounds of the Gulf of Maine. Recruitment to most major groundfish stocks in the Gulf of Maine region has been below average in recent years.

Exploitation rates for Southern New England flatfishes (winter and yellowtail flounder) have declined substantially since 1992 (Figure 10). The spawning biomass for winter flounder has increased more than twofold over the time series low observed in 1994. Biomass of yellowtail flounder, although increasing, is well below levels necessary to sustain a significant fishery (Figure 10).

Overall, the New England groundfish resource is beginning to increase in abundance (Figure 6), and exploitation rates for many of the key stocks are at levels which should allow stock rebuilding. Recruitment has been generally poor in recent years, and exploitation of some stocks (e.g. in the Gulf of Maine) remains excessive.

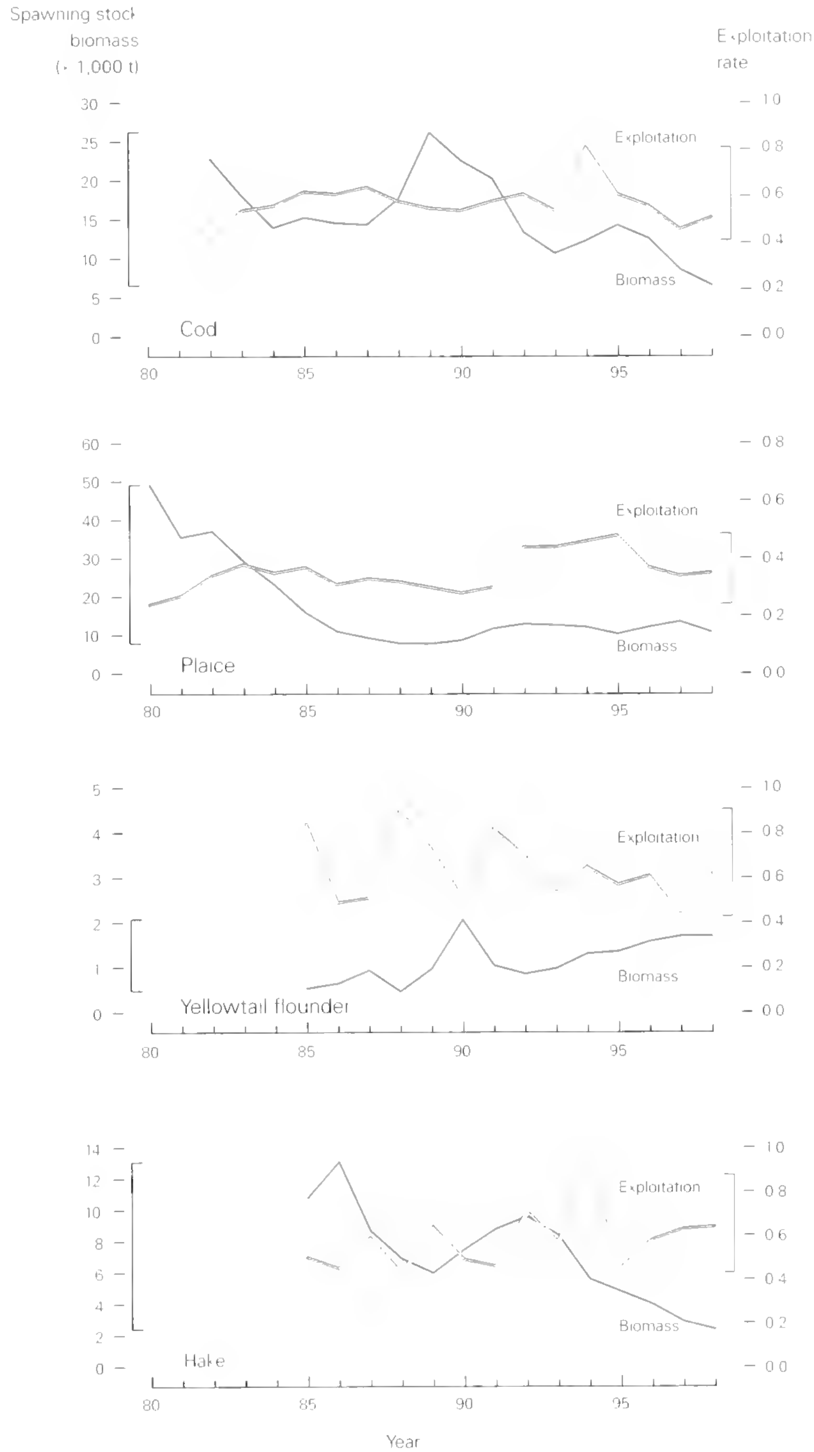


Figure 9
Spawning stock biomass (× 1,000 t) and exploitation rate for four Gulf of Maine groundfish stocks, 1980–98

PROSPECTS FOR THE RESOURCE AND FISHERY

Groundfish abundance and landings from the offshore New England region have varied considerably over the past 100 years, primarily due to their exploitation history. Dramatic reductions in most offshore stocks occurred due to the distant-water fleets, who pulse-fished the wide array of available species. After elimination of the foreign fleets, some stocks rebounded to high levels, only to be overfished again by domestic fleets in the

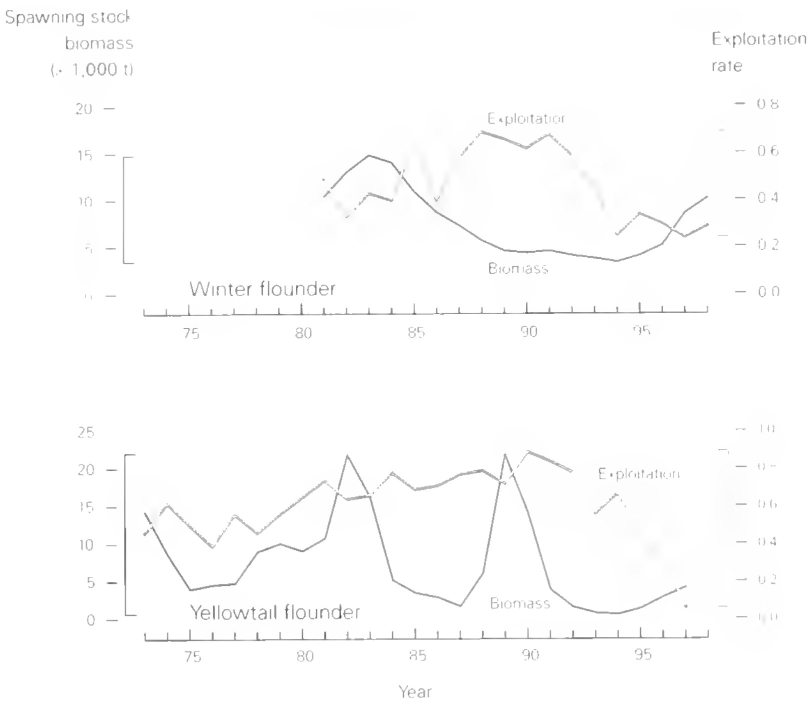


Figure 10
Spawning stock biomass (× 1,000 t) and exploitation rate (U) for two southern New England groundfish stocks, 1973–98.

1980's and early 1990's.

Projections of stock recovery included in recent groundfish fishery management plan amendments indicate that under exploitation rates such as those observed currently for Georges Bank stocks, recovery times of about a decade were required for most species, with some stocks rebuilding sooner (yellowtail flounder) and some later (haddock). This process has clearly begun on Georges Bank and in Southern New England, but additional conservation measures are required for many Gulf of Maine stocks. Managers are currently evaluating specific proposals for additional closed areas, effort reductions, and other measures to meet these goals.

Passage of the Sustainable Fisheries Act of 1996 has placed stringent new requirements for conservation and management of all fishery resources, including New England groundfish. The new statute requires that overfished populations be rebuilt to levels that would produce maximum sustainable yields over the long term. Current rebuilding target exploitation rates for New England groundfish will, in many cases, also be the long-term management goals required under the new law.

Management measures enacted since 1994 have had significant positive benefits for many of the resources, reflected in reduced exploitation rates, increased spawning stock sizes, and more balanced population age and size structures. One factor implicated in the decline of many groundfish stocks was the increased reliance on first-time spawners, a consequence of high and increasing exploitation rates. Reduced effort on some stocks has resulted in greater proportions of fish spawning two or more times before capture. A more balanced age structure is an important element rebuilding stocks (and fisheries) that can sustain normal year-to-year variations in recruitment, which may be extreme. Likewise, closed areas have been beneficial in promoting the recovery of the western Georges Bank spawning components of cod and haddock, which were fished to very low levels prior to 1995.

The New England groundfish resource has shown remarkable resiliency to changes in fleet size, target species shifts, and technological change over the past century. However, in some cases, stocks sensitive to overfishing (halibut, redfish) were "written-off" in favor of more productive resources. New fishery management legislation (i.e. the Sustainable Fisheries Act of 1996) requires that depleted resources be restored, and currently productive resources remain so. Fishing at sustainable exploitation rates will eventually result in much higher yields with less year-to-year variation in landings, more diverse catches (flounders, cod, haddock, redfish, pollock, etc.), and more stable catch rates in the fishery.

Status Review of King Mackerel in the Gulf of Mexico

Feature Article 3

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INTRODUCTION

This feature reviews the biology of king mackerel, the history and management of the fisheries for it in the Gulf of Mexico, and the issues of concern as the resource is recovered from being overfished. This review is based on the most recent stock assessment which was carried out in the spring of 1998. The status of king mackerel and other coastal migratory pelagics is described in Unit 7.

The king mackerel is a migratory coastal pelagic species found in the western Atlantic Ocean from New England to Brazil and in the Gulf of Mexico. Two groups are currently recognized in U.S. waters for management purposes: the Atlantic group and the Gulf of Mexico group. Both groups undergo long-distance migrations each year from the northern part of their range in the summer, where they spawn, to the southern part of their range in the winter, where they feed on large schools of baitfish. The Gulf of Mexico group splits during the winter migration with some fish going to Mexican waters and others going to southern Florida waters where they intermingle with the Atlantic group. Genetic studies have found some differences between the Atlantic and Gulf groups, but they have concluded that there is some gene flow between the two groups. Similar genetic studies within the Gulf of Mexico have found much smaller differences between king mackerel in the eastern and western Gulf.

Based on mark-recapture studies conducted during 1975–79, the boundary between the Atlantic and Gulf of Mexico groups was set at Florida's Volusia-Flagler County border in winter (1 November–31 March) and the Monroe-Collier County border in summer (1 April–31 October). The area between these two boundaries, the southeast coast of Florida, is known as the mixing zone with fish from both groups present in the winter, although for management purposes all the fish caught in this area in the winter are assigned to the Gulf of Mexico group.

King mackerel are relatively fast growing fish that form large schools and eat voraciously. They reach maturity quickly, as early as 2 years, and can live up to 20 years, although the majority of catches are younger than 6 years old. Their large size (up to 40+ kg for females), appealing taste, and strong fighting ability when hooked make them a target for both commercial and recreational fishermen. Landings from the commercial sector alone have been valued at approximately $6,000,000 on average over the past few years.

HISTORY

Large-scale exploitation of king mackerel began in Florida in the early 1900's. Sailing skiff operators, using hook-and-line, processed the fish for both local consumption and for sale as a dried and salted product. The introduction of ice houses in the area led to an increase in fishing pressure because the fish could now be shipped frozen, commanding a higher price. Total commercial catches

King and Spanish mackerel, Watson Island, Miami, Florida.

averaged approximately 1,814 metric tons (t) annually during the 1920's and 1930's. These catches decreased in the early 1950's to about 1,134 t and then increased to about 3,629 t in the 1970's.

Recreational fishing for king mackerel in the Gulf of Mexico became important starting in the 1950's and 1960's as boats and technology for offshore fishing became available to large numbers of people. The increasing number of recreational anglers, combined with advances in technology such as larger and more powerful boats, the global positioning system (GPS), and gear improvements, has increased considerably the recreational fishing pressure on the king mackerel. King mackerel have traditionally been an important component of the charterboat fishery in the Gulf of Mexico, and large numbers are taken from private and rental boats. Size and bag-limit regulations were begun in 1986 in an attempt to reduce the fishing pressure from the recreational sector.

CURRENT FISHERIES

Recreational

The recreational fishing sector targeting the Gulf of Mexico group is currently allocated 68% of the total acceptable catch (TAC), making it the largest component of the Gulf king mackerel fishery. Hook-and-line gear is employed in this sector from private and rental boats, chartered fishing trips, and headboats. The fishery is concentrated in Florida, which accounts for about 80% of the recreational landings. Current management regulations in this fishery are a 20-inch (~50 cm) fork length minimum size and a daily bag limit of two king mackerel. Fish caught under the recreational bag limit are occasionally sold, particularly by the captain and crew in the charter boat fleet. These sales are especially important and contentious when the commercial fishery has been closed due to filling its quota. In general, the recreational sector seeks the largest king mackerel while the commercial sector seeks the highest density of fish. Thus, on average the recreational sector catches bigger and older king mackerel than does the commercial sector.

Commercial

The commercial fishing sector targeting the Gulf of Mexico group is currently allocated 32% of the TAC which is further subdivided between the eastern and western sections of the Gulf. The eastern Gulf (east of the Florida-Alabama border) is allocated 69% of the total commercial quota (22% of the TAC) with the western Gulf allowed to catch the remaining 31% of the commercial quota. The fleet is mainly hook-and-line with some gillnetting done in Federal waters. The ban on entangling nets in Florida state waters enacted in 1994 was not as important in this fishery as it was in the Spanish mackerel fishery where commercial catches were reduced approximately 70%. The king mackerel gillnet fleet consists of larger boats (that fish further offshore in the U.S. Exclusive Economic Zone) than the Spanish mackerel gillnet fleet. The fish caught by the commercial sector are mainly sold whole and iced to wholesalers, who may produce fillets or steaks before they reach the market, or directly to restaurants straight from the boats.

Bycatch in Shrimp Trawls

An additional source of king mackerel mortality in the Gulf of Mexico is the catch of juveniles by the shrimp trawl fleet. Although the capture of a king mackerel in a shrimp trawl is relatively rare (<5% of tows), there are hundreds of thousands of days spent trawling by the fleet each year, resulting in annual bycatch estimates ranging from 300,000 to 1,300,000 fish. The estimated catches of king mackerel in the shrimp trawl fishery have been higher in recent years than prior to the start of king mackerel fishery management. Implementation of bycatch reduction devices in the shrimp trawl nets is expected to reduce this large bycatch, but the amount of reduction in terms of fishing mortality that will result is not known.

Management

Large catches by both commercial and recreational fishermen in the late 1970's and early 1980's, associated with perceived declines in catch rates, were the impetus for the inclusion of king mackerel Coastal Migratory Pelagic Resources

Fishery Management Plan in 1985. The goal of management is to achieve maximum sustainable yield (MSY), the largest catch which can consistently be taken from the population while preventing the stock from collapsing. The Gulf of Mexico Fishery Management Council sets the TAC for the Gulf of Mexico group of king mackerel as well as determines the allocations amongst user groups and specific regulations such as minimum size and bag limits. The TAC is based upon a specific fishing mortality rate criteria chosen by the Council. The Stock Assessment Panel provides the scientific advice on the catches that will achieve the target fishing mortality rate in the form of a range of acceptable biological catches reflecting uncertainty in the level of catch that will achieve the target fishing mortality rate. The range of acceptable biological catch is determined by a population analysis using a mixed Monte Carlo/bootstrap[1] algorithm that incorporates uncertainty about a number of important life-history parameters and catch statistics (Legault et al., 1998). The Stock Assessment Panel recommends a specific level of catch from within this range, traditionally the risk-neutral median of the range. The Council also incorporates recommendations from the Socioeconomic Panel and angler anecdotes when setting the TAC. For management purposes, the fishing year for the TAC is defined as beginning on 1 July and ending on 30 June of the following calendar year.

Originally, the TAC was set according to an $F_{0.1}$[2] strategy to achieve the goal of MSY. Implementation of the 602 Guidelines (§50 CFR Part 602 guidelines for the preparation of fishery management plans) in 1991 required a definition of the act of overfishing and a measure of overfished status. The spawning potential ratio (SPR), the ratio between the number of progeny that would be produced under current fishing levels to that which would have occurred in a virgin population, was chosen as this measure. The manner in which the spawning potential ratio has been calculated, as well as a number of important life history parameters, such as the natural mortality rate, have changed over time. The model-tuning indices used in the assessments have changed over time as well. However, king mackerel of the Gulf of Mexico Group have generally remained classified as overfished, but improving, since 1991. Currently, an unweighted SPR of 30% is both the target of management and the threshold for overfishing, a conflict which should be resolved due to the implementation of new Federal guidelines on definitions of overfishing.

Management of the directed fisheries for king mackerel in the Gulf of Mexico has been successful in reducing the average fishing mortality rate and increasing the biomass (Figures 1 and 2) (MSAP, 1998). These changes have occurred even with a general increasing trend in catch and acceptable biological catch since 1987. Thus, management has improved the biomass level while also increasing the fishery yield. This has been possible due to regulations on minimum size of fish allowed to be kept, gear types, and closed fishing seasons, as well as some years of increased recruitment. However, the goal of recovering the stock from an overfished condition has not yet been accomplished.

The Council has always been risk-prone in its TAC selection, choosing from the upper end of the range of acceptable biological catch provided by the Stock Assessment Panel. Furthermore, the TAC allocations have been overrun every year, slowing the recovery from an overfished condition. These allocation overruns have occurred in both the recreational and commercial fisheries, but have been larger both in percentage and amount of fish in the recreational fishery. The commercial fishery is monitored closely during the fishing season through a trip ticket reporting system, and each portion of the commercial fishery is closed once its quota is filled. The recreational fishery is monitored through the Marine Recreational Fisheries Scientific Survey (MRFSS[3]), which provides estimates of recreational catches in 2-month blocks. Bag limits and minimum size regulations

[1] Monte Carlo and bootstrap are two resampling schemes used to estimate uncertainty in the results. The resampling is done from an assumed distribution (Monte Carlo) or from the original data (bootstrap).

[2] At $F_{0.1}$, only a 10% increase in yield per recruit occurs following an additional unit of fishing effort (See Appendix 4).

[3] NMFS Fisheries Statistics and Economics Division, Office of Science and Technology, Silver Spring, MD 20910

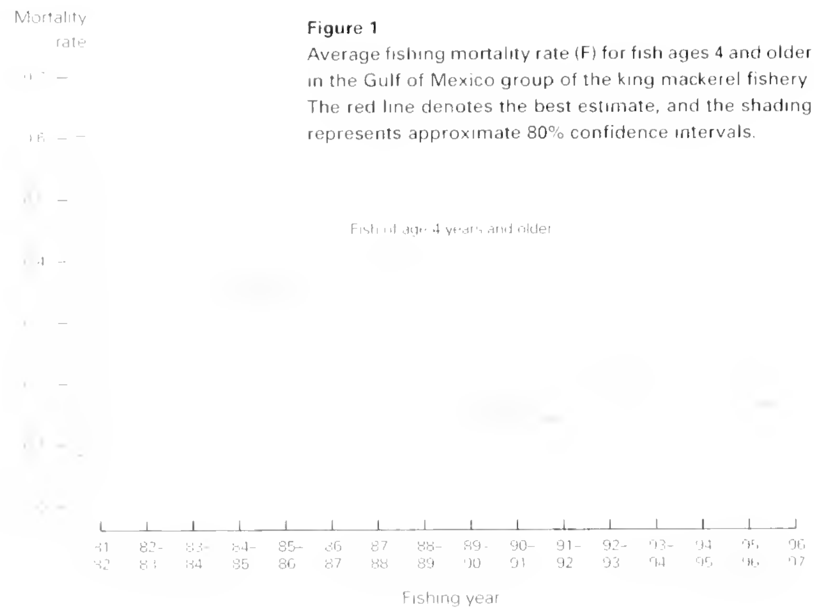

Figure 1
Average fishing mortality rate (F) for fish ages 4 and older in the Gulf of Mexico group of the king mackerel fishery. The red line denotes the best estimate, and the shading represents approximate 80% confidence intervals.

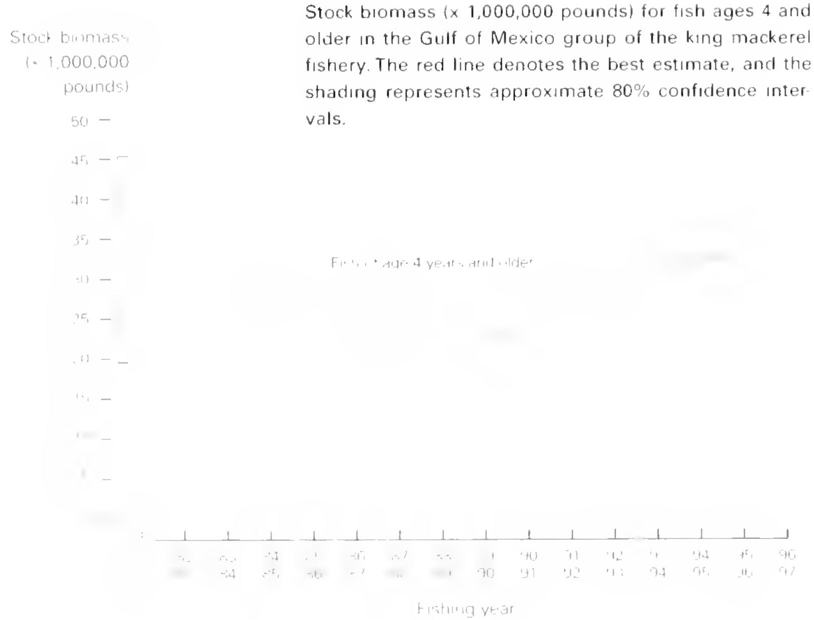

Figure 2
Stock biomass (x 1,000,000 pounds) for fish ages 4 and older in the Gulf of Mexico group of the king mackerel fishery. The red line denotes the best estimate, and the shading represents approximate 80% confidence intervals.

are used in an attempt to limit the amount of catch due to the recreational sector, thus the fishery is no longer closed during a fishing season, although it has been in the past. These regulations have not been successful, resulting in annual overruns of the recreational allocation of 41% on average (1986–96).

ISSUES OF CONCERN

Stock Definition

As more information becomes available, particularly a recent otolith-shape analysis, it is becoming apparent that the king mackerel caught in the mixing zone in the winter are more likely to be from the Atlantic group than from the Gulf of Mexico group. The repercussions of changing the group designation for these fish are not trivial. Preliminary calculations suggest that classifying these fish as of the Atlantic group increases the total acceptable catch and SPR in the Atlantic and decreases the total acceptable catch and SPR in the Gulf of Mexico. These TAC changes are slightly greater than the amount of fish caught within the mixing zone, and thus it could potentially be a net benefit to the fishermen in the Atlantic and a net loss to fishermen in the Gulf of Mexico.

Additionally, Mexico's king mackerel catches are currently not included in stock assessments. The level of catch is not well known but thought to be large, especially relative to the catches from the western Gulf of Mexico. It has been hypothesized that there are two stocks of king mackerel within the Gulf of Mexico, eastern and western, which mix in the summer in the northern Gulf of Mexico. If this hypothesis is correct, the Mexican catches are most likely the largest source of mortality for the western Gulf stock, and cooperative management between the United States and Mexico will have to be undertaken to successfully evaluate and regulate this fishery.

Allocation

The subdivision of the TAC is a contentious issue due to its zero-sum nature; for one sector to increase its portion, at least one other must decrease. This is especially important during the recovery phase when catches should be reduced relative to the status quo. Once the fishery has recovered, the TAC should increase and reduce this source of conflict.

Of special note in the context of allocation is the fact that reductions in the TAC impact mainly the commercial fishery due to its stringent monitoring and the ability to close the fishing season, while the recreational sector is allowed to continue to fish throughout the year. This disparity in impact of smaller TAC's could be reduced by lowering the recreational bag limit or closing parts of the fishing season or specific areas for recreational fishing (SEP, 1998).

Total Acceptable Catch Overruns

A related point is the consistent overruns of the TAC allocations by both the recreational and commercial sectors every year since management began. These overruns significantly reduce the ability of king mackerel to recover from an overfished state, especially when the TAC set is risk-prone from the start. These overruns are expected to continue in the recreational sector due to human population increases and increases in fishing power, for example, through bigger boats, better location devices (GPS), and improved gear, and as accumulated information regarding when, where, and how to fish spreads rapidly through the sportfishing media. As king mackerel recover, more fish will become available, and thus a constant bag limit will allow more fish to be caught, thereby increasing the probability of recreational fishery allocation overruns. Thus, recreational anglers may be faced with the counterintuitive situation of reduced bag limits as the fish become more abundant, at least until full recovery is achieved (SEP, 1998).

Recovery Times

The Gulf of Mexico group of king mackerel was supposed to have been recovered to a level of 30% SPR by the 1997–98 fishing season, based on the Coastal Migratory Pelagic Resources Fishery Management Plan begun in 1985, the implementation of the 602 Guidelines in 1991, and a 12-year generation time. The generation time is a measure of how quickly a fish is able to replace itself in the stock, on average, under conditions of no fishing. This recovery plan has not been met. The redefinition of overfishing guidelines which are in review in 1999 will most likely increase the recovery SPR goal. It is unclear whether a new 12-year period will be allowed for recovery to this level or if a shorter recovery time will be required.

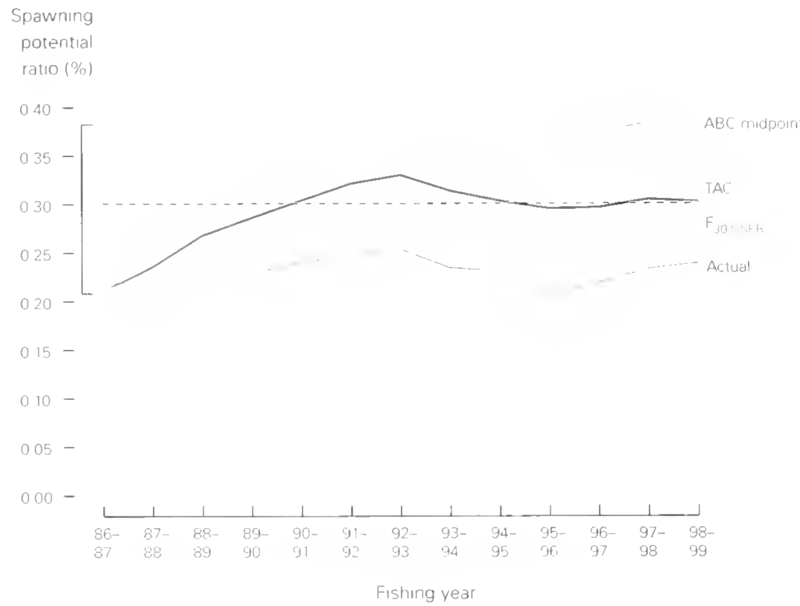

Figure 3
Spawning potential ratio, a measure of stock health where bigger values are better, under three scenarios of what could have happened and what actually happened. The three scenarios are: 1) the midpoint of the acceptable biological catch (ABC) range provided by the Stock Assessment Panel had been caught, 2) the TAC chosen by the Council had been caught without overruns, and 3) the current methods and parameter values had been used to set a risk-neutral TAC, which was then caught without overruns.

What Could Have Happened

The king mackerel group in the Gulf of Mexico could have been recovered already to levels approximating maximum sustainable yield (40% SPR) if the midpoint of the acceptable biological catch range provided by the Stock Assessment Panel had been caught (Figure 3) (see Powers, 1996). Additionally, if the TAC had been caught without overruns, the stock would currently be defined as not overfished (Figure 3). Of course, these gains in spawning potential ratio would have come at the expense of catches during this time period (Figure 4). It should be noted that the methods used to estimate the acceptable biological catch ranges, as well as important parameter values such as natural mortality and tuning indices, have changed during this time period. Thus, these scenarios do not accurately reflect upon the management of the fishery; rather, they provide a demonstration of what could have happened. These "what if" scenarios were generated by starting at the estimated 1986–87 fishing season, projecting the population forward under a modified catch using the same estimated historical selectivity pattern and recruitment values. This was repeated 400 times incorporating uncertainty in the inputs.

If the current methods, parameter values, and risk-neutral TAC's associated with a 30% SPR fish-

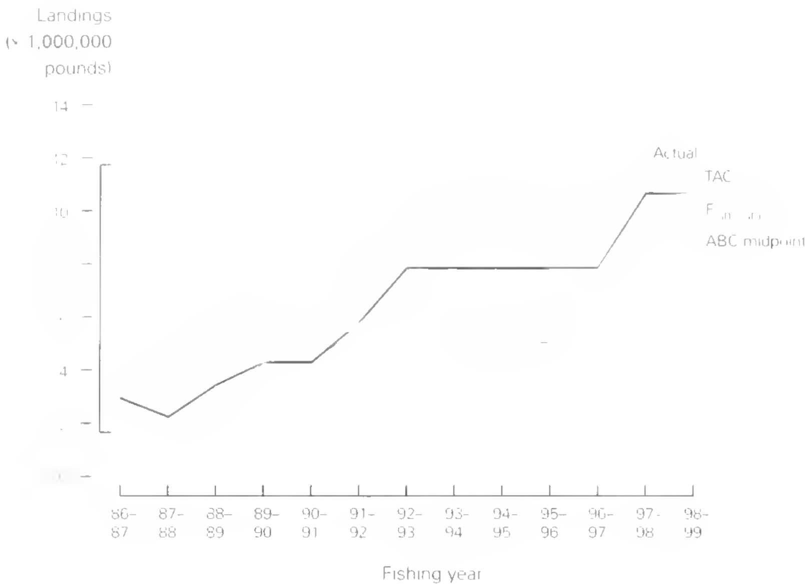

Figure 4
Total catch (x 1,000,000 pounds) that actually occurred in the fishery compared to the three scenarios described in Figure 3.

ing mortality rate ($F_{30\%}$[4]) had been applied, the trajectory of SPR would have been a gentle increase to the recovery level during the recovery period, as expected (Figure 3). Comparing the catches from the $F_{30\%}$ trajectory with those from the actual TAC and ABC midpoint trajectories, it is seen that the TAC's chosen would in fact be risk-averse relative to the $F_{30\%}$ values, at least initially, and thus allow a faster recovery. Had risk-prone TAC's been set each year, that is TAC's larger than those corresponding to the $F_{30\%}$ trajectory, the king mackerel would not have recovered to levels of 30% SPR during this time period. In fact, these "what if" scenarios are conservative in that they assume the same recruitment occurred. If recruitment had further increased with the increase in biomass (it appears there is a relationship in this stock), then this would accentuate the differences between the scenarios.

DISCUSSION

The Gulf of Mexico king mackerel fishery is an example of how catches can increase while fishing mortality rate(s) decreases, and biomass increases, a win-win situation for the fishery and the fish stock. All that is left is to take the final step to full recovery of the species, which will require a reduction in catches and/or further improvement in recruitment. Although it is a complex fishery consisting of migratory groups which overlap in distribution and are exploited mainly by recreational anglers whose total catch cannot be easily measured, the potential exists to fully recover the stocks while providing food, employment, and social benefits to the Nation for generations to come. This recovery will require not just the setting of risk-neutral TAC's, but also a recovery trajectory and a plan to compensate when the TAC allocations are not filled exactly, thereby moving away from the recovery trajectory (Powers, 1996). The seemingly random nature of recruitment levels and possible influence of environmental conditions means there will always be imperfect implementation of a recovery trajectory. The ability to compensate for falling behind the planned trajectory or to take advantage of improved conditions would significantly increase the probability of achieving stock recovery while maintaining viable fisheries.

[4] The spawning potential ratio is the amount of reproductive output for one recruit relative to the amount expected under no fishing (see Appendix 4). $F_{30\%}$ and $F_{40\%}$ are the fishing mortality rates expected to produce 30% SPR and 40% SPR, respectively.

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Previous page: Bigeye trevally, Pacific Ocean. © Brandon D. Cole

Northeast Demersal Fisheries

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Atlantic cod.

Unit 1

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INTRODUCTION

Northeast demersal (groundfish) fisheries include about 35 species and stocks, primarily in New England waters, but also off the Mid-Atlantic states. In New England, the groundfish complex is dominated by members of the cod family (cod, haddock, hakes, and pollock), flounders, goosefish, dogfish sharks, and skates. The Mid-Atlantic groundfish fisheries are primarily for summer flounder, scup, goosefish, and black sea bass.

Northeast groundfish fishermen employ fishing gears such as otter trawls, gillnets, traps, and set lines. Otter trawling is the predominant fishing method for groundfish throughout the region, with 1,229 registered otter trawl vessels in the Northeast region in 1996. Gillnets contribute a substantial proportion of the catch, particularly in the Gulf of Maine, with 472 gillnet vessels registered in 1996. Many of the vessels participating in the groundfish fisheries switch gears on a seasonal basis. Recent average (1995–97) landings (U.S., Canadian, and recreational) of mixed groundfish in the Northeast region were about 160,000 metric tons (t) (Table 1-1), with the 1997 total being 156,700 t, less than one-half of the long-term potential yield.

Groundfish resources in the Northeast occur in mixed-species aggregations, resulting in significant bycatch interactions among fisheries directed to particular target species or species groups. Management is complex because of these interactions. This complexity is reflected, for example, in the use of different mesh, gear, minimum landing size, and seasonal closure regulations set by the various management bodies in the region (e.g. New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), Atlantic States Marine Fisheries Commission (ASMFC), individual states, and the Canadian government). New England groundfish (13 species) are managed primarily under the North-

Table 1-1

Productivity in metric tons and status of Northeast demersal fisheries resources.

Species	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Atlantic cod[2,4]	17,300	6,500	45,400	Over	Below
Silver hake	15,500	Unknown	Unknown	Over	Below
Pollock[2,5]	14,100	Unknown	37,000	Full	Near
Summer flounder	9,700	8,400	24,500	Over	Below
Winter flounder[3]	5,500	Unknown	12,900	Over	Below
American plaice	4,300	Unknown	7,200	Over	Below
Haddock[2,6]	3,800	4,800	52,000	Full	Below
Yellowtail flounder[2,7]	2,900	3,500	31,900	Full	Below
Witch flounder	2,000	Unknown	2,900	Over	Below
Red hake	1,400	Unknown	Unknown	Over	Below
Windowpane flounder	800	Unknown	1,900	Over	Below
Redfish	400	Unknown	14,000	Full	Below
Spiny dogfish[2,3]	23,900	10,000	Unknown	Over	Below
Skates	10,700	Unknown	Unknown	Unknown	Unknown
Goosefish[2,8]	27,900	Unknown	Unknown	Over	Below
Weakfish[3]	4,200	3,900	Unknown	Full	Below
White hake[2,9]	3,800	Unknown	5,700	Full	Below
Black sea bass[3]	3,500	2,800	Unknown	Over	Below
Scup	3,300	3,300	Unknown	Over	Below
Spot	2,500	Unknown	Unknown	Unknown	Unknown
Tilefish	1,200	Unknown	1,200	Over	Below
Cusk[2,10]	700	Unknown	Unknown	Over	Below
Wolffish	400	Unknown	Unknown	Over	Below
Ocean pout	60	Unknown	1,500	Full	Near
Atlantic halibut	15	Unknown	300	Over	Below
Total	159,875	134,475	317,500		
U.S. Subtotal	142,215	118,230	253,555		

[1]1995–97 average (including foreign and recreational landings)
[2]Includes more than 100 t/year of foreign (Canadian) landings
[3]Includes more than 100 t/year of recreational landings
[4]For cod, U.S. portion of RAY is 15,200 t (88% of total)
[5]For pollock, U.S. portion of RAY is 3,800 t (27% of total)
[6]For haddock, U.S. portion of RAY is 900 t (24% of total)
[7]For yellowtail flounder, U.S. portion of RAY is 2,400 t (83% of total)
[8]For goosefish, U.S. portion of RAY is 27,600 t (99% of total)
[9]For white hake, U.S. portion of RAY is 3,300 t (87% of total)
[10]For cusk, U.S. RAY is 600 t (86% of total)

east Multispecies Fishery Management Plan, as well as peripherally under provisions of the ASMFC's Northern Shrimp Fishery Management Plan. Summer flounder, scup, and black sea bass are managed under a joint ASMFC-MAFMC fishery management plan, and weakfish is managed under an ASMFC fishery management plan. Demersal fisheries in New England were traditionally managed primarily by indirect methods such as mesh sizes, minimum fish lengths, and some area closures. The principal regulatory measures currently in place for the major New England groundfish stocks are allowable days at sea for fishing coupled with closed areas, trip limits (for cod and haddock), and target total allowable catch corresponding to target fishing mortality rates. The Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan includes provisions for catch quota targets aimed at restoring these stocks.

Extensive historical data for the Northeast demersal fisheries have been derived from both fishery-dependent (i.e. catch and effort monitoring) and fishery-independent (e.g. National Oceanic and Atmospheric Administration research vessel) sampling programs (since 1963). Since 1989, a sea sampling program has been conducted aboard commercial fishing vessels for documenting discard rates and collecting high quality, high resolution data on their catch. Despite the past management record, some of the Northeast demersal stocks (cod, yellowtail flounder, haddock, American plaice, and summer flounder) are among the best understood and assessed fishery resources in the country.

SPECIES AND STATUS

Principal Groundfish and Flounders

The principal groundfish and flounders group includes important species in the cod family (Atlantic cod, haddock, silver hake, red hake, and pollock), flounders (yellowtail, summer, winter, witch, windowpane, and American plaice) and redfish (Figure 1-1). Recent annual landings of these 12 species (representing 19 stocks) have averaged 77,700 t (70% U.S. commercial, 21% Canadian, and 9% U.S. recreational), compared with a combined long-term potential yield of 246,600 t (Table 1-1). Total ex-vessel revenue from the principal U.S. groundfish and flounder commercial landings in 1997 was $109 million compared to $121 million in 1994. The Northeast groundfish complex supports important recreational fisheries for species including summer flounder, Atlantic cod, winter flounder, and pollock.

Fishing effort restrictions have been implemented under Amendments 5 and 7 to the Northeast Multispecies Fishery Management Plan through days-at-sea allocations based on either individual vessel or fleet-level performance criteria. Under the individual vessel category, the total number of permitted vessels and the allocated number of days at sea declined continuously between 1995 and 1997. The total number of vessels in the fleet-level category rose between 1995 and 1996 when the fixed-gear sector was brought under the fishery management plan following the adoption of Amendment 7. Both vessel numbers and their associated days at sea declined substantially between 1996 and 1997 as restrictions on the fixed-gear sector were implemented.

The research vessel survey abundance index for this group of species declined by almost 70% between 1963 and 1974 (Figure 1-1), reflecting substantial increases in exploitation associated with the advent of distant-water fleets. Many stocks in

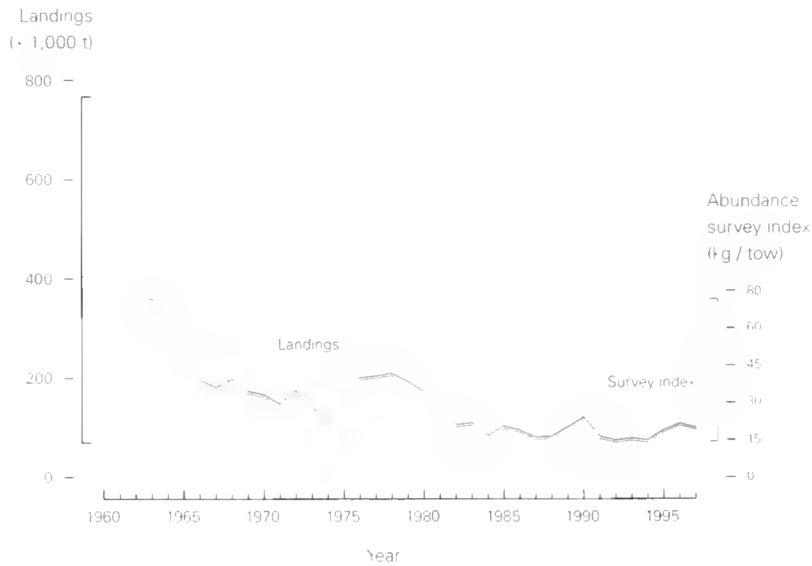

Figure 1-1
Landings in metric tons (t) and abundance index of principal groundfish and flounders, 1960–97.

this group declined sharply, notably Georges Bank haddock, most silver and red hake stocks, and most flatfish stocks. By 1974, indices of abundance for many of these species had dropped to the lowest ever recorded.

Groundfish partially recovered during the mid-to-late 1970's because of reduced fishing effort associated with increasingly restrictive management under the International Commission for the Northwest Atlantic Fisheries in the early 1970's, and implementation of the Magnuson Fishery Conservation and Management Act in 1977 (Mayo et al., 1992). Cod and haddock abundance increased markedly, stock biomass of pollock increased more or less continually, and recruitment and abundance also increased for several flatfish stocks. The aggregate index peaked in 1978, but subsequently declined, reaching new lows in 1987 and 1988. The 1989 and 1990 abundance values were slightly higher than the previous two years, primarily due to recruitment of moderate 1987 year classes of Atlantic cod, haddock, and yellowtail flounder. However, subsequent abundance indices declined due in large part to the rapid depletion of the 1987 yellowtail flounder year class, and declining cod abundance. The overall index for the principal groundfish and flounders reached a 30-year low in 1992 and during 1995–97 had increased by about 35%. Landings of most of these species declined substantially from 1994 through

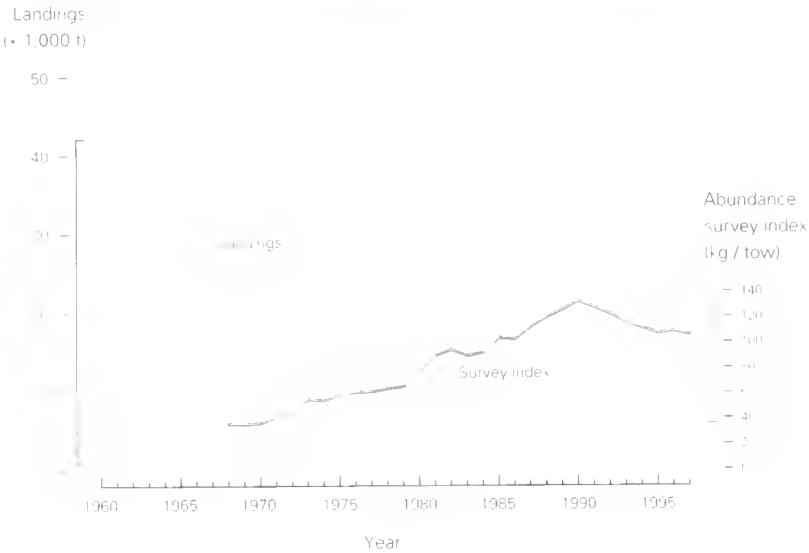

Figure 1-2

Landings in metric tons (t) and abundance index of skates and spiny dogfish, 1960–97.

1997 and were predicted to decline further in 1998 in the face of generally poor recruitment and continued restrictions on days at sea and/or reduced target total allowable catches. Landings of cod in 1997 were the lowest on record, while those for haddock and yellowtail flounder[1] improved slightly in 1996 and 1997 as a result of improvements in stock biomass and sharp reductions in fishing mortality beginning in 1995 (Northeast Fisheries Science Center, 1997c,d) as a result of regulatory measures. A more detailed description of these changes is contained in the feature article on the rebuilding of New England groundfish stocks.

Summer flounder, one of the most valuable groundfish species in the Mid-Atlantic area, is the focus of both commercial and recreational fisheries, with about 60% of the landings commercial and 40% recreational. Prior to the implementation of management measures in 1988, stock abundance had been steadily declining and fishing mortality rates had been excessively high. However, spawning stock biomass subsequently increased over threefold from 1989 to 1996 (Northeast Fisheries Science Center, 1997e,f), and fishing mortality has declined, particularly after 1992 when greatly reduced target fishing mortality rates for 1993 and subsequent years were adopted. Landings have remained relatively steady at about 10,000 t annually during 1990–97, compared with a long-term potential yield of 24,500 t (Table 1-1).

Dogfish and Skates

Dogfish and skates are a significant part of the aggregate groundfish stock biomass in the Northeast (Figure 1-2). Of the two dogfishes (spiny and smooth), the spiny dogfish is dominant by far. Seven species of skates, including little, winter, barndoor, clearnose, thorny, rosette, and smooth, occur on the Northeast shelf—winter, little, and thorny skates account for most of the landings.

Skate and spiny dogfish landings underwent a marked increase from 2,900 t in 1978 to 31,500 t in 1992, increasing further to record high levels of 42,500 t in 1996. Recent annual landings averaged 34,600 t (Table 1-1). Discards of both species in fishing activities directed towards other species are thought to be equivalent to the amounts landed. Abundance of skates and dogfish increased throughout the 1970's and 1980's, peaked in 1990, and declined each year since (Figure 1-2). Despite these recent declines, overall abundance of skates and dogfish continues to remain high, although a 1997 assessment (Northeast Fisheries Science Center, 1998a,b) indicated that the biomass of mature female spiny dogfish had decreased by over 50% from a peak in 1989 to 1997 and that the stock is overexploited.

Other Finfish

Other groundfish species taken primarily as bycatch in the Gulf of Maine include goosefish, white hake, ocean pout, cusk, wolffish, and Atlantic halibut. In Southern New England, ocean pout are taken as bycatch, while goosefish are primarily taken in directed fisheries. In the Mid-Atlantic, goosefish, scup, weakfish, black sea bass, spot, tilefish, and several others are landed either in directed fisheries or as bycatch. As a group, they can be characterized generally as overexploited, with recent annual landings totaling 47,575 t (Table 1-1); individually, some have landings well below their long-term maximum as a result of be-

[1] Two out of four stocks of yellowtail flounder and one out of two haddock stocks improved.

ing depleted, while for others (e.g. goosefish), recent landings have been well in excess of their long-term maximum as a consequence of overexploitation. Most of these stocks are managed implicitly with other species included in various fishery management plans. For example, white hake, goosefish, cusk, wolffish, and Atlantic halibut are taken in various groundfish fisheries regulated under the Northeast Multispecies Fisheries Management Plan. Scup and black sea bass represent major components of the summer flounder directed fishery, and those three species are managed under a single fishery management plan. Weakfish, a stock that has responded well to management controls (under an ASMFC fishery management plan) has experienced a recent substantial decline in fishing mortality and increase in stock biomass (Northeast Fisheries Science Center, 1998a,b).

In recent years, goosefish has become one of the most important species in the Northeast region. U.S. landings increased from a yearly average of around 300 t during 1964–72 to about 8,800 t during 1980–88, and then continued to climb to a record high of 28,800 t, valued at $35 million, in 1997 making it the top-ranked demersal species in both landings and value in the Northeast region. The recent average yield was 27,900 t (Table 1-1). This dramatic increase in landings resulted from a diversion of fishing effort and attention caused by the decline in abundance of the principal groundfish and flounders as well as increased market demand and prices. As a consequence, goosefish abundance has dropped to low levels and the stock is now overexploited (Northeast Fisheries Science Center, 1997a,b). The growth of this fishery has prompted development of regulations to control both landings and the size of fish landed. Since landings occur both from directed fishing (primarily by otter trawls and gillnets) and as bycatch from fishing directed towards many other species, regulatory measures being developed under a joint New England Council and Mid-Atlantic Council Goosefish Fishery Management Plan are extensive and complicated.

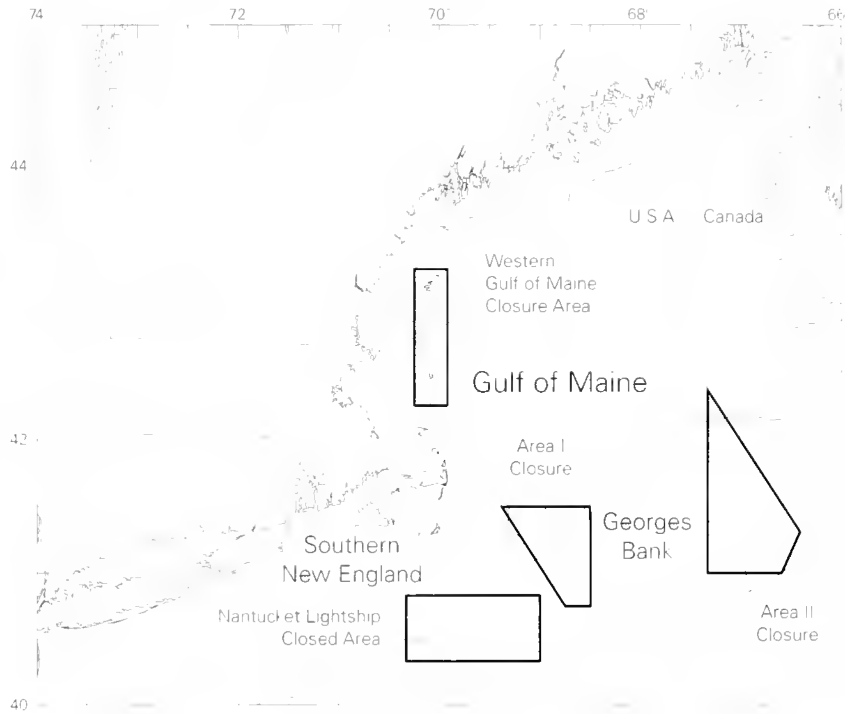

Figure 1-3
Areas closed year-round to protect New England groundfish.

ISSUES

Management Concerns

Until the early 1990's, New England groundfish harvests were regulated by indirect controls on fishing mortality, such as mesh and minimum fish size restrictions and some area closures. However, as a result of litigation filed by the Conservation Law Foundation and the Massachusetts Audubon Society, which significantly raised public awareness and concern and stimulated demands for strong action to eliminate overfishing and restore depleted stocks of cod, haddock, and yellowtail flounder, regulatory measures since 1994 have been more stringent and focused. Amendment 5 to the NEFMC's Multispecies Fishery Management Plan, implemented in March 1994, marked the beginning of an effort reduction program to address the requirement to eliminate the overfished condition of cod and yellowtail flounder in 5 years and haddock in 10 years. The regulatory package included a moratorium on new vessel entrants, a schedule of reduction in days at sea for trawl and gillnet vessels, increases in regulated mesh size, and expanded closed areas to pro-

Goosefish.

tect haddock. The objective of the plan was to gradually eliminate the overfished condition of cod, yellowtail flounder, and haddock over 5–7 years. Since December 1994, three large areas (i.e. Closed Areas I and II on Georges Bank and Nantucket Lightship Closed Area) (Figure 1-3) have been closed through emergency action by the Secretary of Commerce to protect the regulated groundfish, particularly spawning fish. In view of a Special Advisory on Groundfish Status on Georges Bank (Northeast Fisheries Science Center, 1994), based on new assessments which indicated that the stocks of haddock and yellowtail flounder had already collapsed and that cod was in imminent danger of also collapsing, Amendment 7 to the Northeast Multispecies Fishery Management Plan was developed and implemented (in 1996) to accelerate the existing days-at-sea reduction schedule established in Amendment 5 and impose other tighter restrictions, including three closed areas in the Gulf of Maine, in order to reduce fishing mortality to the $F_{0.1}$ level.[2] Since 1994, the Multispecies Plan has been modified by a series of framework adjustments, with Framework 25 (implemented in April 1998) imposing reduced trip limits and area closures to achieve management objectives for cod in the Gulf of Maine (i.e. reduce landings and fishing mortality to target levels).

The joint MAFMC-ASMFC Summer Flounder Fishery Management Plan, initially approved in 1988 but subsequently modified by a series of amendments, has a strategy to reduce fishing mortality to F_{max},[2] the level chosen as the overfishing definition for this stock. The Summer Flounder Plan uses commercial catch quotas, allocated by state and season, and recreational harvest limits and possession size limits to achieve these management goals. Increased recruitment levels, combined with lower fishing mortality rates during 1993–96, have resulted in increased biomass.

Transboundary Stocks and Jurisdiction

Significant catches are taken from transboundary stocks of Atlantic cod, haddock, and pollock from Canadian waters of Georges Bank and the Gulf of Maine. In 1997, 18% of the cod, 64% of the haddock, and 73% of the pollock landings were taken by Canadian fishermen. Management regulations employed by the two countries, although different, are based on a common objective of maintaining fishing mortality at or below $F_{0.1}$. There is coordination of stock assessment activities between the countries, and beginning in 1998, the two countries embarked on a joint process for annually performing and peer reviewing the assessments of these transboundary stocks. The two countries will, however, continue to independently prepare management advice on the basis of jointly prepared and reviewed assessments. There is no formal joint management of these shared resources, although regular informal discussions take place between government officials, managers, and industry representatives of the two countries.

Economics

Rebuilt stocks eventually will provide increased net benefits to producers and consumers, but in the short term, effort reductions will curtail revenues to fishermen and may raise prices to consumers. Recent analyses (New England Fishery Management Council, 1997) indicate that fish-

[2] $F_{0.1}$ and F_{max} are two reference rates of fishing mortality used in fisheries management (see Appendix 4). F_{max} maximizes the amount of yield from the average recruit to the stock; $F_{0.1}$ results in nearly as much yield per recruit but is more conservative than F_{max}.

ing mortality rates in 1997 for the Georges Bank stocks of cod, haddock, and yellowtail flounder and the Southern New England stock of yellowtail were at or below the overfishing definitions for those stocks and below the more restrictive Amendment 7 targets ($F_{0.1}$) for all but Georges Bank cod. For Gulf of Maine cod, however, fishing mortality in 1997 was well above both the overfishing definition and the target (F_{max}). Substantial reductions in fishing effort have occurred in the New England area in recent years. For example, the total number of limited access permitted vessels with individual days-at-sea allocations declined from 197 in 1995 to 162 in 1997, and the total days at sea allocated to these vessels declined from 37,320 in 1995 to 18,295 in 1997. The fixed-gear sector was brought into the limited access category in 1996, and the total number of days allocated to the fleet days-at-sea category decreased from 187,372 in 1996 to 109,888 in 1997. In addition to these reductions in days at sea for fishing vessels, a vessel buyout program, authorized by the Secretary of Commerce and administered by the National Oceanic and Atmospheric Administration, was initiated in 1995, first as a pilot project and later as a comprehensive fishing capacity reduction project. The program was designed to provide economic assistance to fishermen adversely affected by the collapse of the groundfish fishery and who voluntarily chose to remove their vessels permanently from the fishery, while helping fish stocks recover to a sustainable level by reducing the excess fishing capacity in the Northeast. The vessel buyout program, which concluded early in 1998, removed 79 fishing vessels at a cost of nearly $25 million and resulted in an approximate 20% reduction in fishing effort in the Northeast groundfish fishery. The ultimate net benefits of all these effort reductions for the Northeast groundfish resources will be both positive and substantial to the Nation as a whole.

Progress

Considerable progress in the development and implementation of management alternatives for the Northeast demersal resources has been made since 1994. The implemented measures include reductions in days at sea, increased minimum mesh sizes, a moratorium on new vessels, expanded closed areas to fishing (Figure 1-3), and trip limits for depleted cod and haddock stocks. An annual review provision allows the level of effort reduction measures to be changed, depending on the actual state of fishing mortality relative to plan targets. Mandatory reporting systems for Northeast resources have been developed to better monitor the performance of the fishery. New assessments for principal species including cod, haddock, and yellowtail flounder have documented patterns of fishing mortality, discarding, and recruitment, and form the basis for additional regulatory proposals.

Winter flounder.

Fishing effort in the Northeast demersal fisheries has been reduced substantially since 1994 when Amendment 5 to the Northeast Multispecies Fishery Management Plan became effective. Beginning in March 1994, Amendment 5 introduced a phased-in, 5-year, 50% reduction in days at sea, and expanded Closed Area II on the Northeast Peak of Georges Bank. Closed Areas I and II were closed on a year-round basis by emergency action in December 1994, and the closures became permanent following implementation of Framework 9 in April 1995. Amendment 7, which became effective in July 1996, incorporated the essential features of Amendment 5 and Framework 9. Amendment 7 introduced further restrictions on days at sea to cover fixed-gear as well as mobile-gear sectors, accelerated the days-at-sea reduction schedule, and adopted biomass targets. These tar-

Juvenile skate from research trawl catch, Georges Bank

gets were keyed to rebuilding the spawning stock through fishing mortality levels well below the 20% maximum spawning potential overfishing definition. Annual adjustments to the allowed days at sea are determined by monitoring a series of target total allowable catches keyed to the fishing mortality rates.

Management of the summer flounder stock has proceeded with a goal of reducing fishing mortality to F_{max}. A series of state-by-state allocations of the annual quota has been the primary regulatory measure. With improved recruitment, coupled with reduced fishing mortality, catch rates for the commercial and recreational sectors improved during 1993–96. Lower fishing mortality rates and slightly improved recruitment will result in increased landings and a rebuilding of the spawning stock biomass and its age structure (currently comprised primarily of fish aged 2 years or younger).

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Northeast Pelagic Fisheries

NMFS

Unit 2

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INTRODUCTION

Northeast pelagic fisheries target small schooling species in the U.S. Exclusive Economic Zone, particularly Atlantic mackerel, Atlantic herring, bluefish, and butterfish.[1] The fisheries on these stocks are seasonal and reflect the migratory patterns and availability of these species. Generally, these species overwinter in relatively warm offshore waters of the Mid-Atlantic continental shelf and southward to avoid seasonal cooling of nearshore northern waters. This is followed by a northward and inshore migration during the spring and summer to feed and reproduce.

Various fishing gears including bottom trawls, midwater trawls, gillnets, and seines are employed to harvest pelagics in the Northeast Region. During 1995–97, total landings averaged 158,500 metric tons (t) (Table 2-1), 77% by the United States and 23% by Canada, including recreational landings (primarily bluefish and mackerel) of about 9,000 t. The ex-vessel value of the 1997 U.S. commercial landings was about $28 million. Recreational landings of bluefish and mackerel are also important in the Northeast Region. For example, over $300 million is spent annually by recreational anglers fishing for bluefish.

The two principal Northeast pelagics, Atlantic mackerel and Atlantic herring, were exploited heavily by distant-water fleets during the early 1970's. As a result, stock sizes and yields declined to very low levels by the late 1970's. Abundance has since increased due to low harvest rates and improved recruitment. Current stock sizes for these species are at historically high levels.

Northeast pelagic fisheries are managed under three fishery management plans, the first developed by the Mid-Atlantic Fishery Management

[1]Long- and short-finned squid are described in Unit 4 for taxonomic consistency.

Atlantic herring

Table 2-1

Productivity in metric tons and status of Northeast pelagic fisheries resources

Species	Recent average yield (RAY)[1]	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Atlantic herring[2,4]	111,000	317,000	317,000	Under	Above
Atlantic mackerel	33,500	383,000	326,000	Under	Above
Bluefish	11,200	4,350	42,700	Over	Below
Butterfish	2,800	7,200	16,000	Under	Above
Total	158,500	711,550	701,700		
U.S. Subtotal	121,300	439,350	462,000		

[1]1995–97 average (including foreign and recreational landings)
[2]Includes significant foreign (Canadian) landings
[3]Includes significant recreational landings
[4]For herring, U.S. portion of RAY is 92,700 t (84% of total)
[5]For mackerel, U.S. portion of RAY is 14,600 t (44% of total)

Council, the second jointly by the Mid-Atlantic Council and the Atlantic States Marine Fisheries Commission, and the third by the New England Fishery Management Council in coordination with the Atlantic States Marine Fisheries Commission—the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan, the Atlantic Bluefish Fishery Management Plan, and the Atlantic Sea Herring Fishery Management Plan.

SPECIES AND STATUS

The Northeast pelagic fisheries are dominated by four species: Atlantic mackerel, Atlantic herring, bluefish, and butterfish. Three of these are considered to be underutilized (mackerel, herring, and butterfish), while bluefish is considered to be overutilized. The abundance of mackerel, herring, and butterfish is presently above average, while that of bluefish is below average.

The long-term population trends for mackerel and herring, as measured by research vessel survey data, have fluctuated considerably during the last 25 years (Figure 2-1). The combined abundance index for these two species reached minimal levels in the mid-to-late 1970's, reflecting pronounced declines for both and a collapse of the Georges Bank herring stock, but it climbed steadily because of the rebuilding of both species and reached a peak in 1994. The abundance of both species has remained at a high level in recent years and will be reassessed in 1999.

William B. Folsom, NMFS

This page: Atlantic mackerel; opposite page: Atlantic herring on catch table

Atlantic Mackerel

The Atlantic mackerel stock recovered during the 1980's, and the most recent stock assessment (Northeast Fisheries Science Center, 1996a,b) indicated that the spawning stock biomass was around 2 million t in 1994. Abundance indices from research vessel surveys have remained fairly stable in subsequent years suggesting that stock biomass has remained approximately at that level. In comparison, recent annual landings were about 33,500 t (Table 2-1), of which 57% was taken by Canada. Although the size of the mackerel stock is imprecisely known (because of low harvest rates, and abundance indices from bottom trawl surveys are not the most efficient method to index schooling species), mackerel landings could be increased severalfold without jeopardizing stock productivity. U.S. commercial landings of mackerel nearly doubled from 1995 (8,500 t) to 1996 (15,800 t) due to increased effort on mackerel because of improved world markets for mackerel and continued low abundance of traditional groundfish stocks. There are indications that growth and maturity rates of mackerel declined as stock size increased during the 1980's.

Atlantic Herring

The Atlantic herring stock complex in the Northeast Region is considered to be underutilized (Northeast Fisheries Science Center, 1996c,d). Total landings of herring were 118,900 t in 1997 (U.S. landings were 98,200 t), down slightly from 1996 and about 29% higher than in 1995. Recent average landings totaled 110,500 t (Table 2-1). The coastal stock complex consists of three major stock groups in U.S. waters: Gulf of Maine, Georges Bank, and Nantucket Shoals. Canadian catches off New Brunswick have also been included in the combined stock analysis since these fish mix with those from the other stocks during portions of the year. The Georges Bank herring stock had collapsed by 1976 after intensive exploitation by distant-water fleets during the 1960's and early 1970's. Although the stock complex is capable of supporting much higher levels of landings than presently taken, there is concern that the Gulf of Maine stock, from which the majority of the landings have recently been taken, may be fully exploited.

Bluefish

Bluefish landings peaked in 1981 at 51,400 t, but have declined to a recent annual average of only 11,200 t (Table 2-1). About two-thirds of the recent bluefish landings have been taken by recreational fishermen. The recent downward trend in recreational and commercial landings corresponds to a decline in stock biomass. Currently, the bluefish stock is overutilized and at a low level of abundance (Northeast Fisheries Science Center, 1997a,b).

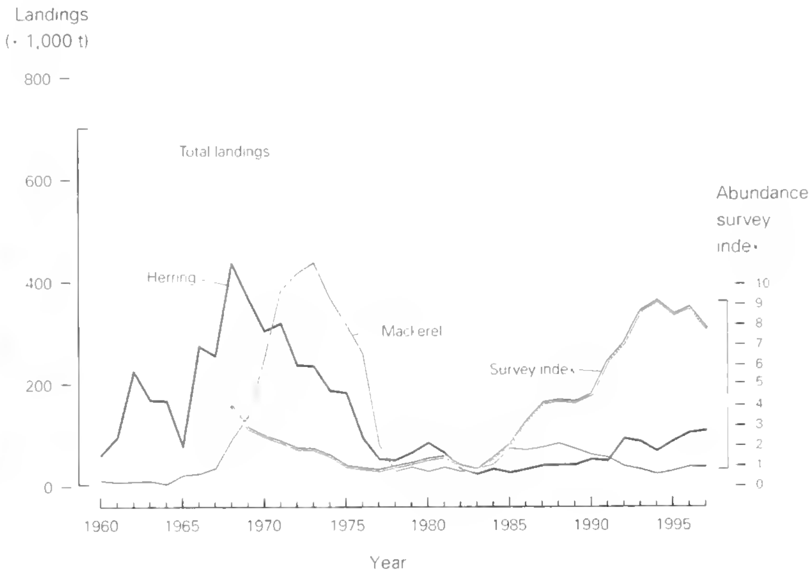

Figure 2-1
Landings in metric tons (t) and abundance index of principal pelagic stocks, 1960–97.

Butterfish

The butterfish stock is considered to be underutilized based on current research survey results and historic landing patterns. Butterfish landings have declined significantly in recent years to less than 3,000 t/year, primarily due to reduced export demand. The stock is currently being fished well below its long-term potential yield (Table 2-1) and is considered to be above average in abundance based on research survey indices.

ISSUES

Scientific Advice and Adequacy of Stock Assessments

Although historical catch data (except perhaps for bluefish) are generally adequate for assessment purposes, stock assessments for the Northeast pelagic resources are relatively imprecise, owing to the highly variable trawl survey indices of abundance used for calibrating cohort analysis models, the short life-span of some stocks (butterfish), and current low exploitation rates of some species (mackerel and herring). The development of more precise assessments will require the use of

Bluefish.

hydroacoustic and midwater trawl surveys to estimate herring and mackerel abundance, and alternative types of sampling surveys to estimate bluefish abundance. A modest effort to improve stock assessments using these methods has begun.

Underutilized Species

All of the pelagic species, except bluefish, are considered to be underutilized. Total recent average yields (158,500 t) could be quadrupled and still not reach the aggregate long-term potential yield for the Northeast pelagics (477,700 t, Table 2-1). The aggregate current potential yield (477,550 t) is nearly five times the total recent average yields. Although current estimates of stock sizes for the principal pelagic stocks are relatively imprecise (see above), the foregone yields for mackerel and herring are substantial, and domestic harvests could be increased without jeopardizing the productivity of these stocks.

Bycatch and Multispecies Interactions

Concentrations of schooling fish such as the Northeast pelagics are utilized by a wide variety of predatory fish, marine mammals, and birds. In winter months, the fisheries directed for Atlantic mackerel and herring historically have taken some marine mammals, including pilot whales and common dolphins, as bycatch. An intensification of these fisheries to take advantage of these underutilized resources might result in greater marine mammal takes. Choosing the correct time and place for fisheries could keep these takes at minimal levels.

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Atlantic Anadromous Fisheries

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Unit 3

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INTRODUCTION

The anadromous fishes of the Atlantic seaboard are a diverse group, including river herrings (alewife and blueback herring), American shad, hickory shad, striped bass, Atlantic salmon, sturgeons (Atlantic and shortnose), and rainbow smelt. Regulation of these stocks is likewise diverse: the Atlantic States Marine Fisheries Commission (ASMFC) has implemented fishery management plans for shad, river herring, and Atlantic sturgeon, while shortnose sturgeon are managed under a recovery plan prepared under the Endangered Species Act. Atlantic salmon are regulated by a New England Fishery Management Council fishery management plan and by the North Atlantic Salmon Conservation Organization (NASCO). Striped bass are regulated under an ASMFC fishery management plan and by special Congressional authority under the Striped Bass Conservation Act (implemented by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service).

Recent average landings of Atlantic anadromous species (Table 3-1; Figures 3-1 and 3-2) are about 9,400 metric tons (t), far below historic levels. Several species have recreational importance to the region (including American shad, striped bass, and Atlantic salmon). The recreational portion of the recent average landings is dominated by striped bass which averaged 6,300 t annually during 1995–97.

Landings of most Atlantic anadromous species have declined greatly in recent years. River herring catches peaked in 1965 at about 28,000 t coast-wide, but have since declined to less than

Striped bass

Table 3-1

Productivity in metric tons and status of Atlantic anadromous fisheries resources.

Species	Recent average yield (RAY)[1]	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Striped bass[2]	8,300	8,100	Unknown	Full	Above
American shad	600	Unknown	Unknown	Over	Below
Alewife/blueback	500	Unknown	Unknown	Over	Below
Sturgeons	7	Unknown	Unknown	Over	Below
Atlantic salmon	1	Unknown	Unknown	Over	Below
Total	9,408	9,208	9,208		

[1] 1995–97 average (including recreational landings)
[2] Includes significant recreational landings

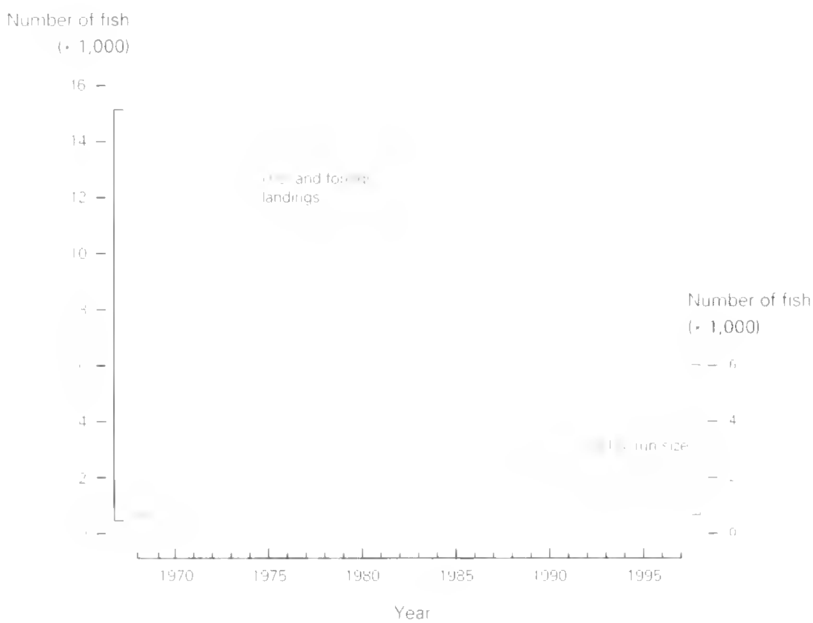

Figure 3-1

Size of spawning run of Atlantic salmon returning to Maine rivers, and total catch by U.S. anglers from Maine rivers and by at-sea foreign fisheries, 1968–97. The catch for 1980 was not reported. Catches since 1994 are not estimated because of fishery closures.

500 t annually. Likewise, commercial landings of American shad had a peak of over 2,500 t in 1970, but are now only averaging 600 t. Striped bass commercial landings were over 6,000 t in 1973, but decreased to less than 1,000 t by 1985. Following several years of sharply reduced landings of about 400 t due to severe management restrictions, commercial landings of striped bass increased to 2,200 t in 1997. Catches of U.S.-origin Atlantic salmon, taken primarily in foreign commercial fisheries, were in excess of 10,000 fish annually during the 1980's. Currently, domestic and foreign fisheries for U.S.-origin Atlantic salmon are closed by regulation or private quota purchase agreement.

SPECIES AND STATUS

Unlike most of the offshore resources in the Northeast region, Atlantic anadromous stocks have been greatly influenced by nonfishing human activities in the coastal zone. Damming of rivers preventing access to former spawning grounds was a major factor in the decline of Atlantic salmon, sturgeons, river herrings, and shad. Environmental contamination is implicated in the decline of several species. Today, these species are threatened by coastal pollution and development as well as reduced population sizes from which recovery is uncertain.

Atlantic Salmon

In the United States, Atlantic salmon were indigenous from the Housatonic River in Connecticut to tributaries of the St. John River in northern Maine. As a consequence of industrial and agricultural development, all native runs south of the Kennebec River in Maine were extirpated. The only primarily self-sustaining U.S. runs now occur in several small (<100 km) rivers in eastern Maine, and these populations are perilously small with total run sizes of less than 300 spawners annually. In addition, the Penobscot River in Maine has remained the largest U.S. population, but it is heavily supplemented by hatchery production from returning adults. Current rehabilitation of these stocks in Maine is being undertaken with an innovative river-specific fry stocking program. Wild parr or returning adults are collected and held until spawning time, and their progeny are scatter-stocked as fry in their natal rivers. In addi-

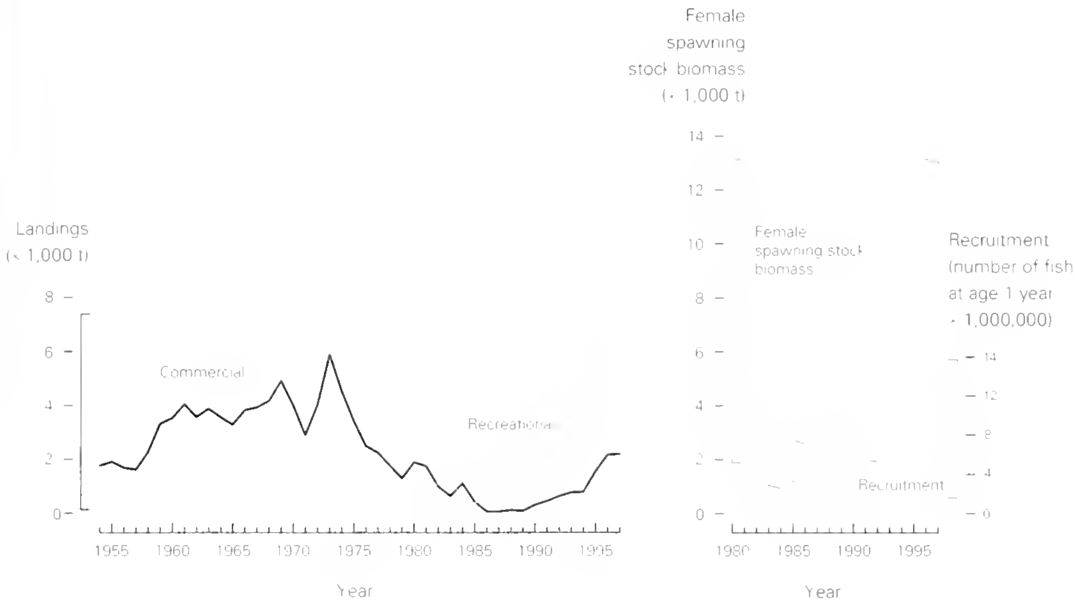

Figure 3-2

Commercial and recreational landings and female spawning stock biomass in metric tons (t), and recruitment of striped bass, 1954–97.

tion, restoration efforts, in the form of stocking and fish passage construction, are underway in the Connecticut, Pawcatuck, Merrimack, and Saco rivers. In these rivers, as well as in the Penobscot River, some Atlantic salmon are also stocked as smolts. The donor stocks for these programs are largely from the Penobscot River. NMFS is involved in assessing the viability of these populations, the success of supplementation, and the conservation of these unique genetic resources.

In U.S. rivers, juvenile salmon are resident in freshwater streams for 2 or 3 years before migrating to the sea where they typically remain for two winters. While at sea, they generally undergo extensive migrations to waters off Canada and Greenland before returning to their natal rivers in June and spawning in November.

The abundance of Atlantic salmon stocks in Maine rivers is represented by estimates of catch and run size (Figure 3-1). The abundance of extant U.S. stocks, like most stocks in North America, has declined during the past decade. Home-water fisheries (those in U.S. waters) are limited to catch and release angling in Maine. Tagging experiments conducted by the NMFS have demonstrated that distant-water commercial gillnet fisheries off Canada and Greenland had previously exploited U.S. stocks at approximately 50%. Those commercial oceanic fisheries are now regulated more stringently under the auspices of NASCO. Canadian interception fisheries have been greatly curtailed, and the Greenland fishery is quota controlled to allow for adequate spawning escapement. Despite these conservation measures, the overall abundance of Atlantic salmon throughout North America continues to decline, and several populations would be extirpated if supplementation of them did not continue.

Striped Bass

Four primary stocks of striped bass occur along the Atlantic coast: Hudson River, Delaware Bay, Chesapeake Bay, and Roanoke River (North Carolina). Striped bass stocks historically have supported important commercial and recreational fisheries, with recreational harvests often equaling or exceeding commercial landings (Figure 3-2). Commercial fisheries use a variety of gears including haul seines, trawls, pound nets, gillnets, and hook-and-line.

Commercial landings peaked in 1973 and then began a precipitous decline. The declining landings coupled with consistently poor recruitment indices in the Chesapeake Bay provided the impetus for highly restrictive management actions taken by ASMFC in the mid1980's. Additionally, Congress passed the Striped Bass Conservation Act which empowered the Departments of Commerce and Interior to impose a moratorium on striped

Striped bass from Chesapeake Bay.

bass fishing in any state which ASMFC found not in compliance with its fishery management plan.

The fisheries were monitored closely and under severe management restrictions. However, a high recruitment index in 1989 in the Chesapeake Bay triggered a slight relaxation of management restrictions and allowed increased fishing on migratory Atlantic striped bass stocks the following year. Recruitment has continued to improve, and the growth of the population has reached a level of abundance equivalent to the mid1970's (prior to the decline). Owing to the improved conditions, ASMFC has declared Atlantic striped bass fully restored, allowing a further relaxation of management restrictions in the commercial and recreational fisheries.

A recent assessment of the striped bass coastal complex (Northeast Fisheries Science Center, 1998a,b) indicates that the current level of fishing mortality is at the target level established in the fishery management plan. The large recreational fishery, which includes both landings and discard losses, accounted for the majority of the fishing mortality. The recent average yield is about 8,300 t (Table 3-1), 74% of which is attributed to recreational landings. The spawning stock biomass has continually increased since the reopening of the fishery in 1990 (Figure 3-2). Recruitment of historically large year classes in 1993 and 1996 (Figure 3-2) should result in a continued population increase under the current levels of fishing mortality.

ISSUES

Transboundary Stocks and Jurisdiction

The interception of U.S.-origin Atlantic salmon in commercial fisheries off Canada and West Greenland is an impediment to the restoration of runs and U.S. fisheries. However, beginning in 1992, the largest portion of the Canadian fishery, that around Newfoundland, was closed and remains severely restricted. Likewise, the Greenland fishery quota, set to meet spawning escapements to North American rivers, should provide adequate protection. If these conservation tools remain in place, the threat of those intercept fisheries to U.S. salmon is greatly reduced.

Endangered Species Concerns

Anadromous Atlantic salmon populations throughout their U.S. range were petitioned for listing under the Endangered Species Act. The National Marine Fisheries Service and the U.S. Fish and Wildlife Service, working in partnership, formed a biological review team to evaluate the status of these populations. This team determined that available biological evidence indicated that the population structure described in the petition did not meet the definition of species under the Endangered Species Act. The team also concluded that native population segments south of the Kennebec River were extirpated. However, the two Federal agencies proposed a rule to list a population complex in several Maine rivers containing remnant native populations as threatened. The proposed rule has been withdrawn in lieu of a conservation plan put forward by the State of Maine. The National Marine Fisheries Service now lists this population segment as a "species of concern" and is committed to improving the health of these stocks to make them viable populations with sus-

Atlantic salmon.

tainable fisheries through its partnership in support of the Maine conservation plan. Shortnose sturgeons are listed as endangered, and a status review of Atlantic sturgeon is currently underway.

Management Controls

An issue of particular concern for striped bass is the potential impact of discard mortality. Recreational fishing effort for striped bass currently far exceeds commercial effort, and over 90% of the recreational catch was released alive during the 1990's. Even with high survival rates of hooked and released striped bass, the large number of fish subjected to hooking mortality may compromise the conservation benefit from high minimum-size regulations. Another concern as the striped bass population increases is the greater likelihood of striped bass bycatch in nondirected commercial fisheries. There is a desire by all interests not to negate the progress made in rebuilding the severely depleted spawning stocks in Chesapeake Bay.

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Northeast Invertebrate Fisheries

National Undersea Research Program, NOAA

American lobster off Maine coast.

Unit 4

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INTRODUCTION

Offshore fisheries for crustaceans and mollusks are among the most valuable in the region. U.S. commercial landings of American lobster (32,100 metric tons (t)) and sea scallops (6,000 t) in 1997 ranked first and second in overall ex-vessel value with $223 million and $87 million, respectively. Additionally, landings of surfclams, ocean quahogs, squids, and northern shrimp contributed another $100 million in revenue. The combined value of these fisheries exceeds that for all Northeast offshore finfish fisheries combined.

Four separate fishery management plans regulate the harvest of these invertebrate species. Two of these are the Mid-Atlantic Fishery Management Council's Surfclam and Ocean Quahog Fishery Management Plan and the New England Fishery Management Council's Sea Scallop Fishery Management Plan. The northern shrimp and American lobster fisheries are regulated by the Atlantic States Marine Fisheries Commission under the Atlantic Coastal Fisheries Cooperative Management Act.

SPECIES AND STATUS

American Lobster

Comprehensive stock assessments of the American lobster resource, last completed in 1996 (Northeast Fisheries Science Center, 1996a,b), indicated that recent fishing mortality rates on the Gulf of Maine portion of the resource were nearly double the overfishing level. For the resource fished inshore from Cape Cod through Long Island Sound, fishing mortality was substantially greater and nearly three times higher than the overfishing level. Throughout the range, the fishery has become increasingly dependent on newly recruited animals (in some areas more than 90% of the lobsters landed are newly recruited to the fishery),

Table 4-1

Productivity in metric tons and status of Northeast invertebrate fisheries resources.

	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
American lobster	32,300	20,000	Unknown	Over	Above
Surfclams	27,700	19,800	22,000	Under	Near
Ocean quahogs	21,200	18,100	25,000	Full	Near
Longfin squid	15,600	21,000	26,000	Full	Near
Shortfin squid	14,900	19,000	24,000	Full	Near
Sea scallops[d]	10,200	3,700	13,300	Over	Below
Northern shrimp	7,600	5,000	5,000	Unknown[e]	Unknown
Red crab	1,000	2,700	2,700	Unknown	Unknown
Total	130,500	109,300	138,000		
U.S. subtotal	127,200	108,100	133,900		

[a] 1995–97 average (including foreign landings).
Data for bivalve species are in shucked meat weights.
RAY includes landings from both inshore (state) and offshore (U.S. EEZ) areas.
[c] CPY and LTPY refers only to EEZ.
[d] For sea scallops, U.S. portion of RAY is 7,100 t (70% of total).
[e] High fishing mortality. No overfishing definition currently in place.

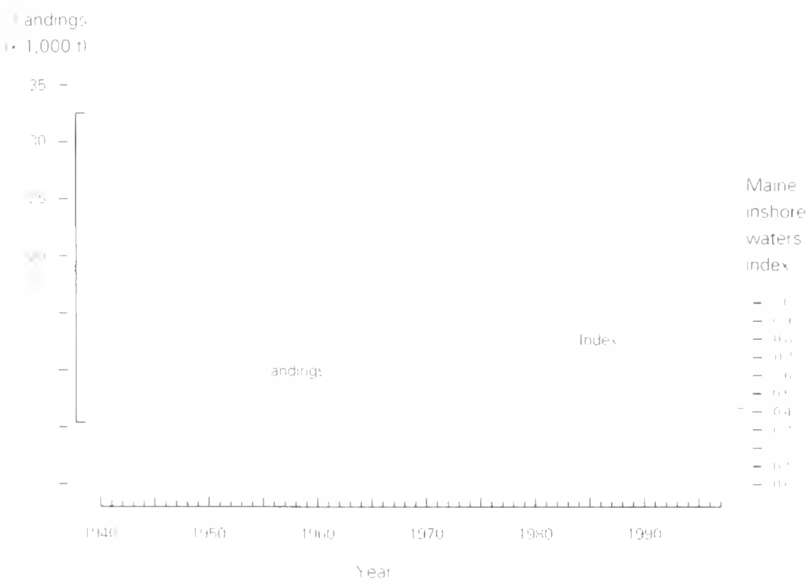


Figure 4-1

Landings of American lobster in the northeastern United States, 1940–97, in metric tons (t). The index shows the average number of legal-sized lobsters caught per trap averaged over a 24-hour period in Maine inshore waters.

with a great majority of all lobsters landed not yet sexually mature. Fishing mortality rates for both inshore and offshore populations greatly exceed the rates that would provide maximum yields. Recent average landings of lobsters have been 32,300 t (Table 4-1), with landings in 1997 also at that level (Figure 4-1).

Sea Scallop

Sea scallops are harvested on the continental shelf from the Virginia Capes to the "Hague Line," which separates the U.S. and Canadian portions of Georges Bank, and in the Gulf of Maine. Canadian landings on Georges Bank represent a significant part of the total (Figure 4-2), i.e. 30% (3,100 t) of the recent average yield (Table 4-1). Sea scallops are harvested primarily using epibenthic dredges in the Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight. A small but rapidly growing proportion of the landings is taken with otter trawls in the Mid-Atlantic Bight.

Management of the sea scallop fishery by the New England Fishery Management Council changed markedly in 1994 as maximum meat count regulations (numbers of scallop meats per pound) were eliminated. In their place, controls on the number of days at sea, reduced crew size, and increased dredge mesh-ring sizes were instituted. Also, the harvesting of sea scallops within three areas in the Georges Bank and Nantucket Shoals region, closed to protect depressed groundfish stocks, has been prohibited since December 1994.

A comprehensive assessment completed in the fall of 1996 (Northeast Fisheries Science Center, 1997a,b) indicated that sea scallops were overfished both on Georges Bank and in the Mid-Atlantic Bight and were at a low overall level of abundance. Reductions in days at sea and crew size and an increase in mesh-ring size have shown limited effectiveness in preventing the resources from being overfished. In contrast, the sea scallop biomass within the closed groundfish areas tripled during the first 20 months of closure. Sea scallop populations are characterized by wide variability in year-class strength and little relationship among dominant cohorts between the Mid-Atlantic Bight and Georges Bank. Several strong year classes resulted in record high U.S. landings in 1990–91 of about 17,000 t (Figure 4-2), but landings dropped abruptly in 1993 to only 7,400 t, remaining at about that level during 1994–96. Sea scallop landings declined further to about 6,000 t in 1997, reflecting much poorer recruitment in recent years. Fisheries in all areas depend almost entirely on the growth of new recruits into the exploitable size range. In the Mid-Atlantic Bight, current landings are dependent on poor 1996 and 1997 year classes. Additional areas in the Mid-Atlantic Bight were closed in April 1998 under the authority of the Secretary of Commerce. Given the rapid growth, low natural mortality rates, and early age at entry into the fishery by this species, considerable yield is currently being foregone because of growth overfishing.

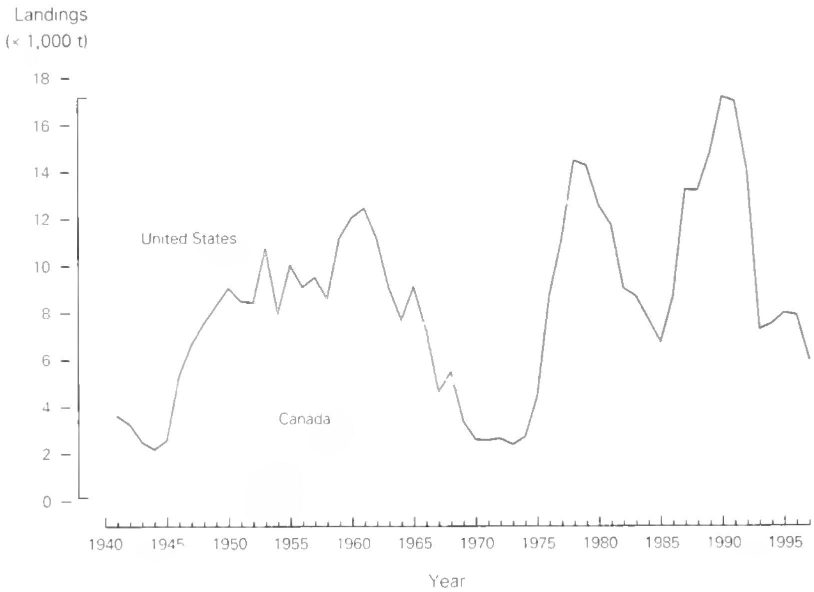


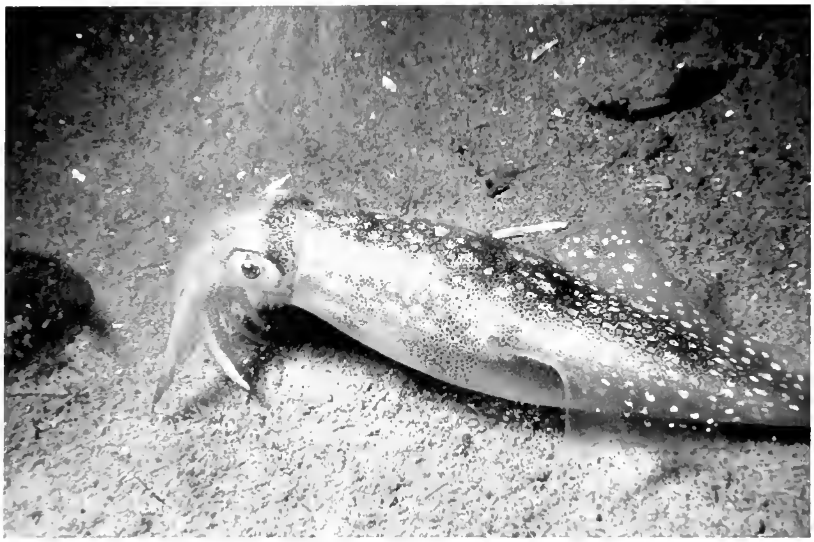
Figure 4-2
Atlantic sea scallop landings by the United States and Canada, 1940–97.

Atlantic Surfclams and Ocean Quahogs

These shellfish are harvested with hydraulic dredges in the U.S. Exclusive Economic Zone (EEZ). The majority of surfclams are taken off New Jersey, while the majority of landings of ocean quahogs now come from Southern New England and Long Island waters. Small quantities of ocean quahogs are also taken off the coast of Maine and sold at a higher price to the raw seafood restaurant trade (halfshell market). Fisheries for both of these species have been closed on Georges Bank since late 1989 due to the risk of paralytic shellfish poisoning. They are managed under the Surfclam and Ocean Quahog Fishery Management Plan of the Mid-Atlantic Fisheries Management Council. The primary management tool is a system of individual transferable quotas allocated on the basis of historical participation in the fisheries.

Surfclam landings increased steadily during the 1960's and early 1970's, peaking in 1974. Subsequently, a succession of poor year classes, combined with a large die-off of the surfclam resource off the New Jersey coast in 1976, led to a very low stock biomass and reduced landings. Since 1977, a fishery management plan has regulated total annual surfclam landings from the 200-mile Federal zone (where most landings are derived) and has addressed the earlier significant overcapitalization in the fishery. Large year classes spawned in 1976 and 1977 off New Jersey and the Delmarva Peninsula supported the fishery throughout the 1980's. Evidence from the most recent assessment (Northeast Fisheries Science Center, 1998a,b) suggests consistent but modest levels of recruitment. New incoming year classes have supported the fishery in the 1990's. Based on surfclam biomass production off New Jersey, where most harvesting takes place, there are adequate resources to support the fishery at the current harvest level in the near future. Recent annual landings from state and Federal waters averaged 27,700 t (Table 4-1).

Ocean quahog landings increased rapidly as the surfclam resource declined in the mid 1970's, and a market substitute for processed clam products developed. Ocean quahogs inhabit relatively deep waters of the Mid-Atlantic continental shelf and Georges Bank. In the Gulf of Maine, they are found relatively near the shore in these cooler waters. Ocean quahogs are one of the longest living (>100 years) and slowest growing marine bivalves in the world. Current annual landings (recent av-



Atlantic longfin squid.

erage yield is 21,200 t, Table 4-1) can be sustained for the next 54–76 years in existing fishable areas (Northeast Fisheries Science Center, 1998c,d). Over the past two decades, ocean quahog fisheries have moved progressively northward from the Mid-Atlantic Bight to Southern New England. Large resources still exist off Southern New England and on Georges Bank, but portions of these areas cannot be easily fished with existing technology due to depth or bottom type.

Northern Shrimp

Gulf of Maine northern shrimp are at the southern extent of their geographical range, and abundance is generally associated with low water temperatures. Northern shrimp are harvested using small-mesh trawls and inshore traps. The fishery began as an inshore winter fishery, but expanded during the 1960's to a year-round offshore fishery until the stock collapsed in the 1970's, following peak landings of 12,800 t in 1969, which prompted a closure of the fishery. A restricted seasonal fishery resumed in the 1980's. Landings have increased substantially since 1994, peaked at 9,500 t in 1996, declined to 6,400 t in 1997, and averaged 7,600 t during 1995–97 (Table 4-1). In response to concerns that the stock cannot sustain recent increases in fishing effort, which were associated with restrictions on the groundfish trawl fishery, a new analytical assessment was completed in 1997 (Northeast Fisheries Science Center, 1997c,d) which indicated that the stock is currently at a low level of biomass and the fishing mortality rate exceeds sustainable levels.

Longfin Inshore Squid

Longfin inshore squid form commercially significant aggregations that sustain otter trawl and trap fisheries from Georges Bank to Cape Hatteras, N.C. Recent research shows that longfin squid generally live for less than 1 year, grow rapidly, and spawn year-round. The original fishery began in the 1800's as a bait fishery, and a valuable market for human consumption developed in the 1960's. Annual landings fluctuate widely because squid generations have little overlap from year to year, and seasonal dynamics are sensitive to environmental factors. Fishing patterns reflect the seasonal distribution of the stock—offshore from October to March, then inshore from April to September. In recent years, most landings were taken in the offshore fishery. The most recent stock assessment of longfin squid (Northeast Fisheries Science Center, 1996c,d) indicated that the stock was fully exploited and at an above-average biomass level. Recent average landings were 15,600 t (Table 4-1), with 16,200 t landed in 1997 which generated $26 million in ex-vessel revenue.

Northern Shortfin Squid

Northern shortfin squid are fished commercially from Cape Hatteras, N.C., to Newfoundland, Can., and are considered a single stock throughout that range. This species exhibits rapid growth, has a lifespan of about 1 year, and undergoes long-distance migrations. Both its distribution and annual abundance are strongly influenced by oceanographic factors. The domestic fishery generally occurs during summer and autumn in offshore waters south of New Jersey and is conducted by otter trawl vessels, the larger of which freeze the whole squid at sea, while the smaller vessels deliver fresh squid. A robust distant-water fishery existed during the 1970's and 1980's, with the bulk of the landings occurring off Canada. Peak international landings of nearly 180,000 t were taken in 1979, 90% of which were from Canadian waters. This fishery subsequently collapsed in the early 1980's, and annual landings during 1983–96 averaged only about 3,300 t, but demonstrated a significant increase to 15,400 t in 1997. U.S. landings increased steadily from 1988 to a record high of 18,350 t in 1994, but they have dropped somewhat to a recent average yield of 14,900 t (Table 4-1). This decline has been due primarily to a weak export market. The stock was classified as fully utilized and at a medium level of biomass when it was last assessed (Northeast Fisheries Science Center, 1996c,d).

ISSUES AND PROGRESS

Individual Transferable Quota

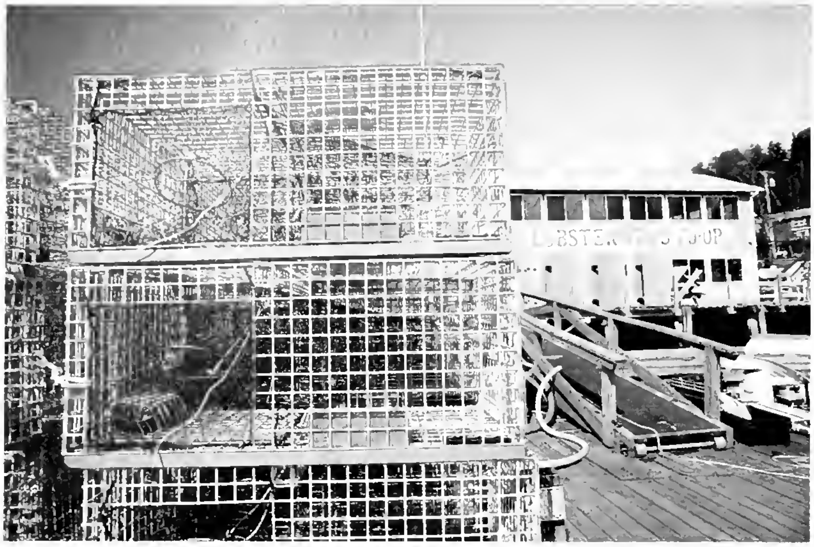
An individual transferable quota system for the surfclam and ocean quahog fisheries was implemented in 1990 (Amendment 8 to the fishery management plan). This system eliminated the need for complex restrictions on the amount of effort and time each vessel could fish, which had been characteristic of the management system under the Mid-Atlantic Fishery Management Council since 1977. As a consequence of the individual transferable quota, the number of vessels in the surfclam fleet has decreased substantially, with a reduction from about 160 to fewer than 100 vessels in the first year alone. Further consolidation of fishing effort, as well as construction of new and more efficient vessels to reduce overhead, is expected in the future. Fewer than 60 vessels are now used to fish for both surfclams and ocean quahogs.

Scientific Advice and Adequacy of Assessments

Considerable progress has been made in the past several years in assessing the status of many of the exploited invertebrate stocks of the Northeast region. In 1996, an independent panel of internationally recognized scientists, convened by the Atlantic States Marine Fisheries Commission and the National Marine Fisheries Service (NMFS), reviewed and endorsed the scientific basis for the existing overfishing definition for lobsters and the validity of current assessment methods. This panel offered a number of recommendations for improvements (Atlantic States Marine Fisheries Commission, 1996). A major benchmark assessment of American lobsters followed later in 1996 (Northeast Fisheries Science Center, 1996a) and employed length-based cohort analysis, life-history-stage-based population estimation models, and an improved egg-production-per-recruit model as the basis for management advice. In 1997, a major breakthrough was made in the ability to provide reliable swept-area estimates of surfclam and ocean quahog populations from research vessel dredge surveys as a result of successful NMFS-academia-industry field experiments to estimate efficiency of the research dredge and improved capability to monitor dredge performance (Northeast Fisheries Science Center, 1998a). Also in 1997, a first-time analytical assessment of Gulf of Maine northern shrimp was conducted integrating catch and survey abundance indices into estimates of stock size and fishing mortality rates (Northeast Fisheries Science Center, 1997c).

Management Controls

Fishing mortality on sea scallops is well above the level defined as constituting overfishing. In 1994, the New England Fishery Management Council implemented Amendment 4 to the fishery management plan which was aimed at reducing fishing mortality on sea scallops. Measures included provisions to reduce fishing effort through days-at-sea reductions and a moratorium on new vessel entrants, while removing the meat count requirement. Meat count regulations did not control the overall rate of fishing mortality, but redirected mortality onto older scallops. To reduce fishing mortality rates on smaller scallops, the minimum ring diameter in the chain bag at the end of the scallop dredges was increased to 3-1/2 inches (87.5 mm). This was intended to compensate for the removal of the meat count requirement by reducing fishing mortality on small scallops. Given the current overfished status of the sea scallop resource, the New England Fishery Management Council is currently considering additional management measures for reducing fishing mortality, protecting undersized scallops in the Mid-Atlantic region by means of closed areas, and possibly allowing limited scalloping in the three ground-


William B. Folsom NMFS

Lobster traps, Boothbay, Maine.

fish closure areas in the Georges Bank-Nantucket Shoals region.

To comply with the overfishing definition, the fishing mortality rate of the lobster fishery needs to be reduced significantly. Recent increases in landings stem from increased effort and apparent increases in abundance most likely due to favorable environmental conditions for the survival of pre-recruits. The lobster fishery is almost exclusively supported by animals recently molted, most of which are not sexually mature. At present, American lobster populations are regulated primarily by a minimum carapace length set at 3-1/4 inches (81.3 mm). Amendment 3 to the American Lobster Fishery Management Plan, approved in December 1997, incorporates effort reduction and area management and contains regulations on minimum and maximum landing sizes, prohibition of berried and v-notched[1] female lobsters, limits on gauge size, trap sizes and numbers, limits on nontrap fishermen landings, and requirements for biodegradable mesh panels and escape vents in traps. U.S. management effort continues to be complicated by the international trade in live lobsters from Canada.

The Atlantic States Marine Fisheries Commission regulates the northern shrimp fishery in the Gulf of Maine. Regulations control the duration of the harvesting season (December to May) and gear specifications. However, the fishery has open access, and an overfishing threshold is not defined by the current fishery management plan despite concerns that the stock is overfished.

The Mid-Atlantic Fishery Management Council develops management measures for squids under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. Management targets for both species of squid were recently reevaluated according to new research results on life history parameters. Research continues to improve our understanding of squid growth, maturity, and reproductive dynamics to better assess appropriate levels of sustainable fishing. The United States, which joined the Northwest Atlantic Fisheries Organization at the end of 1995, is actively promoting efforts to implement more realistic management goals for this species. Real-time management of both squid species is desirable to avoid recruitment overfishing during periods of poor recruitment and to maximize landings during periods of good recruitment.

Surfclams and ocean quahogs have been managed since 1977 and by individual transferable quotas since 1990 (Amendment 8 to the fishery management plan). In 1996, Amendment 9 changed overfishing definitions for both species from a maximum sustainable yield basis to a maximum spawning potential basis. Amendment 10, currently under consideration, will specify management regulations for an ocean quahog fishery off the coast of Maine.

Bycatch and Multispecies Interactions

Bycatch and associated discard of groundfish in the Gulf of Maine trawl fishery for northern shrimp, which had earlier been considerable, has been reduced following the adoption of a fish-excluding device, the "Nordmore Grate," as a condition of participation in this fishery. Sea sampling efforts continue to monitor this fishery. Bycatch of goosefish and flounder in the sea scallop fishery continues to be a concern as a source of fishing mortality on these stocks as a whole, and particularly on very small fish. Scalloping, either by dredges or otter trawls, is prohibited in several large

[1]V-notching is a mark inscribed on the carapaces of berried females so that they will be recognized as female and released, even when not carrying eggs.

areas of Southern New England and Georges Bank which have been closed since December 1994 to assist in rebuilding depleted stocks of cod, haddock, and yellowtail flounder.

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Atlantic Highly Migratory Pelagic Fisheries

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Bluefin tuna.

Unit 5

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INTRODUCTION

Oceanic pelagic fish are highly migratory species that include swordfish, bluefin tuna, yellowfin tuna, bigeye tuna, albacore, skipjack tuna, blue and white marlin, sailfish, longbill spearfish, and others. In the Atlantic Ocean, swordfish and bluefin tuna have long provided important fisheries, while in recent years yellowfin tuna and bigeye tuna have increased in significance to U.S. fishermen. Many recreational anglers target yellowfin and bluefin tuna, blue marlin, white marlin, and sailfish in U.S. waters and occasionally longbill spearfish. All commercial retention of the latter four billfish species is now banned in U.S. waters; however, they are still incidentally caught in tuna and swordfish longline fisheries.

Because these large pelagic fish migrate widely and are harvested over broad ocean areas by U.S. and foreign fishermen, both national and international management measures are necessary. In all cases, stock assessments are conducted using aggregate data and provide the basis for regulations. U.S. fleets operate in the western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. These fleets are regulated under the Magnuson-Stevens Fishery Conservation and Management Act and the Atlantic Tunas Convention Act, which provides authority to implement international agreements reached by the International Commission for the Conservation of Atlantic Tunas (ICCAT). A draft Fishery Management Plan (FMP) for Atlantic tunas, sharks, and swordfish, and Amendment One to the Atlantic Billfish FMP (which addresses blue marlin, white marlin, sailfish, and spearfish) were proposed in 1998 and are slated to be finalized in 1999. Management of Atlantic tunas and swordfish has been based largely on rec-

Table 5-1

Productivity in metric tons and status of highly migratory pelagic fisheries in U.S waters of the Atlantic Ocean

Species and area	Recent average yield (RAY)[1,2]	Current potential yield (CPY)[3]	Long-term potential yield (LTPY)[3]	Fishery utilization level	Stock level relative to LTPY
Yellowfin tuna (Atlantic)	137,500	~137,500	147,500–155,800	Full	Near
Bigeye tuna (Atlantic)	100,700	60,000–80,000	70,000–90,000	Over	Below
Albacore (N. Atlantic)	31,900	Unknown	32,000	Over	Below
Skipjack tuna (W. Atlantic)	27,100	Unknown	Unknown	Possibly full	Near
Bluefin tuna (W. Atlantic)	2,300	2,000–2,500	2,800–7,700	Over	Below
Other tunas (Atlantic)	31,900	Unknown	Unknown	Unknown	Unknown
Swordfish (N. Atlantic)	14,800	11,400	13,000	Over	Below
Blue marlin (Atlantic)	4,100	1,920	4,500	Over	Below
White marlin (Atlantic)	1,600	900	2,200	Over	Below
Sailfish (W. Atlantic)	900	600	700	Over	Below
Total	352,800	315,470	348,300		
U.S. subtotal	18,300	16,400	18,100		

[1]Total LTPY, CPY, and RAY under present fishing patterns by U.S. and foreign nationals
[2]1995–97 average from ICCAT (1998a) (1994–96 average used for billfishes)
[3]ICCAT (In press (a))
[4]Individual LTPY's, CPY's and RAY's based on entire stock regardless of harvesting nation

ommendations by ICCAT and implemented via regulatory articles under the Atlantic Tunas Convention. ICCAT has set and allocated western bluefin tuna quotas by country since 1982 and eastern bluefin quotas since 1994. ICCAT first established catch limitations for north Atlantic swordfish in 1991 and south Atlantic swordfish in 1994; country-specific quotas have since been adopted for both stocks.

SPECIES AND STATUS

From the early 1960's through 1977, U.S. fishermen caught an average of about 5,000 metric tons (t) per year (2,000–12,000 t/year) of the highly migratory pelagic species (Figure 5-1). During the late 1970's and early 1980's, U.S. fishermen caught 8,000 t or more per year, and since 1985 they have caught 15,000–20,000 t/year. The U.S. share of current potential yield for the highly migratory pelagic resource is 16,400 t/year, and long-term potential yield to the U.S. fleet is estimated at 18,100 t/year (Table 5-1) (ICCAT, 1998a).

Since 1960, the top species by volume in the U.S. harvest has changed from bluefin tuna to swordfish to yellowfin tuna (Figure 5-1) as each species declined due to fishing pressure and U.S. fishing effort shifted. During 1961–73, bluefin tuna represented 45–80% of the U.S. western Atlantic catch of large pelagics. But since 1980, the percentage has dropped to less than 15%, reflecting the decline in the bluefin tuna population, catch restrictions, and the increasing harvests of alternative species. During 1961–73, swordfish represented 5–20% of the U.S. catch, rose to 65% in 1982, but has since dropped to about 25%. During 1961–83, the percentage of yellowfin tuna in the U.S. north Atlantic catch was usually less than 10%, but that has since risen to 35–45%.

Catch of yellowfin tuna, Manteo, North Carolina

The U.S. dockside ex-vessel revenue from these fishes soared from about $20 million (early 1980's) to nearly $100 million in 1988. The average annual commercial ex-vessel value has continued at about this level since.

Angler harvests of large pelagic fishes are estimated from dockside and telephone surveys. The average annual catch by recreational anglers for 1995–97 is estimated conservatively at 7,500 t. Fishing tournament surveys indicate a substantial increase in billfish fishing since 1972. Although the practice of tagging and releasing of large pelagics has grown in recent years, more data are needed to quantify the recreational fishery trends for these fishes in U.S. Atlantic and Gulf of Mexico waters.

The value of the recreational fisheries for highly migratory species has not been estimated for all species; however, preliminary estimates indicate that they are highly valued.

NMFS has classified the following Atlantic highly migratory species (HMS) as overfished: west Atlantic bluefin tuna, north Atlantic swordfish, bigeye tuna, blue marlin, white marlin, and sailfish. Other oceanic pelagics in the HMS FMP are considered fully fished. The HMS FMP and Billfish Amendment include rebuilding plans for the overfished species as well as measures designed to maintain healthy stocks at the optimum yield. Catch of blue and white marlin by domestic and foreign fleets has resulted in overharvesting these stocks. Fishing mortality rates on swordfish have been excessive in recent years, prompting the development of international agreements to substantially reduce catches beginning in 1991. U.S. harvests since July 1991 are consistent with ICCAT's recommendations designed to reduce the risk of further declines. While yellowfin and bigeye tunas are fully and over utilized respectively, no catch quotas are in place for either of these species. Western Atlantic bluefin tuna have been overharvested to the point of being severely depleted, and as a result the harvest of this species has been restricted since 1982. The most recent assessment indicates that current quotas may result in a gradual rebuilding of the spawning stock in the future.

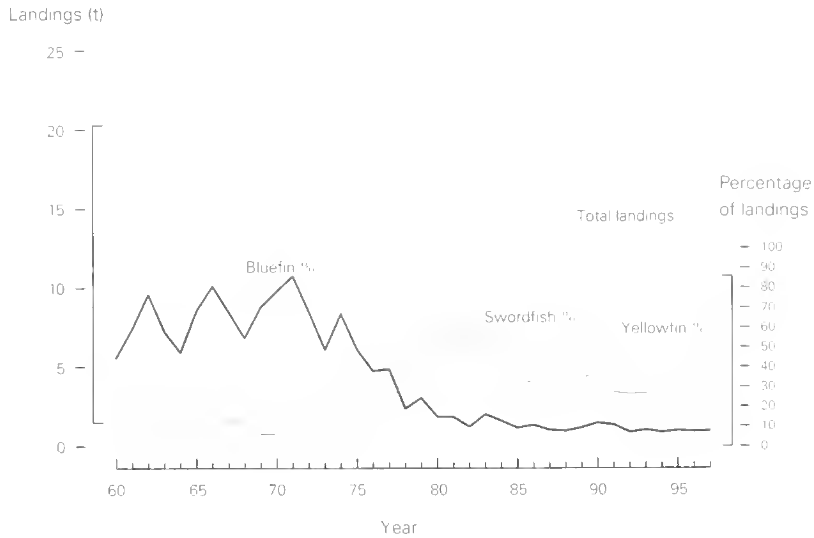

Figure 5-1
Landings in metric tons (t) and percentage of landings of bluefin tuna, yellowfin tuna, and swordfish in U.S. waters of the Atlantic Ocean, 1961–96.

ISSUES

Transboundary Stocks

Regulation of species that migrate across international boundaries is difficult. Domestic regulation without international agreements inherently is limited, but international agreements can be difficult to achieve. The latter is particularly true if the primary fishing nations cannot agree on fishing and conservation objectives, or do not abide by agreements once they are adopted. An additional problem is that not all fishing nations are members of ICCAT. The recent United Nations agreement on straddling fish stocks and highly migratory fish stocks may help to resolve these problems.

Bycatch and Multispecies Interactions

Marlin and sailfish bycatch in tuna and swordfish fisheries are a major concern, especially as commercial fisheries encounter concentrations of billfish important to recreational anglers. Expansion of the U.S. longline fishery for Gulf of Mexico yellowfin tuna and Spanish longline fishing in the tropical eastern Atlantic have heightened concern for distressed stock of Atlantic tunas, swordfish, and the billfish sought by recreational anglers.

Albacore tuna, Hudson Canyon, off New Jersey-New York coast.

Allen Shimada, NMFS

Domestic Management

Although the number of permits for large pelagics increased substantially during the 1990s, actual levels of effort in the longline fishery have declined in recent years. NMFS has proposed a limited access system for the swordfish, shark, and tuna longline fisheries as part of the draft HMS FMP in order to reduce latent effort and prevent future expansion of these fleets.

Progress

In recent years scientists from the United States and several other nations have made substantial progress towards improving our understanding of the biological basis for managing Atlantic highly migratory fisheries. Analyses of the genetic structure of Atlantic and Mediterranean swordfish have been completed and have corroborated some of the stock structure assumptions made by ICCAT. Genetic studies of other large pelagic species, and bluefin tuna in particular, are underway. Additional studies of bluefin tuna stock structure using various tagging methods and biological markers are in various stages of implementation. Several years of research on the growth and reproductive biology of male and female swordfish is being used to increase the understanding of the effect of fishing on the north Atlantic and Mediterranean management units. At recent ICCAT meetings (1996–98), several recommendations and resolutions have been adopted that, if fully implemented, will result in substantial progress in conserving stocks and achieving the following management objectives: 1) adoption of recovery plans and rebuilding strategies for bluefin tuna and swordfish, 2) establishment of country-specific quotas for swordfish and eastern bluefin tuna, 3) reduction of blue and white marlin catches, and 4) adoption of measures facilitating the monitoring of catch by both member and nonmember countries, and the use of trade measures for nonmember nations that fish in a manner that diminishes the effectiveness of management measures (ICCAT, 1997, 1998b, and In press (b)).

At the domestic level, discussions on procedures to establish limited access for some large pelagics are currently well underway.

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Atlantic Shark Fisheries

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School of hammerhead sharks.

Unit 6

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INTRODUCTION

Sharks have been managed under a Federal fisheries management plan (FMP) developed by the National Marine Fisheries Service for the Secretary of Commerce since 1993 (NMFS, 1993, 1996). Since then, management activities for shark species have escalated and currently include annual shark evaluation workshops and meetings of the Highly Migratory Species Advisory Panel. A draft Fishery Management Plan for tunas, sharks, and swordfish was proposed in 1998, and will be finalized in 1999 (NMFS, 1998). This new framework will replace the 1993 shark FMP.

Species and Status

Currently, Atlantic shark fisheries are divided into three management groups: 1) Large coastal sharks, which include tiger, lemon, smooth hammerhead, scalloped hammerhead, great hammerhead, blacktip, sandbar, dusky, spinner, silky, bull, bignose, Caribbean reef, Galapagos, night, narrowtooth, and nurse; 2) small coastal sharks, which include Atlantic and Caribbean sharpnose, finetooth, blacknose, bonnethead, smalltail and Atlantic angel; and 3) pelagic sharks, which include longfin and shortfin mako, blue, porbeagle, thresher, bigeye thresher, oceanic whitetip, sevengill, sixgill, and bigeye sixgill.

Of these three management groups, species in the large coastal group are overutilized and, consequently, they are the subject of more intense management attention than the other two groups. In 1997, possession of five additional species of large pelagic sharks was prohibited (i.e. whale, basking, sand tiger, bigeye sand tiger, and white sharks). Species in the pelagic and small coastal groups are considered to be fully utilized. Rough indications of the status of these three management groups are presented in Table 6-1.

Determining the quantity of sharks that are

Table 6-1

Productivity in metric tons and status of Atlantic shark fisheries

Species and area	Recent average yield (RAY)[1]	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Large coastal sharks[2]	5,216	4,253	n/a[3]	Over	Below
Small coastal sharks[4]	685	n/a	n/a	Full	Above
Pelagic sharks[5]	1,492	Unknown	Unknown	Unknown	Unknown
Totals	7,393	6,430	6,430		

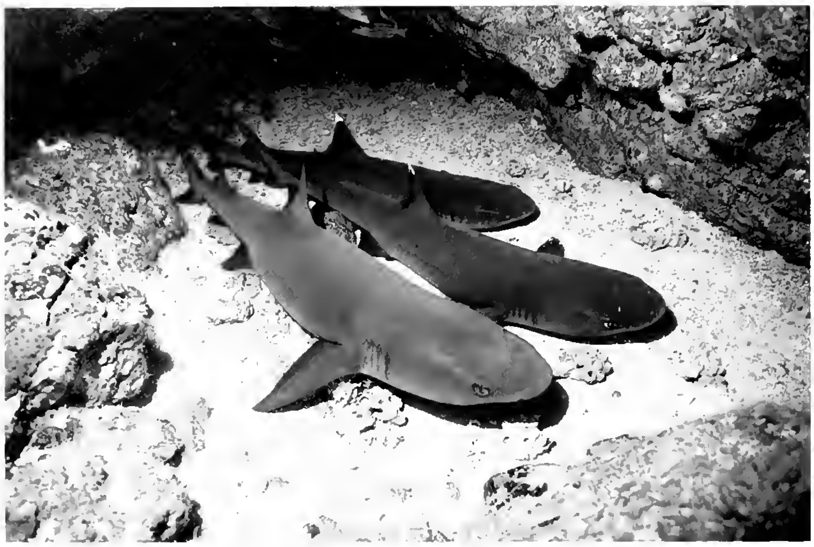
[1]1994–96 average

[2]Includes sandbar, Caribbean reef, blacktip, dusky, spinner, silky, bull, bignose, Galapagos, night, tiger, lemon, nurse, narrowtooth, scalloped, smooth and great hammerhead sharks

[3]The LTPY for large coastal shark species by number of individuals is 143–149

[4]Includes Atlantic and Caribbean sharpnose, finetooth, blacknose, bonnethead, smalltail, and Atlantic angel sharks

[5]Includes longfin and shortfin mako, blue, porbeagle, thresher, bigeye thresher, oceanic whitetip, sevengill, sixgill, and bigeye six-gill sharks



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Whitetip reef sharks.

landed in weight measurements is difficult for two reasons. First, weight estimates for recreational catches are highly variable because a relatively small number of animals are measured and weighed by the biologists that collect recreational statistics. Second, a significant amount of the commercial catch is only reported under the general category of "sharks," and the species identification either cannot be or is not reported. As a result, these landings are assigned to one of the management groups analytically for statistical purposes.

Thus, another set of estimated mean weights per fish for recreational catches or another set of assumptions regarding the allocation of the unidentified commercial shark landings is likely to produce different total weights for the recent average yield (RAY). To help minimize some of the effects of these two factors, the landings and catch statistics used in the stock assessments are compiled in numbers of animals instead of weight measurements. Thus, the estimates of long-term potential yield (LTPY) in Table 6.1 are presented as ranges in numbers of fish.

The numbers that were reported landed or discarded for sharks in the large coastal management group for 1988 through 1997 are presented in Figure 6-1. Although fishery statistics for sharks were collected prior to 1988, these earlier statistics are not considered as suitable for assessment and management purposes. The decreasing trend in these data is apparent beginning in 1992; however, estimates of the numbers of sharks that are discarded by commercial fishing were not available prior to 1993. Also, the data for 1997 are preliminary and likely to change as the final reviews are completed on these data.

The 1996 Shark Evaluation Workshop report (SEFSC, 1996) concluded that catch rates of many of the species and species groups declined by about 50–75% from the early 1970's to the mid 1980's. However, the rapid rate of decline in the catch rates that characterized the stocks in the early 1980's had slowed significantly in the 1990's. Partly based on results from the 1996 workshop (SEFSC, 1996), a 50% reduction in catches of large coastal species (i.e. relative to 1995) was targeted. This reduction was to be achieved by a 50% reduction in the commercial quota for the large coastal management group and a reduction of the recreational bag limit to two fish (the previously established recreational bag limit was four fish per boat per day). During the 1998 Shark Evaluation Workshop (SEFSC, 1998), preliminary data for 1997 were presented and reviewed, and the indications are that commercial catches, in numbers of animals, were reduced from 1995 by more than 50%, but recreational catches were reduced by only 12%.

Two important points were recognized at the 1998 workshop (SEFSC, 1998). First, to continue to improve shark stock assessments, it is critical to 1) continue to improve species- and size-specific catch (landed and discarded animals) and effort data and 2) improve fishery-independent measures of shark abundance and productivity. Second, it was recognized that every effort should be made to manage shark species separately. New analyses indicate that individual species are responding differently to exploitation. Thus, management of large coastal aggregates can result in excessive regulation on some species and excessive risk of overfishing on others. The draft highly migratory species FMP (NMFS, 1998) includes a number of proposed measures for sharks, including the following: the addition of fifteen Atlantic sharks to the prohibited species list, the separation of the large coastal shark management group into ridgeback[1] and non-ridgeback species, a minimum size for ridgeback sharks, a quota reduction for non-ridgeback sharks, a quota reduction for small coastal sharks, and catch-and-release only for small coastal sharks and large coastal sharks. The final FMP is slated to be published in 1999.

ISSUES

Scientific Information and Adequacy of Assessments

The lack of extensive time series and species-specific landings and effort data continues to be a problem for stock assessments. Without reliable species-defined data and stock assessments, management measures will necessarily continue to be based on species aggregates (e.g. 22 species of large coastal sharks), and they may be more broad-brushed and restrictive than otherwise might be possible.

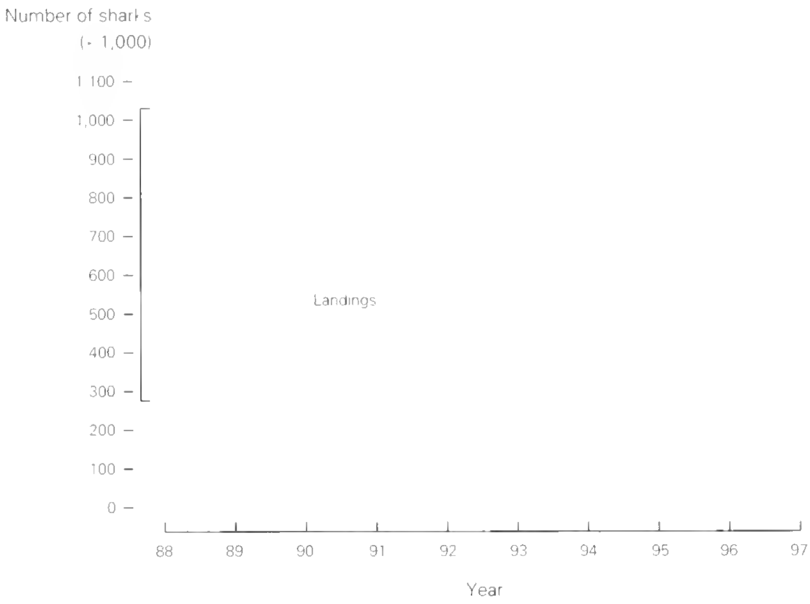

Figure 6-1
Landings of large coastal sharks, 1988–97.

Management Concerns

Recreational and commercial fishermen have both voiced concern about declining shark populations. As shark stocks declined before the 1993 FMP was implemented, derby-style fishing conditions developed in the commercial fisheries ("the race for fish"), and recreational fisheries experienced reduced fishing opportunities. Such conditions often result in fishermen fishing further inshore than they might otherwise in order to minimize transit time from fishing grounds to off-loading sites. Fishing in inshore areas where immature sharks predominate can have several negative ecological ramifications, including higher fishing effort and higher catches of immature fish with associated higher effective fishing mortality rates, because more small fish than large fish must be caught to reach the same weight-based quota. Additionally, concerns about high fishing mortality of juvenile sharks in recreational fisheries were raised at the 1998 Shark Evaluation Workshop.

[1] A number of species in the large coastal shark management unit are characterized by a mid-dorsal ridge that is easily identified even after the fish has been gutted and finned. This mid-dorsal ridge is useful as diagnostic characteristic for management and enforcement purposes. Ridgeback sharks include sandbar, dusky, silky, night, and bignose sharks. Non-ridgeback sharks include blacktip, spinner, bull, tiger, nurse, lemon, narrowtooth, and hammerhead sharks.

Dressing shark catch near Folly Beach, South Carolina

In both commercial and recreational fisheries, species identification problems continue and may only be remedied through extensive public outreach and educational programs.

Progress

Considerable progress has been made since the original 1993 Atlantic shark FMP. Since that time (when 98% of commercial landings was reported as "sharks"), mandatory commercial permitting and reporting has increased the level of fishery-dependent species-specific information such that less than 17% of landings are now reported as "sharks." The National Marine Fisheries Service has also funded an observer program since 1994 in the directed shark fishery that has provided extensive information on species and size composition of catches, disposition of catches, fishing effort and distribution, and bycatch in these fisheries. Additionally, several fishery-independent nursery area and tagging studies in the Atlantic and Gulf of Mexico have been expanded and incorporated into stock assessments. Population modeling on several species has also contributed substantially to stock assessments.

Progress has also been made in both domestic and international management. In the United States, the National Marine Fisheries Services' Highly Migratory Species Management Division is responsible for developing management measures consistent with the requirements of the Magnuson-Stevens Fishery Conservation and Management Act. To that end, a Highly Migratory Species Advisory Panel was formed and is preparing a Highly Migratory Species FMP for Atlantic Tunas, Swordfish, and Sharks, which will amend the original 1993 shark FMP. The new FMP will establish rebuilding programs for the overfished large coastal sharks, prevent overfishing on the fully fished pelagic and small coastal sharks, and limit access to the commercial shark fishery. Internationally, the United States continues to play a key role in the United Nations Food and Agriculture Organization's Consultation on Shark Conservation and Management. This consultation will culminate in a plan of action to guide national, regional, and international science and management under the precautionary approach.

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Atlantic and Gulf of Mexico Migratory Pelagic Fisheries

Unit 7

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INTRODUCTION

Coastal pelagic fishes inhabiting waters off the southeastern United States include king and Spanish mackerels, cero, dolphinfish, and cobia. These species range in coastal and continental shelf waters from the northeastern United States through the Gulf of Mexico and the Caribbean Sea and as far south as Brazil. Coastal pelagics are fast swimmers that school and feed voraciously, grow rapidly, mature early, and spawn over many months.

U.S. and Mexican commercial fishermen have fished Spanish mackerel since the 1850's and king mackerel since the 1880's. The Spanish mackerel fishery began off New York and New Jersey but shifted southward through the decades to the southern U.S. Atlantic and Gulf of Mexico. In 1996, over 90% of the commercial catch was landed in Florida. Although early commercial fisheries harvested Spanish mackerel by hook and line, nearly all the commercial catch now is taken by runaround gillnet. A recreational fishery also exists for Spanish mackerel and accounts for about 17–40% of all the Gulf stock and 31–51% of the Atlantic stock of Spanish mackerel landed.

King mackerel are fished commercially from Chesapeake Bay southward. Four major production areas exist: North Carolina, Florida east coast (Cape Canaveral to Palm Beach), the Florida Keys, and off Grande Isle, La. The Louisiana fishery began in the early 1980's; the area was believed to harbor older king mackerel females that served as a major spawning population for the Gulf of Mexico stock. Unrestricted fishing mortality was believed to be high on these fish from the late 1970's through the early 1980's, and these stocks currently comprise about 31% of the commercial quota for the Gulf regulatory group. Landings, which approached 680 metric tons (t) in 1983, were reduced from one-half to two-thirds by Federal quota management from the mid 1980's to the present.

Dolphinfish

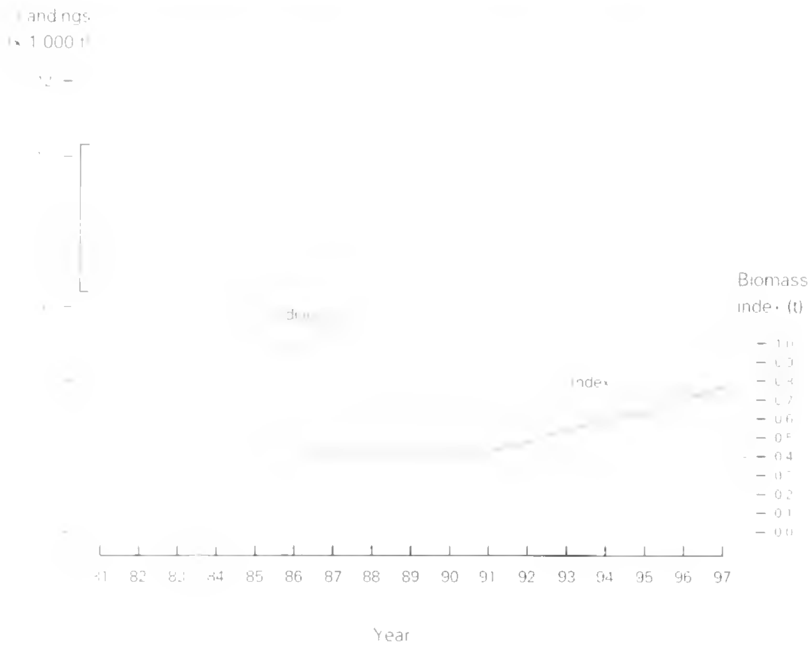

Figure 7-1

Landings and biomass index in metric tons (t) of king mackerel, 1981–97. The biomass index is the estimate in weight (t), and the highest year is given the relative value of 1.0.

Commercial king mackerel vessels have employed gillnets, troll lines, handlines, purse seines, otter trawls, and pound nets. King mackerel sport fisheries exist off many southeastern states throughout the year. Commercial yields were unregulated until the mid 1980's. Recreational landings are thought to have been reduced by an expanding commercial runaround gillnet fishery in the 1970's and a driftnet fishery operating off southeast Florida in the late 1980's. Purse seines were used also to exploit the Gulf of Mexico king mackerel during the 1980's but are now prohibited as part of the stock recovery plan.

Coastal pelagics are comanaged under the Coastal Migratory Pelagic Resources Fishery Management Plan and regulations adopted by the South Atlantic and Gulf of Mexico Fishery Management Councils and implemented by the National Marine Fisheries Service. Total allowable catch and commercial and recreational allocations are established by the Councils for two separate groups of migratory king and Spanish mackerel: the Gulf group and the Atlantic group. Acceptable biological catches are defined for separate geographical areas within the Gulf migratory group. Quota management began in the 1985–86 fishing year. Presently, both commercial and charterboat operators must apply for and hold current Federal permits to fish for king mackerel, Spanish mackerel, or other coastal pelagics. Recreational catches are regulated by creel and size limits. In addition to quota limits, commercial catches must comply with minimum size restrictions and, off some states as in Florida and North Carolina, daily landing limits and/or trip limits apply. In 1998 the National Marine Fisheries Service invoked a mandatory reporting requirement from commercial king mackerel fishermen through logbook reports for all trips. Currently, only U.S. fishermen are regulated, while Mexican fishermen fish under no regulations. Mexican catches are thought to be large relative to the U.S. fishery.

SPECIES AND STATUS

Recreational fishermen caught 8,000–17,000 t/year of coastal pelagic species, and commercial fishermen caught 5,000–14,000 t/year during

Table 7-1

Productivity in metric tons and status of coastal migratory fishes in the U.S. Atlantic Ocean and Gulf of Mexico

Species and area	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
[illegible]	4,642	Unknown	Unknown	Unknown	Unknown
King mackerel, Gulf of Mexico	3,307	2,024	9,750	Over	Below
King mackerel, Atlantic	2,823	5,581	3,632	Under	Near
Spanish mackerel, Gulf of Mexico	1,427	3,956	3,702	Full	Near
Spanish mackerel, Atlantic	2,065	2,946	3,702	Full	Near
Cobia	1,168	Unknown	998	Unknown	Unknown
[illegible]	22	Unknown	Unknown	Unknown	Unknown
Total	15,454	20,339	26,448		

1981–96. King and Spanish mackerel account for about 95% of all coastal pelagic species harvested (Figures 7-1 and 7-2). In addition to king and Spanish mackerel, Atlantic dolphinfish and cobia contributed significantly to the total recreational yield of coastal pelagics. Some cobia are incidentally caught by commercial mackerel fishermen; however, cobia are for the most part a recreationally caught species. Cero are relatively unimportant and are taken as bycatch in other fisheries. Cero are not known to form large schools and are more difficult to target individually; in general, they do not contribute significantly to coastal pelagic catches.

As a group, coastal pelagics yield only about 68% of their long-term potential (Table 7-1), and certain species are fished near or over maximum production levels. The Gulf king mackerel stock is considered overfished because of previous overexploitation and has been managed under rigid rebuilding schedules since 1985.

The mackerels have been managed recently according to spawning potential ratio[1] (SPR). The management benchmark selected for determining overfishing is $F_{30\%}$.[1] The 1996–97 Atlantic Spanish mackerel SPR is estimated to be 39% of the maximum potential. Fishing mortality from bycatch in the shrimp fishery is believed to be greater than currently anticipated. Additional information is needed to quantify this source of mortality. Gulf Spanish mackerel were removed from overfished status in 1995 following a period of regulation to rebuild the stock that began in 1987. The 1996–97 estimated SPR is 43% of the maximum potential for Gulf Spanish mackerel. Currently, fishing mortality on Gulf Spanish mackerel is less than $F_{30\%}$ SPR, but additional information is needed on the exact level of bycatch to evaluate the stock status with more certainty.

The Gulf king mackerel stock is believed to have a large long-term potential yield, but the stock is severely depleted. Recent average annual production is at 15% of its maximum level, and major stock reductions were due to excessive harvests from the late 1970's through the early 1980's. Absence of fishing effort controls and sparse data hampered determining stock status and conservation efforts until 1986.

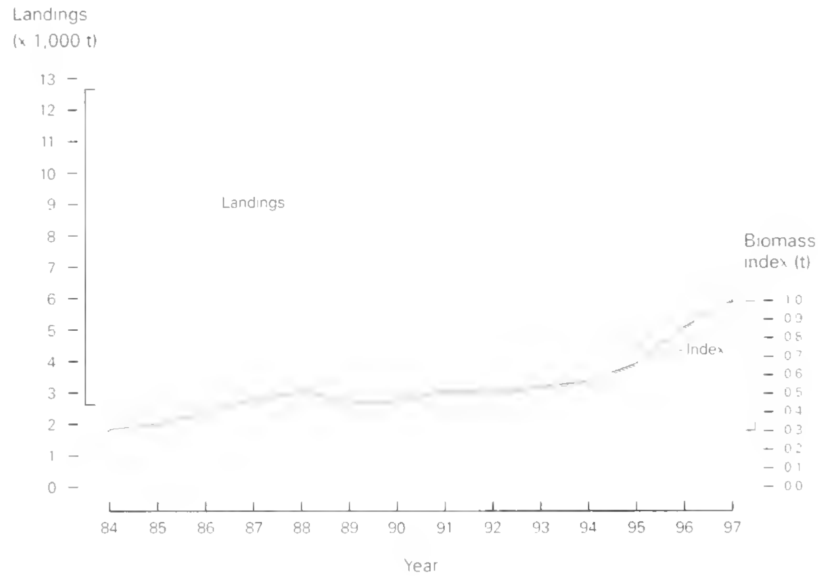

Figure 7-2
Landings and biomass index in metric tons (t) of Spanish mackerel, 1984–97. The biomass index is the estimate in weight (t), and the highest year is given the relative value of 1.0.

The Atlantic king mackerel stock is near its long-term potential yield. Catches have remained stable since 1981 with annual total allowable catches not reached in most years. Bycatch of Atlantic king mackerel is assumed low. The 1996–97 estimated SPR level is 27% of the maximum level.

The status of cobia and dolphinfish stocks remains uncertain. Atlantic cobia yields have ranged from 351 to 627 t since 1987. Gulf cobia yields are traditionally much larger than those of Atlantic cobia. Fishing mortality is assumed to be low for the Atlantic group, and Gulf cobia are believed to be more heavily exploited. The 1994 SPR calculation for Gulf cobia was about 20%. Management of cobia stocks assumes two separate stocks for assessment. Cobia and dolphinfish mostly are caught by recreational anglers, but data needed to assess their long-term potential are limited. In addition, updated information is needed to investigate the possibility of separating cobia into Gulf and Atlantic stocks. Also, refined estimates of cobia bycatch, natural mortality rate, and increased biostatistical sampling throughout the range of cobia are needed to improve assessment of stock status and accurately estimate long-term potential yields.

[1]The spawning potential ratio is the amount of reproductive output for one recruit relative to the amount expected under no fishing (see Appendix 4). $F_{30\%}$ is the fishing mortality rate expected to produce 30% SPR

Left: Spanish mackerel; right: catch of dolphinfish, Manteo, North Carolina

ISSUES

Transboundary Stocks and Jurisdiction

Effective management of migratory species will continue to require the coordination of Federal, state, and international regulatory actions. Accurate determination of the status of western Gulf of Mexico resources will require an increase in the information base on Mexican catches, their associated biological data, and cooperation of international scientists involved.

Allocation

The division of total allowable catches between recreational and commercial users remains an important issue. Future allocation decisions require improvements in the precision and accuracy of user-specific harvest levels and in the understanding of the spatial segregation of the resource.

FOR FURTHER READING

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Atlantic, Gulf of Mexico, and Caribbean Reef Fisheries

Unit

8

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INTRODUCTION

Reef fish include more than 100 species that prefer coral reefs, artificial structures, or other hard bottom areas, and tilefishes that prefer muddy bottom areas. They range along the coast to a depth of about 200 m, from Cape Hatteras, N.C., through the Gulf of Mexico and the Caribbean Sea. Reef fish fisheries are extremely diverse, have many users (commercial, artisanal, recreational, and scientific), and vary greatly by location and species. Anglers fish for food, commerce, sport, and trophies. They operate from charterboats, headboats, private boats, and shore while using fish traps, hook and line, longlines, spears, trammel nets, bang sticks, and barrier nets.

Reef fish fisheries are associated closely with fisheries for other reef animals including spiny lobster, conch, stone crab, corals, and living rock and ornamental aquarium species. Nonconsumptive uses of reef resources (e.g. ecotourism, sport diving, education, and scientific research) also are economically important and can conflict with traditional commercial and recreational fisheries. Although reef fish have been caught for generations, good statistical data for most areas began to accrue in the late 1970's when recreational fishing surveys were started. Fishery data collection remains difficult because there are diverse users, and landings are made at many ports. Fishing pressure has increased with growing human populations, greater demands for fishery products, and technological improvements, such as longlines, wire fish traps, electronic fish finders, and navigational aids.

Reef fish fisheries vary widely by area. In most cases, the current and long-term potential yields are unknown, though for many species they are

Schoolmaster snappers.

Table 8-1

Productivity in metric tons and status of Atlantic, Gulf of Mexico, and Carribean reef fish fisheries.

Area and species	Recent average yield (RAY)[2]	Current potential yield (CPY)[1]	Long-term potential yield (LTPY)[1]	Fishery utilization level	Stock level relative to LTPY
Gulf of Mexico					
Red snapper	3,815	2,722	15,000	Over	Below
Red grouper	3,322	Unknown	Unknown	Full	Near
Nassau grouper and jewfish[3]	2	0	Unknown	Over	Below
Shallow groupers (7 species)	2,197	Unknown	Unknown	Over	Unknown
Other groupers (5 species)	575	Unknown	Unknown	Unknown	Unknown
Other snappers (13 species)	3,479	Unknown	Unknown	Unknown	Unknown
Porgies (6 species)	125	Unknown	Unknown	Unknown	Unknown
Amberjacks (2 species)	1,462	Unknown	Unknown	Unknown	Unknown
Grunts (3 species)	1,358	Unknown	Unknown	Unknown	Unknown
Sea basses (3 species)	364	Unknown	Unknown	Unknown	Unknown
Others (14 species)	1,000	Unknown	Unknown	Unknown	Unknown
Atlantic					
Wreckfish	349	Unknown	Unknown	Full	Near
Vermillion snapper	564	Unknown	Unknown	Over	Below
Red snapper	155	Unknown	Unknown	Over	Below
Red porgy	236	Unknown	450	Over	Below
Nassau grouper and jewfish[3]	1	0	Unknown	Over	Below
Other groupers (16 species)	1,150	Unknown	Unknown	Over	Below
Sea basses (3 species)	751	Unknown	Unknown	Full[4]	Near
Other snappers (11 species)	652	Unknown	Unknown	Over	Below
Amberjacks (2 species)	1,078	Unknown	Unknown	Under	Unknown
Other porgies (8 species)	67	Unknown	Unknown	Unknown	Unknown
Grunts (11 species)	354	Unknown	Unknown	Unknown	Unknown
Others	1,662	Unknown	Unknown	Unknown	Unknown
Caribbean					
Nassau grouper	4	Unknown	Unknown	Over	Below
Snappers (10 species)	422	Unknown	Unknown	Unknown	Unknown
Other groupers (6 species)	61	Unknown	Unknown	Unknown	Unknown
Grunts (5 species)	70	Unknown	Unknown	Unknown	Unknown
Others (50 species)	462	Unknown	Unknown	Unknown	Unknown
Total	25,737	24,641	37,136		

[1] LTPY is probably greatly underestimated and CPY overestimated, although potential production estimates are not available for most species groups, many are probably overutilized

[2] 1989–91 average

[3] A total fishing prohibition has been imposed or is being considered

[4] Approaching full utilization level

probably higher than present recent average yields would indicate (Table 8-1). Data are often not available by species, fishery component, or area. Statistics are confounded because species are not further identified into market categories (i.e. groupers, snappers, grunts). The reef fish management unit includes about 100 species (excluding those for the marine aquarium trade). In the Southeast Region, reef fish fisheries occurring in the 200-mile U.S. zone are managed by the South Atlantic Fishery Management Council, the Gulf of Mexico Fishery Management Council, and the Caribbean Fishery Management Council. The 3-mile territorial waters are managed by eight coastal states, the U.S. Virgin Islands, and the Commonwealth of Puerto Rico.

In the Gulf of Mexico, the Reef Fish Fishery Management Plan prohibits the use of fish traps, roller trawls, and powerheads on spearguns within an inshore stressed area; places a 38 cm (15-inch) total length minimum size limit on red snapper; and imposes data reporting requirements. A 20% spawning potential ratio was established as a basis to measure overfishing. Presently, there is a 4-fish

A large grouper of the Genus *Epinephelus* and a remora.

recreational bag limit for red snapper, and the commercial catch is limited by an annual quota. For grouper, a 5-fish recreational bag limit and 4,455 metric ton (t) shallow-water and 727 t deep-water commercial quotas were established. Other regulations included a ban on the harvest of jewfish, a framework procedure for establishing total allowable catches and allowing the target date for rebuilding to be changed depending on scientific information, and a revised target year of 2019 for rebuilding the red snapper stock. In 1992, a moratorium was established to stop issuing new commercial reef fish permits.

In the southern U.S. Atlantic, the Snapper-Grouper Fishery Management Plan emphasizes minimum size limits, bag limits, and commercial quotas. Seasonal closures exist, and the taking of jewfish and Nassau grouper are prohibited. Various gears are restricted, including a prohibition of roller trawls and fish traps (except sea bass traps). Certain commercial fishing methods are prohibited in designated special management zones around some artificial reefs. An individual transferable quota system has been established for commercial wreckfish fishermen which is based on historic catch. It provides fishermen with a quota that can be taken any time during the season or bartered or sold to another fisherman.

In the U.S. Caribbean, the Fishery Management Plan for the Shallow Water Reef Fish Fishery of Puerto Rico established regulations to rebuild declining reef fish stocks in the exclusive economic zone and reduce conflicts among fishermen. It established criteria for the construction of fish traps, required owner identification and marking of gear and boats; prohibited hauling or tampering with another person's traps without the owner's written consent; prohibited the use of poisons, drugs, other chemicals, and explosives for the taking of reef fish; and established a minimum size limit on the harvest of yellowtail snapper and Nassau grouper. Additional regulatory amendments have been designed to protect and rebuild the stocks.

SPECIES AND STATUS

More than 100 reef fishes are important to commercial or sport fishermen (Table 8-1). While landings and value for individual species are not large, reef fishes overall produce significant landings and values (Figures 8-1, 8-2, and 8-3). Recent average commercial catches for the U.S. Atlantic and Gulf have been about 24,000 t with a

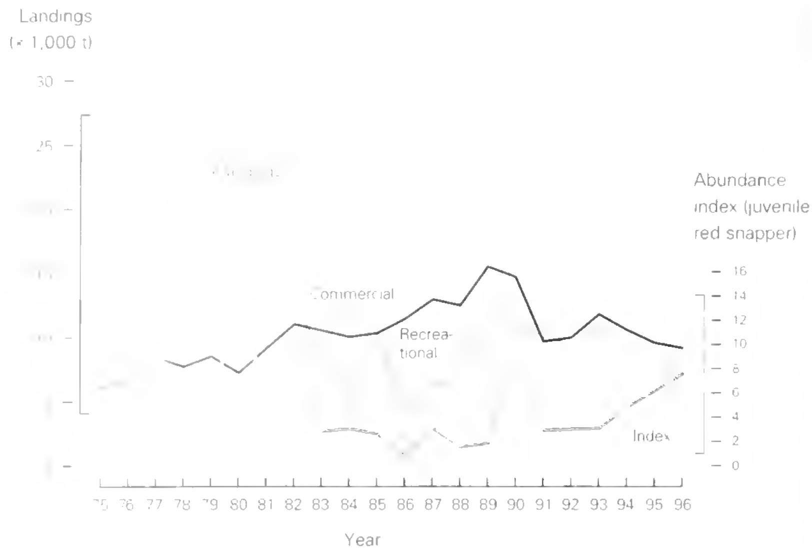

Figure 8-1
Gulf of Mexico reef fish landings, 1975–97, in metric tons (t). The abundance index is a relative value showing fish per standarized haul.

dockside ex-vessel revenue of $48 million. Sport fishermen make more than 20 million angler-trips annually.

Reef fishes are vulnerable to overfishing owing to their long lives, slow growth, ease of capture, large body size, delayed reproduction, and other factors. Most are probably either fully utilized or overutilized (Table 8-1). Red snapper, traditionally the most important Gulf reef fish, is overutilized in part as a result of its incidental catch by the shrimp fishery. Eight of the ten major species in the Atlantic headboat fishery show significant size declines since 1972. In the Caribbean, such traditional fishery mainstays as Nassau grouper have practically disappeared, and total landings of species of more recent importance like the red hind have declined since the late 1970's. Landings of amberjack, lane snapper, vermilion snapper, and similar species have increased as catches of traditional species have declined.

ISSUES

Bycatch and Multispecies Interactions

Reef fish form a complex, diverse multi-species system. The long-term harvesting effects on reefs are not well understood, requiring cautious management controls of targeted fisheries as well as bycatch. Removals of apex predators from the reef complex may result in shifts of species composition. Major bycatch issues currently occur with the capture and discarding of red snapper by vessels fishing for shrimp with small-mesh nets. This bycatch problem means that, in order to meet the rebuilding goals for the stock, targeted harvests must be even more restricted. Bycatch of other species may pose similar difficulties as will the capture of undersized fish, even if they are released. The mortality rate of released fish is not well known.

This page: Nassau grouper, facing page: Gustave Quetel Fishing Center, Frenchtown Harbor, U.S Virgin Islands

Scientific Information and Adequacy of Stock Assessments

Several stocks of reef fish are currently depleted and need to be rebuilt (e.g. jewfish and Nassau grouper). A variety of management measures need to be explored, including the use of artificial reefs and the effectiveness of marine parks and reserves to protect spawning areas.

There are a number of important scientific issues which need to be addressed to improve the advice for management. The long-term potential yields for most of the reef fish species is unknown. Data on catch and the identification of species are inadequate for many stocks. They should be collected on a routine basis. Additional life history and biological data are needed to better understand this complex of species.

William B Folsom, NMFS

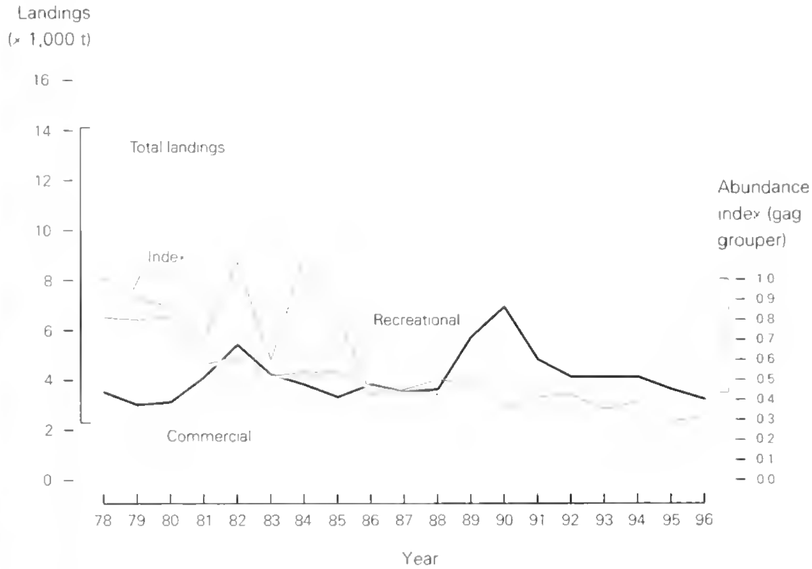

Figure 8-2
U.S. Atlantic Coast reef fish landings, 1978–97, in metric tons (t). The abundance index is a relative value showing fish per standarized haul.

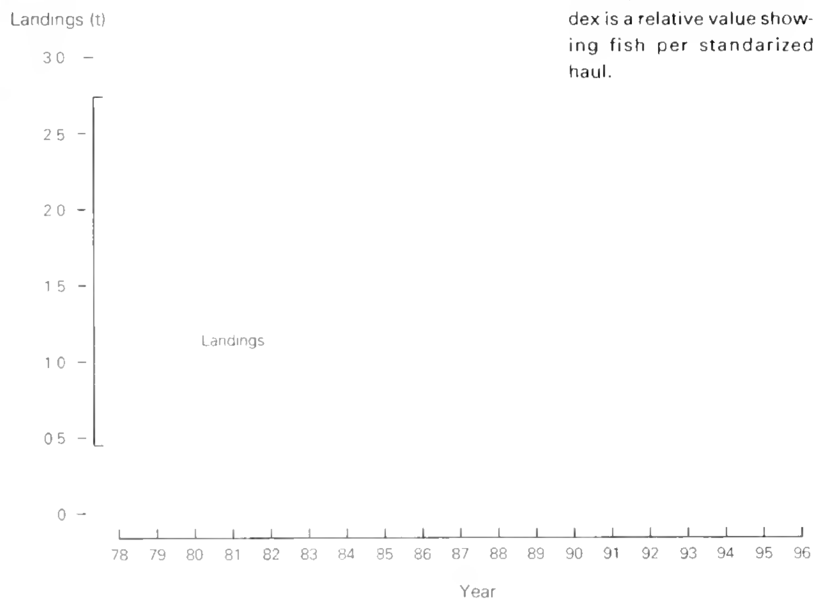

Figure 8-3
Carribean waters reef fish landings, 1978–97, in metric tons (t).

Allocation

Reef fish resources are utilized by a wide range of groups. Commercial and recreational fishermen may come into conflict with one another as well as with other users such as ecotourists. Balancing the interests of these groups is an important management issue.

Progress

An individual transferable quota system was implemented for wreckfish in April 1992. Since then, the shares are generally holding their value and fish prices have improved.

FOR FURTHER READING

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Southeast Drum and Croaker Fisheries

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Unit

9

LARRY MASSEY

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INTRODUCTION

Important recreational and commercial species in the family Sciaenidae include the Atlantic croaker, spot, red drum, black drum, kingfishes (whiting), weakfish, spotted seatrout, and other seatrouts. These have constituted an important fishery resource since the late 1800's, although significant increases in commercial landings did not occur until the 1950's when the pet food industry began harvesting them in the northern Gulf of Mexico. In recent years the recreational harvest of sciaenids has roughly paralleled and almost equaled commercial landings by weight (Figure 9-1). However, since most recreational fishing occurs within state jurisdiction, it is managed primarily through state authorities. Some states have established regulations heavily favoring recreational uses of Sciaenidae resources: in particular the prohibition of commercial fishing for red drum and spotted seatrout. The recent average annual yield of sciaenids is estimated at 33,500 metric tons (t) (Table 9-1).

Large numbers of sciaenids are also caught and killed as an incidental catch in the shrimp fishery. The small mesh used in shrimp trawls can catch nontarget species such as sea turtles, red snappers, croakers, seatrouts, and other species. Sciaenids constitute the bulk of the finfish bycatch biomass, and since many are harvested as juveniles, their mortality may slow recovery of overfished stocks or otherwise prevent full use of the adult resource.

SPECIES AND STATUS

Commercial landings of drum and croaker in the northern Gulf of Mexico peaked in 1956 at over 32,000 t, more than 20,000 t above that of

Red drum

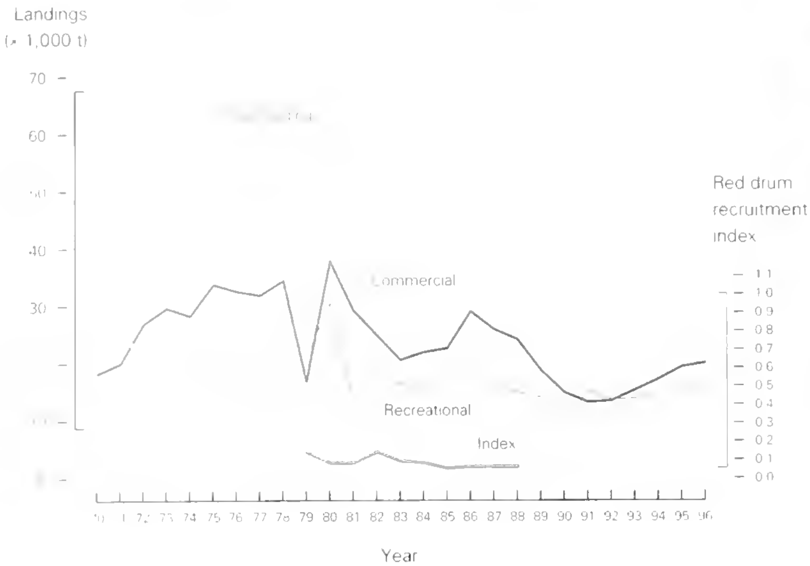

Figure 9-1

Southeast Atlantic and Gulf of Mexico groundfish and red drum landings, 1970–96, in metric tons (t).

1953. This increase for the most part resulted from a demand for sciaenids as raw material in the production of canned pet foods, of which about 76% were Atlantic croaker and sand and silver seatrout.

Commercial landings of red drum increased rapidly in the mid 1980's when public popularity and demand suddenly grew for a new seafood preparation called blackened redfish. To supply this demand, a red drum purse-seine fishery evolved in the Gulf of Mexico, primarily targeting the offshore adult spawning stock. Prior to this, most red drum were harvested in nearshore state waters as juveniles. But as the offshore purse-seine fishery developed, it became clear that the schooling adults were extremely vulnerable to overexploitation, thus jeopardizing recruitment in subsequent years. Fishery analyses showed that the sustainability of the long-term potential yield depended in a large part upon limiting the harvest of larger adult red drum in the offshore waters as well as limiting the take of smaller individuals in inshore waters both by recreational and commercial fishermen (Goodyear 1989, 1996).

These conservation measures were established by a fishery management plan developed and implemented first in the Gulf of Mexico and later in the U.S. Atlantic. The first plan is the Fishery Management Plan for the Red Drum Fishery of the Gulf of Mexico (administered by the Gulf of Mexico Fishery Management Council), and the second is the Atlantic Coast Red Drum Fishery Management Plan (South Atlantic Fishery Management Council). Both plans ban red drum fish-

Table 9-1

Productivity in metric tons and status of Southeast Region drum and croaker fisheries resources.

Species and area	Recent average yield (RAY)[2]	Current potential yield (CPY)[1]	Long-term potential yield (LTPY)[1]	Fishery utilization level	Stock level relative to LTPY
Black drum	3,712	Unknown	Unknown	Unknown	Unknown
Atlantic croaker	7,657	Unknown	50,000	Over	Below
Spot	4,145	Unknown	Unknown	Unknown	Unknown
Red drum, Gulf of Mexico	5,031	2,828	7,900	Over	Below
Red drum, Atlantic	800	Unknown	Unknown	Over	Below
Seatrouts	10,820	Unknown	Unknown	Unknown	Variable[3]
Kingfishes (whiting)	1,458	Unknown	Unknown	Unknown	Unknown
Total	33,623	31,420	78,835		

[1] LTPY is probably underestimated and CPY overestimated, although potential production estimates are not available for some species groups it is expected that they may be overexploited.

[2] 1994–96 average.

[3] Grey seatrout, *Cynoscion regalis*, is overexploited but the status of other species in this group is unknown.

ing within Federal jurisdiction until the adult population has increased in size. And since state management actions have preserved inshore harvests and allocated much of the catch to recreational uses, they in effect bar the development of another adult red drum fishery in Federal waters.

The absence of an offshore fishery, size limits, limiting the daily take of red drum by recreational fishermen, and an increased incidence of fish released by conservation-oriented anglers are all expected to help rebuild the red drum spawning stock and reduce overall mortality. Current statistics indicate that such conservation measures are having this desired effect, and fishery-independent sampling in Texas, Louisiana, and Mississippi indicate an increased survival rate for juvenile red drum in inshore waters. These findings are supplemented by those from mark-recapture programs that also indicate a decreasing fishing mortality from Texas to Florida since the implementation of red drum conservation actions by the states. In addition, the abundance of newly recruited adults has increased in the offshore stock. Thus, taken together, these results suggest that state and Federal conservation measures have substantially increased the escapement of juveniles from inshore capture and thus will help replenish the adult offshore stock for the good of the resource and its users.

ISSUES

Bycatch

Bycatch of these resources in the shrimp fishery has a significant impact on their status. Large numbers of Atlantic croaker, spot, and seatrout are caught and discarded dead from shrimp trawls. Estimates of as many as 500,000,000 spot, 1 billion seatrout, and 7.5 billion croaker are discarded. These species constitute the bulk of the finfish bycatch that averaged about 175,000 t during the 1980's. The National Marine Fisheries Service and the fishing industry have been working together to develop gear designs which will reduce the bycatch. Several promising solutions are under development.

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Left page: spot; right page, sea trout.

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Southeast Menhaden Fisheries

W. F. Hettler, NMFS

Menhaden.

Unit 10

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INTRODUCTION

The menhaden is a herring-like species found in coastal and estuarine waters of the U.S. Atlantic and Gulf of Mexico. They form large schools at the surface which are located by aircraft and are harvested by purse seines to produce fish meal, fish oil, and fish solubles. An active baitfish fishery along the Atlantic and Gulf Coasts harvests about 5–10% of the amount landed by the industrial fishery. These fisheries are managed by individual states, with interstate coordination handled through the Atlantic States Marine Fisheries Commission and the Gulf States Marine Fisheries Commission. Menhaden are prey for many fishes and sea birds.

In the Atlantic area, the menhaden resource is fully utilized with a long-term potential yield of 480,000 metric tons (t) per year and a recent average yield of 300,000 t/year (Table 10-1). In the Gulf of Mexico, the menhaden resource is fully utilized with a long-term potential yield of 660,000 t/year and a recent average yield of 560,000 t/year.

Atlantic Menhaden

Atlantic menhaden range from West Palm Beach, Fla., to Nova Scotia, Can. As coastal waters warm in April and May, large surface schools form along the coasts of Florida, Georgia, and the Carolinas. The schools move slowly northward, stratifying by age and size during summer, with the older and larger fish generally moving farther north. The southward migration begins in early fall with surface schools disappearing in late December or early January off the Carolinas. Atlantic menhaden may live 10 years, but most fish caught are 3 years old or younger (Smith, 1991).

Menhaden landings rose during the 1940's and early 1950's, peaking at 712,100 t in 1956 (Figure 10-1). Landings remained high during the late


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Aerial photos of an exceptionally large purse seine set.

1950's and early 1960's, dropped precipitously during the mid 1960's, and remained low, bottoming out at 161,600 t in 1969. Since 1970, landings have improved but not to the levels of the late 1950's. Landings peaked in 1983 at 418,600 t. Landings have been relatively stable in recent years at about 300,000 t. While spawning stock biomass recently peaked in 1997 at about 89,000 t, recruitment of 1-year-old fish has declined over the last decade to recent lows (Cadrin and Vaughan, 1997). The commercial ex-vessel revenue of Atlantic menhaden for 1994–97 averaged $41.7 million/year. In 1998, two menhaden reduction or processing plants were in operation, one in Reedville, Va., and one in Beaufort, N.C.; the industrial purse-seine fleet was comprised of about 15 vessels.

The stock decline in the 1960's drove fishing effort southward to Virginia and North Carolina where menhaden are generally younger and smaller than those in the north. Overutilization owing to growth overfishing (catching too many fish before they grow to full size) has been a prime management concern for this stock. While maximum spawning potential estimates have been low (10%), estimates of spawning stock biomass have rebounded from the very low levels of 1965–75, although not to the very high level of the late 1950's. A new fishery management plan was adopted by the Atlantic States Marine Fisheries Commission in September 1992 which provided for an annual review of six trigger variables (landings in weight, percentage of age 0 and adults in numbers in the landings, new recruits aged 1 year old, spawning stock biomass, and maximum spawning potential) (Atlantic Menhaden Advisory Committee, 1992). Exceeding prespecified levels of trigger variables in conjunction with ancillary information will determine the need for specific management actions.

Gulf of Mexico Menhaden

Gulf menhaden are found from Mexico's Yucatán Peninsula to Tampa Bay, Fla. They form large surface schools that appear in nearshore Gulf

Table 10-1

Productivity in metric tons and status of Southeast Region menhaden fishery resources.

Area/species	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Gulf of Mexico Menhaden	560,000	560,000	660,000	Full	Near
Atlantic Menhaden	300,000	300,000	480,000	Full	Near
Total	860,000	860,000	1,140,000		

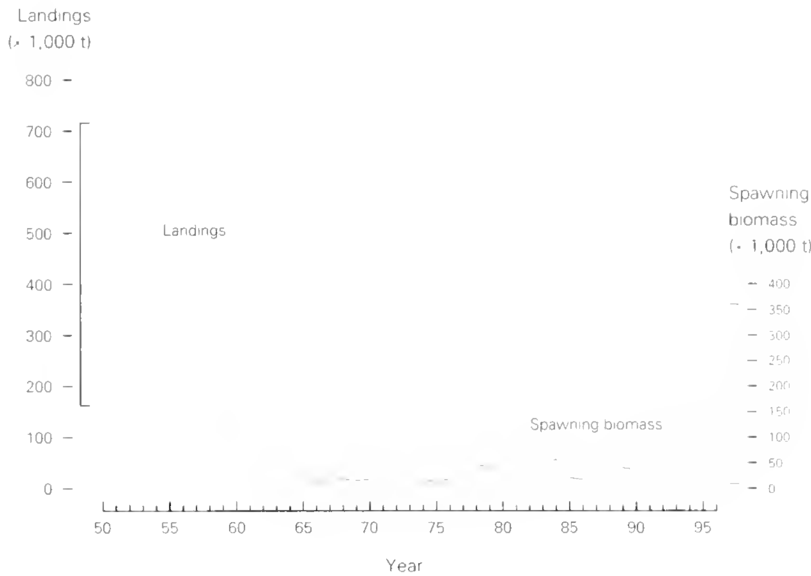
waters from April to November. Although no extensive coastwide migrations are known, some evidence suggests that older fish move toward the Mississippi River delta. Gulf menhaden may live to age 5, but most of those landed are ages 1 and 2. In 1998, active Gulf menhaden reduction plants were located in Moss Point, Miss., and in Empire, Morgan City, Intracoastal City, and Cameron, La.; about 50 purse-seine vessels operate in the Gulf (Smith, 1991).

Historically, landings rose after World War II to a peak of 982,800 t in 1984 (Figure 10-1). Landings were generally high during the mid 1980's (greater than 800,000 t for 1982–87), but they declined steeply from 894,200 t to 421,400 t between 1987 and 1992. During this period (1987–92), the number of processing plants declined from 8 to 6 and vessels fell from 75 to 51. Although catch per unit of effort (expressed as metric tons/vessel-ton-weeks or t/vtw) showed a similar decline (1.48 t/vtw in 1987 to 1.03 t/vtw in 1992), catch per unit of effort is not useful as an index of population abundance for menhaden. The commercial ex-vessel revenue of Gulf menhaden for 1994–97 averaged $66.7 million/year. Landings during 1994–98 have averaged 561,000 t. Landings in 1994 of 761,600 t were the greatest in the past 10 years.

Because Gulf menhaden has a short life cycle and a high natural mortality, growth overfishing has not been a management concern (Vaughan et al., 1996). Management is coordinated through the Gulf States Marine Fishery Commission, and consists of a 28-week fishing season (mid April through 1 November) and closure of inside waters across the northern Gulf of Mexico. The most recent revision to the Gulf Menhaden Fishery Management Plan was completed in 1995 (Gulf Menhaden Advisory Committee, 1995). Another revision is planned for 1999.

Joseph W. Smith, NMFS

Purse boats retrieving wings of purse seine



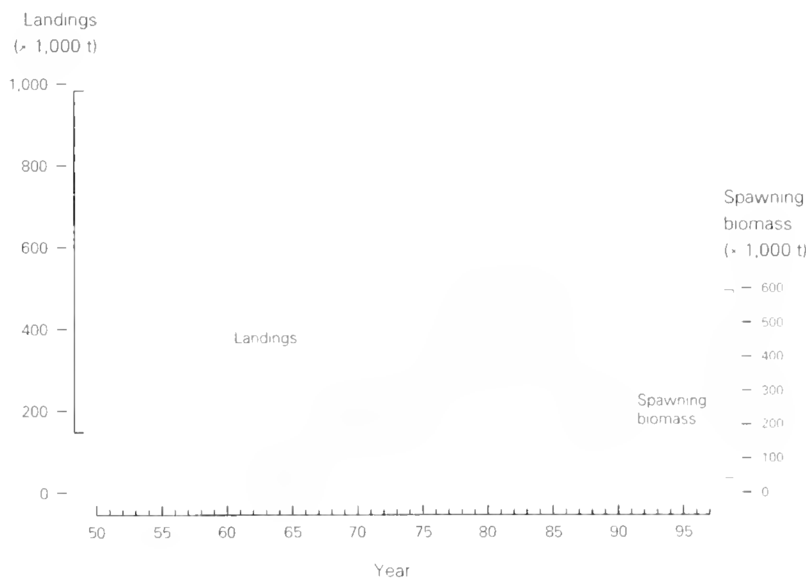


Figure 10-1
Landings and spawning biomass of menhaden, 1950–97, in metric tons (t). Top, Atlantic; bottom, Gulf of Mexico.

ISSUES

Management Concerns

Atlantic menhaden continue to be overfished (growth overfishing), which reduces the future opportunity for greater weight production. Of greater concern is the decline in recruitment noted since 1989 (1988 year class). This is somewhat tempered by the later high estimates for spawning stock biomass (peaking in 1995). Additionally, social con-

"Hardening up" the catch in the net.

cerns have resulted in numerous area closures along the Atlantic coast. Gulf menhaden landings have declined greatly since the mid 1980's, however, estimates of maximum spawning potential remain high (about 40%).

Transboundary Stocks and Fishery Management Jurisdictions

Because this resource migrates long distances along the coast, interstate coordination of menhaden management is required for Atlantic menhaden along the U.S. Atlantic Coast and for Gulf menhaden along the northern Gulf of Mexico through the interstate marine fisheries commissions. During the late 1980's and early 1990's, fish landed at processing plants in New Brunswick and Nova Scotia, Canada, were caught off Maine by U.S. vessels and transported to Canada for processing.

Bycatch and Multispecies Interactions

Two Saltonstall-Kennedy studies, funded in 1992 to investigate bycatch in the Atlantic and Gulf menhaden purse-seine fisheries, showed very low bycatch incidence (<0.1% of other species). The importance of menhaden as prey for other species should be considered with respect to multispecies resource management.

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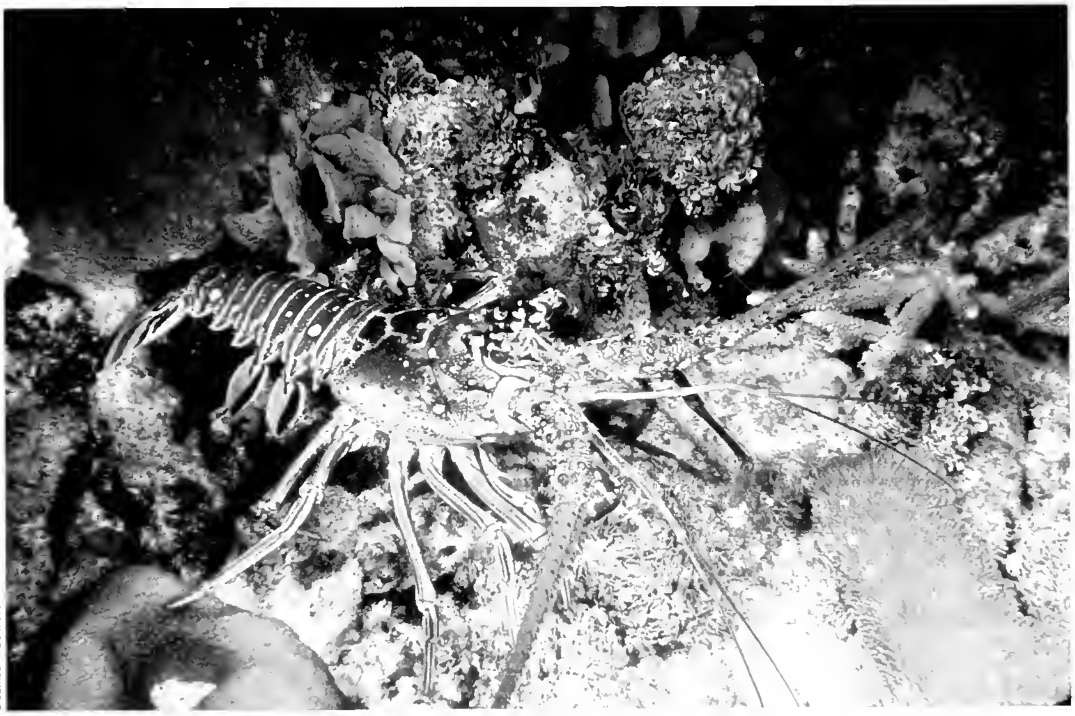
Southeast and Caribbean Invertebrate Fisheries



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Unit 11

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INTRODUCTION

Important recreational and commercial marine invertebrates in the southeastern United States include shrimp, spiny lobster, stone crab, and conch. Some fisheries, as for coral, are almost nonexistent. Others, like the penaeid shrimp fishery, are both extensive and extremely valuable. The southeast region's shrimp fisheries are one of the most valuable U.S. fisheries based on ex-vessel revenue. Some fisheries, such as those for spiny lobster and stone crab, have only moderate value on a national basis but are important locally or regionally. Because of the diversity in species, fisheries, geographic locations, yields, values, etc., each species group in the marine invertebrates unit must be examined separately for proper perspective.

Penaeid shrimp have been fished commercially since the late 1800's. The first fishery used long seines in shallow waters, until the otter trawl, introduced in 1915, extended shrimping to deeper waters. At first, most vessels towed one large trawl, sometimes 120 feet wide at the mouth. Soon, a two-trawl arrangement (each about 40–75 feet wide at the mouth) was found more effective. Some shrimpers are using a twin-trawl system which tows four trawls of about 40 feet wide at the mouth. The twin-trawl system is now very common gear on commercial offshore shrimpers.

Regulations in the Gulf of Mexico Shrimp Fishery Management Plan restricts shrimping by closing two shrimping grounds. There is a seasonal closure of fishing grounds off Texas for brown shrimp and a closure off Florida for pink shrimp. There are also size limits on white shrimp caught in Federal waters and landed in Louisiana. These

Spiny lobster.

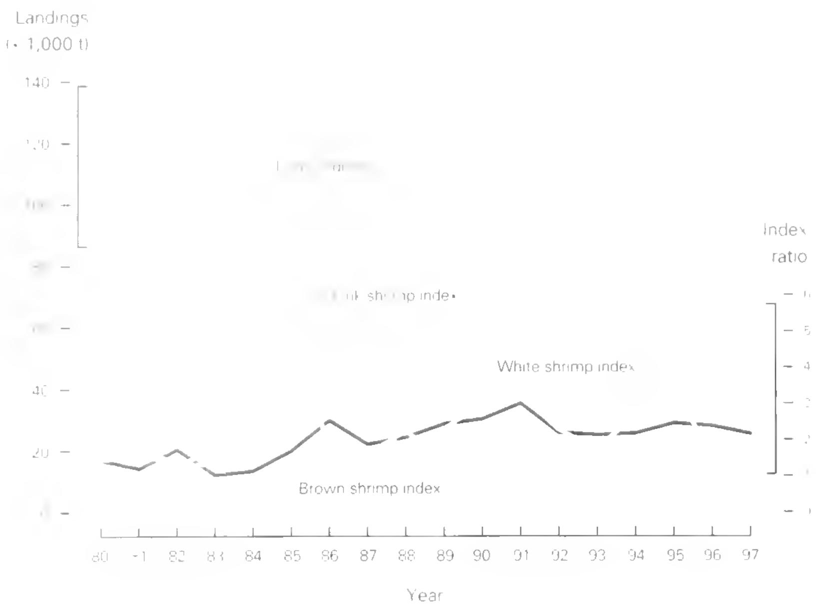

Figure 11-1
Shrimp landings in the U.S. Gulf of Mexico and species ratio, 1980–97, in metric tons (t). Index values are the current level of reproductive-age shrimp divided by the overfishing level; e.g. a value of 2 means that the current number of reproductive-age shrimp is 2× above the overfishing level.

regulations strive to improve the monetary value of the shrimp fishery (Nance, 1998).

In the South Atlantic, white shrimp stocks are centered off the Georgia and South Carolina coasts. Brown shrimp are centered off the North and South Carolina coasts. The Atlantic fishery is much smaller than that of the Gulf and currently is managed under a Federal fishery management plan implemented in November 1993. This provides for compatible state and Federal closures if needed to protect overwintering shrimp stocks. A subsequent amendment added rock shrimp to the fishery management plan.

Spiny lobsters are managed under a joint fishery management plan, coordinated with regulations by the State of Florida. Current regulations specify a 3-inch minimum carapace length, a closed season from 1 April to 5 August, protection of egg-bearing females, closure of some nursery areas, recreational bag limits, and a controversial 2-day sport season.

Caribbean spiny lobsters are caught primarily by fish traps, lobster traps, and divers. The Caribbean Fishery Management Council's Spiny Lobster Fishery Management Plan includes the Federal waters of Puerto Rico and the U.S. Virgin Islands. The Federal plan is based on a 3.5-inch minimum carapace length and protection of young egg-bearing lobsters.

The conch fishery targets the queen conch but also takes other species. Most conch are taken by divers, and the resource can be easily depleted. Conch are currently protected in state and Federal waters off Florida. A fishery management plan is being developed for the Federal waters off Puerto Rico and the U.S. Virgin Islands by the Caribbean Fishery Management Council.

Corals are managed as two groups, hard and soft. Because they are generally slow growing and provide critical habitat for many fishes, hard corals are protected except for very small collections taken by permit for research and educational purposes. Regulations are based on the fact that the value of coral as natural habitat is far more important than their commercial use.

Soft corals include gorgonians and sea fans. Some gorgonians are taken (about 50,000 colonies annually) for the aquarium and pharmaceutical trade. Growth potential for most species is considered limited. Sea fans are completely protected except for research and educational use by permit.

Stone crabs are caught mainly off southern Florida, though some are landed farther north along Florida's west coast. The Gulf of Mexico Stone Crab Fishery Management Plan, approved in September 1979, generally extended Florida's regulations into the U.S. Exclusive Economic Zone. These regulations are based on a minimum claw size of 2.75 inches, biodegradable trap panels, protection of egg-bearing females, and closed seasons. Minimum size regulations assure that crabs have reproduced at least once before being caught.

SPECIES AND STATUS

Shrimp Species

Brown, white, and pink shrimp account for 90% of the total Gulf of Mexico shrimp catch. In 1997 alone, these three important species produced 84,967 t valued at over $437,000,000 in ex-vessel revenue (Figure 11-1). They are found in all U.S. Gulf waters inside 120 m depths. Most of the offshore brown shrimp catch is taken at 20–40 m depths, white shrimp are caught in 10 m or less, and pink shrimp in 20–30 m. Brown shrimp are most abundant off the Texas-Louisiana coast,

Table 11-1

Productivity in metric tons and status of Southeast and Carribean invertebrate fisheries.

Species and area	Recent average yield (RAY)[1]	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Brown shrimp, Gulf of Mexico	53,080	Unknown	57,653[2]	Full	Near
Brown shrimp, Atlantic	2,645	Unknown	3,447[2]	Full	Near
White shrimp, Gulf of Mexico	28,942	Unknown	29,980[2]	Full	Near
White shrimp, Atlantic	6,045	Unknown	6,305[2]	Full	Near
Pink shrimp, Gulf of Mexico	11,009	Unknown	7,469[2]	Full	Near
Pink shrimp, Atlantic	730	Unknown	955[2]	Full	Near
Royal red shrimp	250	Unknown	Unknown	Unknown	Unknown
Seabob shrimp	3,947	Unknown	Unknown	Unknown	Unknown
Rock shrimp	6,240	Unknown	Unknown	Unknown	Unknown
Spiny lobster, SE United States[3]	3,325	2,400	3,565	Over	Below
Spiny lobster, Caribbean	111	Unknown	Unknown	Unknown	Unknown
Stone crab[4]	2,961	1,121	976	Full	Near
Queen conchs[5]	91	55	Unknown	Over	Below
Coral[6]	0	0	Unknown	Unknown	Unknown
Total	119,376	116,575	120,953		

[1]1995–97 average for shrimp. 1994–96 average for other species

[2]Long-term potential of brown, white, and pink shrimp based upon last observed 10-year average annual yield (1988–97)

[3]Yields based upon commercial catches, recreational catch is unknown but may be significant

[4]Yields are in tons of claws, declawed crabs regenerate new claws

[5]Landings from Puerto Rico. Fishing prohibited in Florida

[6]Coral harvests prohibited except for a small take allowed for use in aquarium and pharmaceutical industries

and the greatest concentration of pink shrimp is off southwestern Florida. In the South Atlantic, white shrimp landings are about 21% of their Gulf counterparts, while brown and pink shrimp are around 6% of the Gulf yield. Current, recent, and long-term potential yields for these species are given in Table 11-1.

Gulf brown and white shrimp catches increased significantly from the late 1950's to around 1990, with the most recent years showing a slight decrease from these maximum values. Pink shrimp catches were stable until about 1985; then they declined and were at an all time low in 1990. In recent years the catches have started to increase and are slightly above average levels. The numbers of young shrimp for each species entering the fisheries have generally reflected the level of catch. All commercial shrimps are harvested at maximum levels. The fishery is believed to have more boats and gear than needed (i.e. reducing fishing effort would not significantly reduce the shrimp catch) (Nance, 1993a and 1997). Reducing the bycatch of the shrimp industry, however, would help protect finfish resources.

Recruitment overfishing has not been evident in the Gulf of Mexico shrimp stocks (Klima et al., 1990; Nance, 1993b). The number of young brown shrimp produced per parent increased significantly until about 1991 and has remained near

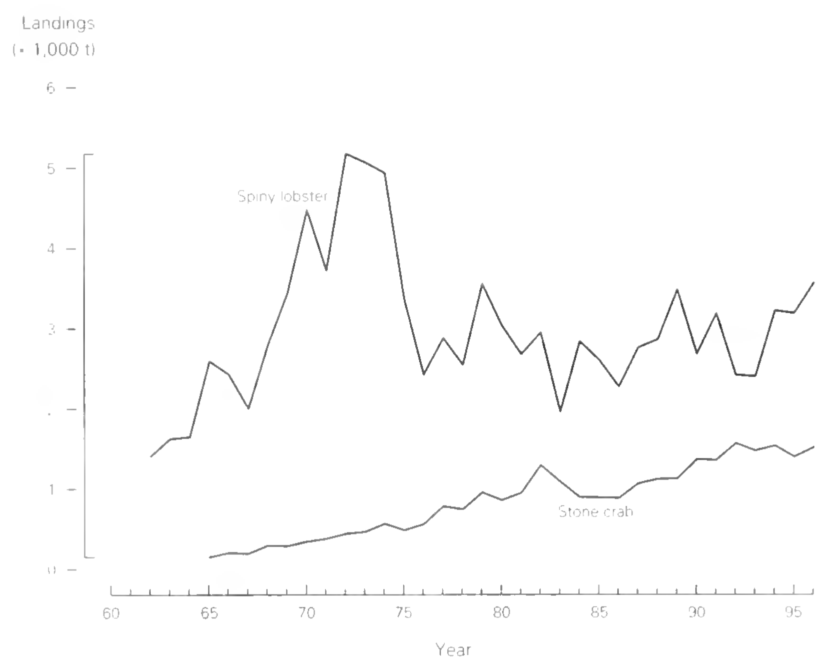

Figure 11-2

Landings of stone crab (claw weight) and spiny lobster, 1960–96, in metric tons (t).

Shrimp boat, Corpus Christi, Texas.

that level in recent years. White and pink shrimp have not shown any general trend, although pink shrimp stocks have rebounded from the low values experienced in the early 1990's. The brown shrimp increase appears related to marsh alterations. Coastal sinking and a sea-level rise in the northwestern Gulf inundates intertidal marshes longer, allowing the shrimp to feed for longer periods within the marsh area. In the Gulf, both factors have also expanded estuarine areas, created more marsh edges, and provided more protection from predators. As a result, the nursery function of those marshes has been greatly magnified and brown shrimp production has expanded. However, continued subsidence will lead to marsh deterioration and an ultimate loss of supporting wetlands, and current high fishery yields may not be indefinitely sustainable. Parent stock indices for the three major Gulf species are shown in Figure 11-1.

Spiny Lobster

Annual Florida spiny lobster landings were fairly stable during the 1980's, running about 2,700 metric tons (t) from the Gulf of Mexico (Figure 11-2), but yielding recent high landings in 1994 of 3,222 t, with ex-vessel revenue of about $30,000,000. On Florida's Atlantic Coast, landings have averaged 230 t, valued at $2,000,000. The fishery is considered overcapitalized with approximately 900,000 lobster traps fished during 1992. In 1993, a trap reduction program was established, not to exceed 10% per year, which would maintain or maximize sustainable spiny lobster harvest from the fishery. Excessive effort in the fishery has been estimated to occur when the number of traps fished exceeds 300,000/year. Spiny lobster fishermen use live undersized lobsters as attractants in their traps, but due to a high mortality rate for these "live bait" animals, about 30–50% of the potential yield is lost. The recreational fishery in Florida had over 120,000 participants purchasing recreational lobster stamps during the 1991 season. Recreational spiny lobster catches were estimated to comprise 41% of total landings during the first month and 22% of the total 1991–92 season landings.

Annual spiny lobster landings for Puerto Rico have averaged 126 t over the past 27 years, varying from 103 t in 1972 to a high of 223 t in 1979. No precise data are available on fishing effort, but the Puerto Rican stock produced landings of 72 t in 1992 and now appears to be overutilized. U.S. Virgin Islands landings for 1980–88 were fairly stable, averaging 19 t.

Spiny lobster larvae may drift at sea for 9 months, and thus identification of their source or parent stock is almost impossible. There is a practical management need to know far more about their origin and subsequent movement into the fishery.

Stone Crab

Annual catches of stone crab (claw weight) varied from 1,200 to 1,400 t on the Gulf of Mexico and Atlantic coasts through the 1980's, with a record 3,065 t landed during 1994 (Figure 11-2). Recent annual ex-vessel revenue averaged $18 million. The number of stone crab traps fished seasonally increased from 295,000 in 1979–80 to 567,00 in 1984–85 to a record 745,000 during 1992–93. While total landings have increased modestly in recent years, it is clear that these landings are the result of increased fishing effort (number of traps fished), especially during the early months of the stone crab season.

ISSUES

Habitat Concerns

Estuarine and marsh loss remove critical habitat for young shrimp. Additional studies are needed to further assess the impacts of human-induced changes in habitat availability, environmental conditions, predator abundance, and pollution in the nursery areas. Florida spiny lobsters depend on reef habitat and shallow-water algal flats for feeding and reproduction. These habitat requirements may conflict with expanding coastal developments. The productivity of stone crabs in Florida Bay is related to water quality and flow through the Everglades. Specific water requirements need to be identified and maintained through comprehensive Everglades water management. A unified program to integrate and study the effects of environmental alterations, fishing technology, regulations, and economic factors on shrimp, lobster, and crab production and restoration is needed, particularly in the reef habitats of South Florida. Steps need to be taken to mitigate or restore lost estuarine habitats.

Transboundary Stocks and Fishery Management Jurisdiction

Spiny lobster stocks in Florida could be of Caribbean origin, being swept into the region by currents of the Gulf Stream. Another hypothesis is that they could comprise a number of different spawning stocks. The actual sources of all Florida and Caribbean lobster stocks (both U.S. and foreign) need to be identified and international management established to prevent overharvesting.

Management Concerns

Many small spiny lobsters are caught in the Puerto Rican fishery. If these lobsters were allowed to grow larger before harvest, there would be a substantial increase in yield by weight. Modification of the traps to allow more of the small lobsters to escape needs to be investigated. Small lobsters are sometimes used to bait traps in the lobster fishery. This current practice is wasteful and hinders rebuilding of the stock.

The shrimp fisheries are currently overcapitalized, with more fishing effort being expended than needed to harvest the resource. In addition, the harvesting of small shrimp inshore is sacrificing yield and value of the catch by cutting short future growth.

Bycatch and Multispecies Interactions

Shrimp fisheries use small-mesh nets and can catch nontarget species such as red snappers, croakers, seatrouts, and sea turtles. Juvenile finfish are often harvested, and this may be a major source of mortality for them. Some fish caught by shrimpers are currently at low stock levels (see Unit 9). This bycatch may slow or prevent recovery if not mitigated.

As sea turtles are all listed as endangered or threatened under the Endangered Species Act, shrimp vessels have been required to use turtle excluder devices in their nets since 1988 to avoid capturing sea turtles and thus protect the stocks.

Stone crab traps, Florida Keys, Florida.

Progress

The National Marine Fisheries Service and the fishing industry are working together to finalize bycatch-reduction gear development and implementation to address the problems of finfish bycatch by shrimp fisheries in the Gulf of Mexico and South Atlantic.

A gear conflict between stone crab trappers and shrimp trawlers off southwestern Florida has mostly been resolved in the 200-mile Federal zone with a line separating the fishing areas and seasonal area closures. This approach requires continued monitoring to gauge its success and prevent renewal of conflicts.

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Brown shrimp and mixed bycatch of red snapper, butterfish, and other species.

Pacific Coast Salmon

Spawning sockeye salmon run.

Unit 12

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INTRODUCTION

Pacific salmon support important commercial and recreational fisheries in Washington, Oregon, and California. Salmon are part of the culture and heritage of the Pacific Northwest; having been harvested by Native Americans for millennia.

Pacific salmon are anadromous. They spawn in freshwater and migrate to the ocean where they may undergo extensive migrations. At maturity, they return to their home stream to spawn and complete their life cycle.

Pacific salmon include five species: chinook, coho, sockeye, pink, and chum salmon. Chinook and coho salmon are harvested recreationally and commercially in the Pacific Ocean, Puget Sound, and in freshwater rivers on their spawning migrations. All recreational fisheries use hook-and-line gear. Commercial fisheries use a variety of gear depending on location: in the Pacific Ocean all harvest is by trolling; in Puget Sound, gillnets and purse seines are also used; gillnets are used almost exclusively in freshwater and estuaries. Pink, chum, and sockeye salmon are not harvested in significant numbers recreationally nor outside of Puget Sound, although there are recreational fisheries directed at these species in a few locations. The majority of harvest is by commercial gillnet and purse-seine fisheries in Puget Sound and gillnet fisheries in estuaries. All species are also harvested by Native American tribes for subsistence and ceremonial purposes.

During 1995–97, the average annual commercial salmon catch was 13,100 metric tons (t) and provided revenues averaging almost $22,000,000 at dockside. Recreational catches are more difficult to value since the recreational experience associated with the catch cannot be easily measured. If recreationally caught fish are valued at a conservative $20/fish, the 1995–97 average catch of 661,000 fish would have been worth about $13,000,000 annually.

The abundance of individual stocks of Pacific salmon and the mixture of stocks contributing to fisheries fluctuate considerably. Consequently, landings fluctuate. For all species, there is excess fishing power and overcapitalization of the fishing fleets. While harvest rates in recent years have been held near, or below, levels that would produce the long-term potential yield, environmental conditions have resulted in poor ocean survival of chinook and coho salmon in general and some individual stocks of other species. Because of the depressed status of many populations of chinook and coho salmon, these two species are considered overexploited while the other species are considered fully exploited (Table 12-1).

Emerging salmon fry.

© Alaska Seafood Marketing Inst

Management Situation

The management of this resource is complex, involving many stocks originating from various rivers and jurisdictions. Ocean fisheries for chinook and coho salmon are managed under a fishery management plan by the Pacific Fishery Management Council (PFMC) with the cooperation of the states and tribal fishery agencies. Within Puget Sound and the Columbia River, fisheries for these two species are managed by the states and tribes. The other three species (pink, chum, and sockeye salmon) are managed primarily by the Pacific Salmon Commission (PSC), the State of Washington, and tribal fishery agencies.

Fisheries are managed using a variety of regulations. Ocean fisheries are managed primarily by gear restrictions, minimum size limits, and time and area closures; although harvest quotas have been placed on individual fisheries in recent years. The PSC has used harvest quotas, updated on the basis of inseason abundance forecasts, and cumulative impact quotas for weak stocks have been used to regulate some Columbia River commercial fisheries.

Pacific salmon depend on freshwater habitat for spawning and rearing of juveniles. Because the quality of freshwater habitat is largely a function of land management practices, salmon production is heavily influenced by entities not directly involved in the management of fisheries. Salmon management involves the cooperation of the U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Bureau of Reclamation, Army Corps of Engineers, Environmental Protection Agency, Bonneville Power Administration, state resource agencies, Indian tribes, municipal utility districts, agricultural water districts, private timber companies, and landowners.

On September 12, 1994, in response to an increasing number of petitions to list various popu-

Table 12-1

Productivity in metric tons and status of Pacific Coast salmon resources

Species	Recent average yield (RAY)[1]	Current potential yield (CPY)[2]	Long-term potential yield (LTPY)[2]	Fishery utilization level	Stock level relative to LTPY
Chinook	7,444	11,460	11,460	Over	Below
Coho	1,421	5,300	5,300	Over	Below
Pink	3,931	7,270	7,270	Full	Near
Sockeye	1,740	4,646	4,646	Full	Near
Chum	2,768	4,636	4,636	Full	Near
Total	17,304	33,312	33,312		

[illegible] which is for the years 1993, 1995, and 1997.
[illegible] for some stocks.
[illegible] numbers of fish to approximate weight using average weights of salmon caught in commercial [illegible] 2.95 kg, pink=1.70 kg, sockeye=2.44 kg, and chum=4.16 kg.

lations of Pacific salmon and anadromous trout as endangered species, the National Marine Fisheries Service (NMFS) announced its intent to conduct comprehensive, coastwide status reviews of all species of Pacific salmon. These status reviews have been completed for most species and have resulted in listings of coho salmon from central California through coastal Oregon, chinook salmon in California's Central Valley and the upper Columbia and Snake River Basins, and sockeye salmon in the Snake River Basin. In March 1999, NMFS announced the most comprehensive listing decision yet with final listings of nine evolutionarily significant units (ESU's) of salmon (chinook, chum, and sockeye) and steelhead trout ranging from the upper Columbia River through Puget Sound. These listings include the metropolitan areas of Portland, Ore., and Seattle, Wash., within the boundaries of the listed ESU's.

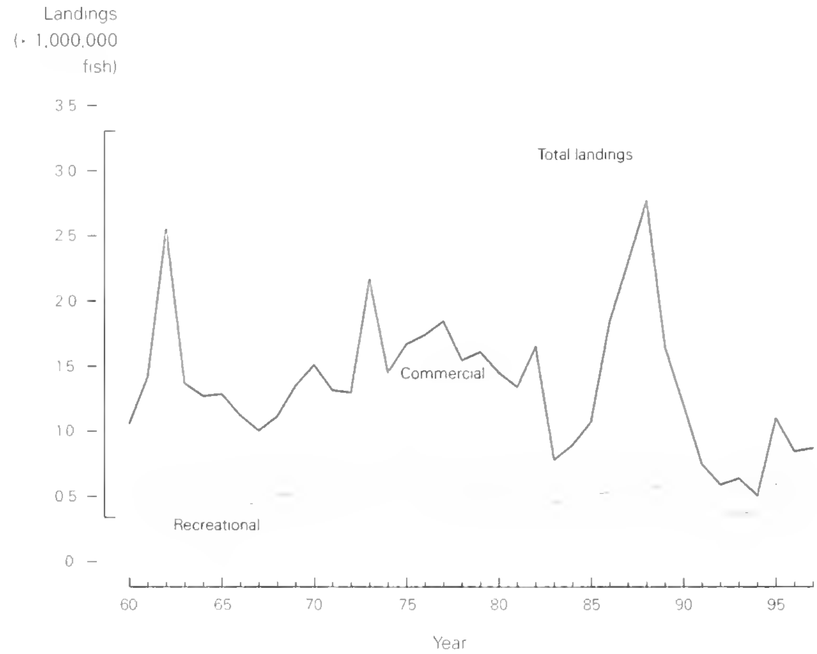


Figure 12-1
Chinook salmon landings, 1960–97.

RESOURCE STATUS

Chinook Salmon

Chinook salmon are produced primarily by rivers and hatcheries in Puget Sound in Washington, the Columbia River, the Umpqua and Rogue Rivers in Oregon, and the Klamath and Sacramento Rivers in California. Chinook salmon stocks are named for the season in which they migrate from the ocean to freshwater to spawn, and include spring, summer, fall and winter runs. The proportion of chinook salmon production originating from hatcheries has been increasing.

Chinook salmon production tends to fluctuate considerably (Figure 12-1) depending on hatchery production, freshwater habitat conditions, and ocean productivity. In recent years, freshwater habitat loss and degradation have been exacerbated by drought in many areas in the west, and ocean conditions have been generally unfavorable for chinook salmon since the late 1970's. This has resulted in historically low levels of a number of stocks and reduced commercial and recreational catches in many areas. Currently, the Snake River spring/summer run and Snake River fall run ESU's are listed as threatened, and the Sacramento River winter-run ESU has been listed as an endangered species by the NMFS. In addition, on 28 February 1998 NMFS proposed listing the Sacramento Central Valley spring run and the Upper Columbia spring run ESU's as endangered and six additional ESU's as threatened. Concern for the status of depressed stocks and biological opinions requiring reduced impacts on listed ESU's has led to increasingly restrictive ocean fishing seasons in recent years.

Coho Salmon

Coho salmon are produced primarily by rivers and hatcheries in the Puget Sound area in Washington, hatcheries on the Columbia River, and coastal rivers and hatcheries in Oregon and California. Hatcheries play a larger role in the production of coho salmon than in the case of chinook salmon, in some areas accounting for over 80% of the catch. Recent reductions in landings have resulted from record low abundances of several stocks of coho salmon including Oregon coast natural and Columbia River hatchery stocks (Figure 12-2). To protect the spawning escapement of these stocks and to provide fish for the legally-mandated tribal allocation, severe restrictions have been placed on ocean fisheries since 1993. In May 1994, retention of coho salmon was prohibited in all ocean fisheries, and no retention of coho salmon

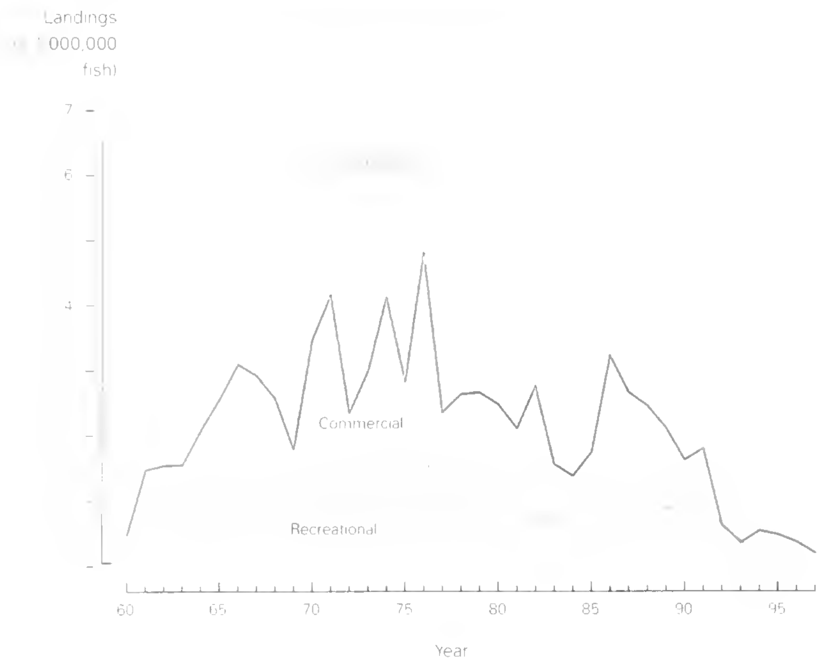


Figure 12-2
Coho salmon landings, 1960–97.

has been permitted south of Cape Falcon in northern Oregon since then. To date, three coho salmon ESU's have been listed as threatened: central California in 1996, northern California-southern Oregon in 1997, and the Oregon coast in 1998.

Sockeye, Pink, and Chum Salmon

Pink and chum salmon originate primarily from tributaries of Puget Sound, Washington. Chum salmon are also produced, in limited numbers, in the Columbia River and coastal streams as far south as the central Oregon coast. Sockeye salmon originate primarily from river systems connected to lakes. They are produced in a few rivers in the Puget Sound area, in limited numbers in a few coastal rivers on the Olympic Peninsula, and in the upper Columbia and Snake River basins. The majority of these species is caught commercially in the Puget Sound region of Washington. Much of the sockeye and pink salmon harvested in Puget Sound originates from the Fraser River in Canada. Though Fraser River runs have been large in recent years, the U.S. catch has been limited under Pacific Salmon Commission rules. Historical landings of the species are shown in Figures 12-3, 12-4, and 12-5.

Recreational Fisheries

Pacific salmon support valuable recreational fisheries in saltwater, freshwater, and estuaries. Recreational landings of chinook salmon have averaged about 450,000 fish annually for the period 1995–97. During the same period, recreational landings of coho salmon have averaged about 133,000 salmon from hatchery and natural production combined. These represent substantial reductions from recreational landings in the recent past, especially for coho salmon which had annual recreational landings averaging 856,000 salmon as recently as the 1990–92 period.

While reduced recreational landings of chinook and coho salmon reflect lower abundance of these two species, declines in abundance are not as pronounced as the declines in landings. Much of the decrease in landings is the result of regulations intended to reduce impacts of both commercial and recreational fisheries on stocks listed under the ESA and to provide adequate spawning escapement for healthier stocks. Consequently, catch per unit of effort and angler success rates have remained high.

Recreational landings for sockeye, pink, and chum salmon combined have averaged about 78,000 fish. Recreational landings of these species are much lower than recreational catches of chinook and coho salmon, while commercial landings are substantially greater. The reason for this lies partly in the life histories and migration patterns of the individual species. Sockeye, pink and chum salmon migrate far offshore into the central North Pacific Ocean and the Gulf of Alaska. Thus they are only available to recreational fisheries briefly during their spawning migration. In addition, pink and chum salmon spawn and die shortly after entering freshwater as adults. By the time they reach terminal areas where recreational fisheries are located, they have undergone physiological changes in preparation for spawning. Consequently, their flesh is of poorer quality, and they are not as highly prized as chinook, coho and sockeye salmon. While the recreational fisheries for sockeye, pink, and chum salmon are substantially smaller than recreational fisheries for chinook and coho salmon, they are still important.

Commercial Landings

For 1995–97, the combined chinook salmon harvest from natural and hatchery production averaged about 936,000 fish. In the same period, the commercial catch of coho salmon averaged about 349,000 salmon. This represents a modest increase in chinook salmon landings over the 576,000 taken during 1992–94, and a further decline in coho landings which averaged about 512,000 during 1992–94 and produced annual landings of more than 2,000,000 fish as recently as 1989. As with recreational landings, the decline reflects restrictions placed on ocean fisheries beginning in 1993 to protect the spawning escapement of depressed and ESA listed stocks. The landings also reflect poor ocean conditions that coho and chinook salmon have been experiencing in recent years.

Sockeye, pink and chum salmon have not suffered the same recent declines as chinook and coho salmon. Trends in the recent landings have generally been stable or increasing, with downturns in landings of chum and sockeye salmon in the last 3 years. While the downturn in chum salmon reflects an actual decline in abundance in the Puget Sound region, sockeye salmon landed in Washington are primarily from the Fraser River in British Columbia. Fraser River sockeye salmon runs have been very strong recently, but ocean conditions have caused a large proportion of the fish to migrate north of Vancouver Island where they were unavailable to U.S. fisheries. Recent average annual catches of these species were roughly 700,000 sockeye salmon (1995–97), 660,000 chum salmon (1995–97), and 2.2 million pink salmon (1993, 1995, and 1997).

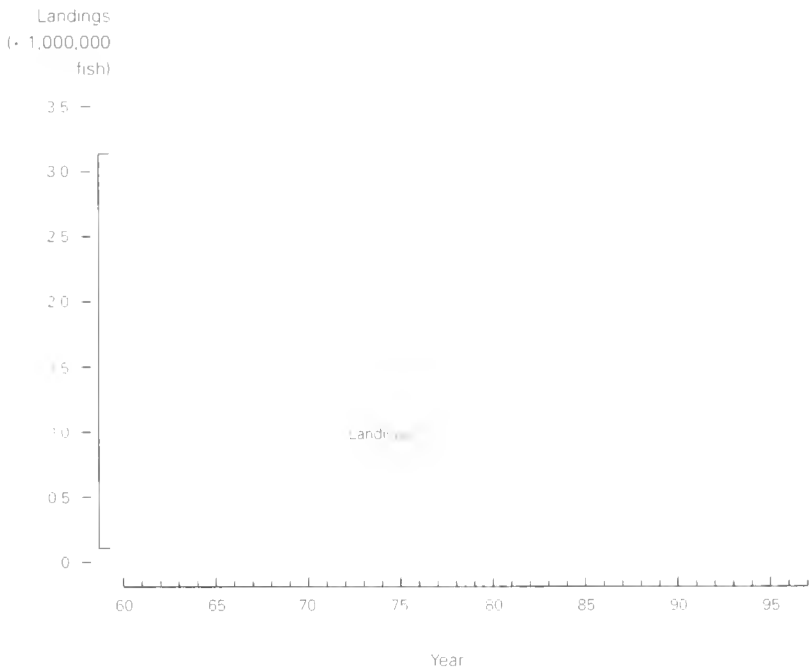


Figure 12-3
Sockeye salmon landings, 1960–97.

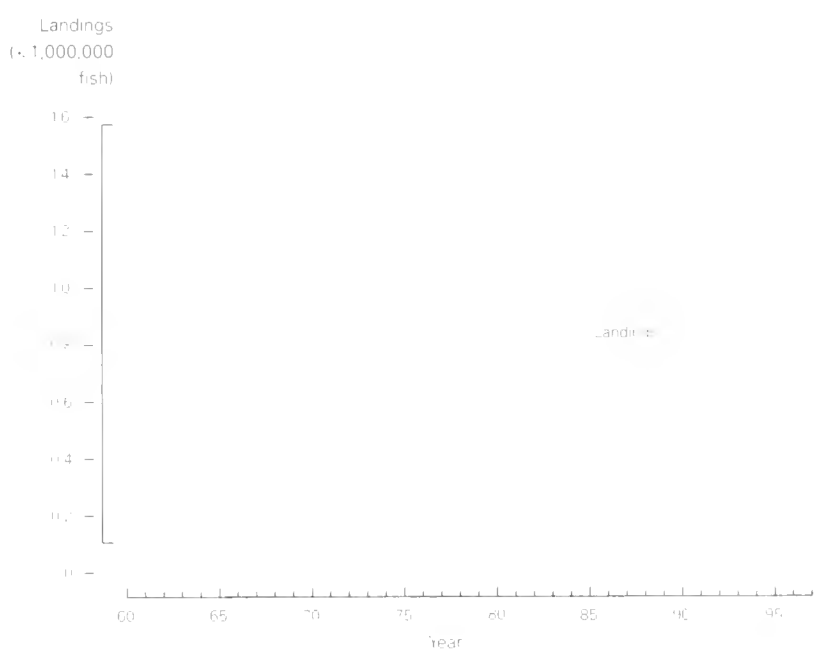


Figure 12-4
Chum salmon landings, 1960–97.

ISSUES AND PROGRESS

Balancing Competing Users

The decline in chinook and coho salmon abundance has forced severe reductions and closures of ocean fisheries in recent years. These reductions, in some cases, follow earlier reductions legally mandated to allocate salmon to interior-water fisheries for harvest by Native American tribes. Ocean salmon fisheries cannot redirect their

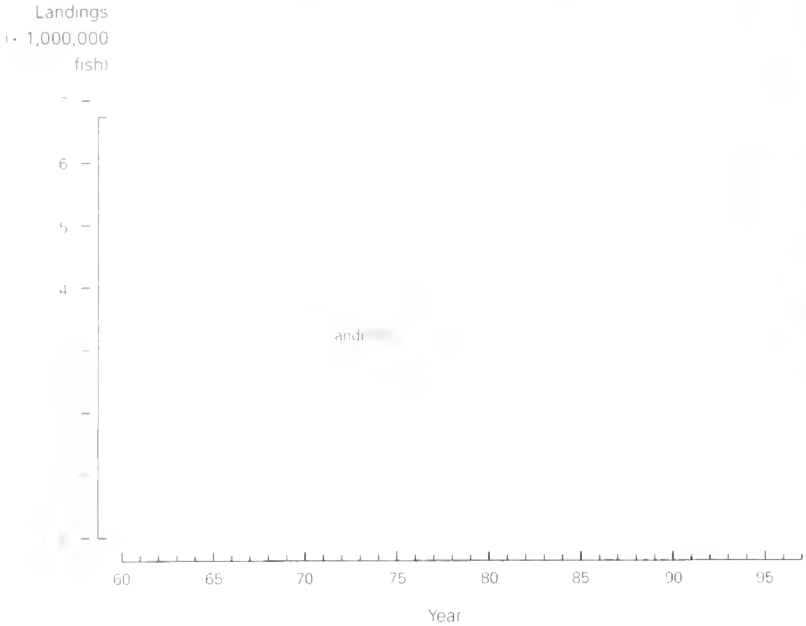
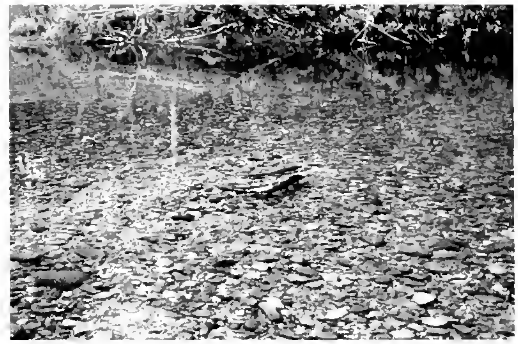


Figure 12-5
Pink salmon landings, 1960–97.

effort to take advantage of abundant sockeye, pink, and chum salmon stocks because the ocean distribution of these species keeps them outside the range of coastal fisheries. With the prospect of even further restrictions that may be required to protect threatened and endangered species, the future viability of these commercial fisheries is uncertain.

Hatchery vs. Wild Salmon

The use of hatcheries to mitigate habitat loss and to enhance fisheries, especially for chinook and coho salmon, has raised concerns about the interactions of hatchery and natural fish. While hatchery fish can supplement natural production, they can also compete with naturally produced fish. In areas where fisheries are managed on the basis of hatchery production, harvest rates may be higher than the natural stocks can sustain. In addition, some hatchery fish fail to return to the hatchery, spawning in natural areas with wild fish. Some hatchery brood stocks are of nonlocal origin, and the insertion of nonlocal genes into natural populations can compromise the genetic integrity of the native stocks and decrease their productivity. To address these concerns, NMFS has drafted an interim policy on artificial propagation in the listing and recovery of Pacific salmon under the Endangered Species Act.



NMFS

Bycatch and Multispecies Interactions

Some salmon, primarily chinook, are caught incidentally in the Pacific whiting fishery. While the numbers are small, this is a sensitive issue given that directed salmon fisheries have been increasingly restricted. Interactions with marine mammals have also become a sensitive issue as populations of California sea lions have increased. Predation by sea lions tends to be localized, but it is also highly visible.

Transboundary Stocks and Jurisdiction

Because salmon migrate long distances, they are subject to interception by fisheries far from their region of origin. Issues of allocation have never been easy to resolve and have been addressed in a variety of forums. Much of the annual process of managing ocean salmon fisheries by the PFMC is concerned with the allocation of fish between different user groups: the United States and Canada, ocean and interior-water fisheries, commercial and recreational fisheries, and tribal and nontribal fisheries. The PSC oversees the allocation of salmon between the United States and Canada. In 1994, a breakdown of the U.S.-Canada negotiations led to aggressive harvesting that compounded forecasting errors and nearly destroyed one of the most productive runs of sockeye salmon from the Fraser River in British Columbia. The PSC has not reached an allocation agreement in any year since then. The allocation of salmon between Native American tribes and nontribal users continues to be defined in Federal courts.

Left page: spring spawning chinook salmon, Columbia River tributary. Right page: Salmon River, near Stanley, Idaho.

Ecosystem Considerations

Coho salmon abundance reached a peak in 1976, and has declined ever since. Chinook salmon abundance has also generally declined since the mid 1970's, although there was a brief increase in chinook salmon abundance in the late 1980's. This decline has affected both hatchery and natural stocks and thus appears to indicate a decline in ocean survival. This decline is coincident with a change in the oceanographic regime off the west coast that occurred around 1978. Since then, the coastal waters off California, Oregon, and Washington, where many chinook and coho salmon stocks mature, have been warmer and less productive than they were in the period from roughly 1950 to 1978. The decline in ocean productivity off the Pacific Coast appears to be linked to increased productivity in the Gulf of Alaska. Sockeye, pink, and chum salmon, which migrate further offshore than chinook and coho salmon, have been relatively stable or increasing during the same period that chinook and coho salmon have declined.

Because Pacific salmon depend on freshwater habitat for spawning and juvenile rearing, they are particularly vulnerable to habitat degradation. Throughout their range, their freshwater habitat has been degraded by dam construction, logging, agriculture, grazing, urbanization, and pollution. Water extraction and flow manipulation for hydropower, irrigation, flood control, and municipal needs directly compete with salmon for the freshwater on which they depend. As the human population in the western United States continues to increase, so will the pressures on salmon habitat. The fact that we still have salmon in harvestable quantities is a tribute to the resilience of these fish.

FOR FURTHER READING

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Alaska Salmon

Sockeye salmon in spawning coloration, near Lake Iliamna, Alaska

Unit 13

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INTRODUCTION

Pacific salmon occupy a special place in the lives of all Alaskans. Its role in the history and modern contemporary life of the 49th State have made the species a keystone resource that continues to shape Alaska today. Native peoples and their heritage have a long, rich tradition of relying on salmon for economic, cultural, and subsistence purposes. Cooley (1961) described the historical focus on salmon by Native Americans along the southeastern and southwestern Alaska coast as representing the most highly developed aboriginal fishing society in North America. Today, residents and nonresidents depend heavily on this resource for recreation, food, and industry. The commercial fisheries, along with a rapidly growing salmon and groundfish sport fishery, provides the state with its largest private-sector employment.

Alaska salmon harvests have increased over the last 3 decades but may have peaked in 1995 (Figure 13-1). After dropping to record low catches in the 1970's, most populations have rebounded, and the fisheries are now at or near all-time peak levels in many regions of the state (Burger and Wertheimer, 1995; Wertheimer, 1997). The record-high commercial catch of 217,000,000 salmon in 1995 was 17% higher than the previous record of 196,000,000 recorded in 1994. However, the commercial landings declined significantly in both 1996 and 1997. Recreational fishermen caught over 1,800,000 salmon in 1995 (Howe et al., 1996), and salmon subsistence fisheries in 1994, the most recent year available, harvested over 1,000,000 fish (North Pacific Anadromous Fish Commission, 1998).

A number of factors have contributed to the current high abundance of Pacific salmon in Alaska. These include: 1) pristine habitats with minimal impacts from extensive development, 2) favorable ocean conditions that allow high survival of juveniles, 3) improved management of the fish-

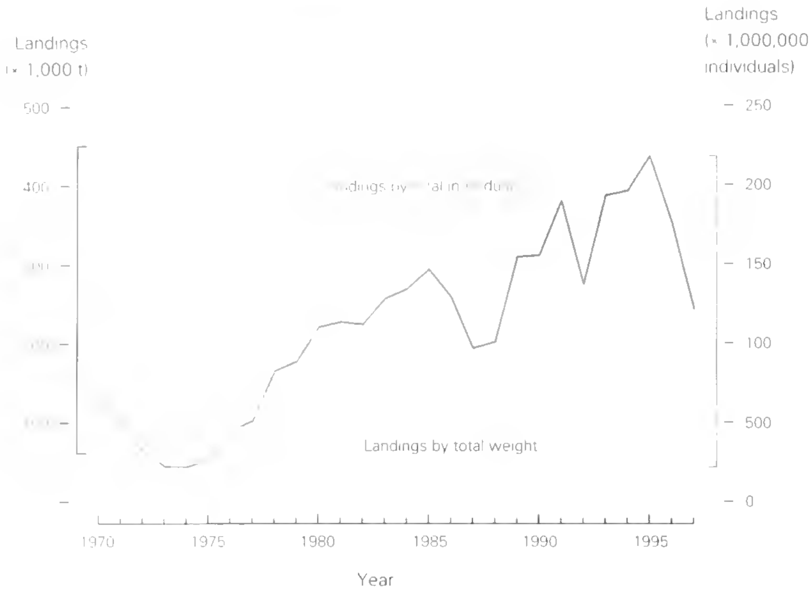

Figure 13-1
Commercial landings of Alaska salmon, all species, 1970–97, by metric tons (t) and individual fish.

eries by state and Federal agencies, 4) elimination of high-seas drift-net fisheries by foreign nations, 5) hatchery production, and 6) reduction of bycatch in fisheries for other species.

Quality spawning and nursery habitat, favorable oceanic conditions, and sufficient numbers of spawning fish are likely the paramount issues affecting current abundance. Alaska salmon management continues to focus on maintaining pristine habitats and ensuring adequate escapements. However, ocean conditions that have favored high marine survivals in recent years, fluctuate due to interdecadal climate oscillations (Mantua et al., 1997). There is recent evidence that a change in ocean conditions in the North Pacific Ocean and Gulf of Alaska may be underway, possibly reflecting the downturn in abundance of Alaska salmon runs in 1996 and 1997.

FISHERY MANAGEMENT

Alaska's 34,000-mile coast is nearly two-thirds the length of the coastline of the conterminous 48 states. Along this coastline, over 14,000 interior water bodies support populations of five salmon species. Salmon management over such a vast area requires a complex mix of domestic and international bodies, treaties, regulations, and other agreements. Federal and state agencies cooperate in managing salmon fisheries. The Alaska Department of Fish and Game (ADFG) manages salmon fisheries within state jurisdictional waters where the majority of catches occurs. Management in the Federal Exclusive Economic Zone (3–200 miles offshore) is the responsibility of the North Pacific Fishery Management Council, which has deferred specific regulations to the state. Management of Alaska salmon fisheries is based primarily on regional stock groups of each species and on time and area harvesting by specific types of fishing gear.

Over 25 different commercial salmon fisheries are managed with a special limited-entry permit system that specifies when and what type of fishing gear can be used in each area of the state. These fisheries, extending from Dixon Entrance in southeastern Alaska to Norton Sound in the Bering Sea, are allowed to catch salmon in different fisheries employing drift gillnets, set gillnets, beach seines, purse seines, hand troll, power troll or fishwheel harvest gear (Commercial Fisheries Entry Commission, 1997). Sport fishing is limited to hook and line, while the subsistence fishery may use gillnets, dipnets, or hook and line. Additional subsistence harvesting is also regulated by special permits.

Management of the fisheries is also negotiated with Canada under the Pacific Salmon Treaty. Recent negotiations for most fisheries, however, have stalled since agreements between the two countries were not reached on catch allocations for certain fisheries and species. Major disagreements exist over several issues including: 1) chinook salmon catches in southeastern Alaska where Canadian salmon are caught along with other U.S. stocks, 2) fisheries in the Dixon Entrance area where each country catches salmon originating in the other nation, and 3) Canadian fisheries off the west coast of Vancouver Island that catch salmon bound for Washington, Oregon, and the Columbia River. A current bright spot in negotiations with Canada involves salmon fisheries in the Yukon River where joint research and management programs in that large transboundary river system are nearing final agreement.

On a broader international scope, the management of salmon harvest in the high seas of the North Pacific Ocean from 1957 to 1992 was authorized by the International North Pacific Fisheries Commission (INPFC), and via bilateral and multilateral agreements and negotiations with Taiwan and the Republic of Korea. In 1993, the North Pacific Anadromous Fish Commission (NPAFC) was formed to replace the INPFC. The Commission (composed of Canada, Japan, the Russian Federation, and the United States) now provides a framework for international cooperation in salmon management and research in the North Pacific Ocean.

The NPAFC Convention prohibits high seas salmon fishing and trafficking of illegally caught salmon. Coupled with United Nations General Assembly Resolution 46/215, which bans large-scale pelagic driftnet fishing in the world's oceans, harvesting of Pacific salmon on the high seas, except for illegal fishing, no longer exists. This allows for effective management control to fully return to the salmon-producing nations.

Because salmon are anadromous fish that spend a portion of their life (1–7 years) at sea and then return to freshwater streams, rivers, and lakes to spawn and die, their well being and harvest management practices are also directly influenced by land management practices. The quality of freshwater habitats determine the success of reproduction and initial rearing of juveniles. Several agencies, entities, and groups have significant influence on the quality of freshwater spawning and rearing habitats for salmon throughout Alaska. Included among these are the U.S. Forest Service, Bureau of Land Management, National Park Service, National Wildlife Refuges, Alaska State Parks and Forests, Alaska Native Regional and Village Corporations, plus municipalities, boroughs, and other private landowners that control watersheds used by salmon.


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Top to Bottom: king, coho, chum, sockeye, and pink salmon.

SPECIES AND STATUS

All five species of Alaska salmon (pink, sockeye, chum, coho, and chinook) are fully utilized, and stocks in most regions of the state generally have rebuilt to or beyond previous high levels (Table 13-1). Research has been extensive into all aspects of salmon life histories (Groot and Margolis, 1991), and this information has been used in Alaska to help regulate fisheries on stocks by monitoring escapement size and catch numbers by species, season, and area. The unprecedented high abundance of Alaska salmon in recent years should not be interpreted as an absence of some of the same factors affecting declines of salmon in the Pacific Northwest. Issues and problems associated with overfishing, incidental take as bycatch in other fisheries, and losses of spawning and rearing habitats in freshwater and in nearshore ocean areas are also of concern in Alaska.

Table 13-1
Productivity in metric tons and status of Alaska salmon fishery resources.

Species	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Pink	153,600	125,700	125,700	Full	Above
Sockeye	128,900	116,800	116,800	Full	Above
Chum	70,800	44,900	44,900	Full	Above
Coho	17,700	17,700	17,700	Full	Near
Chinook	5,100	5,500	5,500	Full	Below
Total	376,100	310,600	310,600		

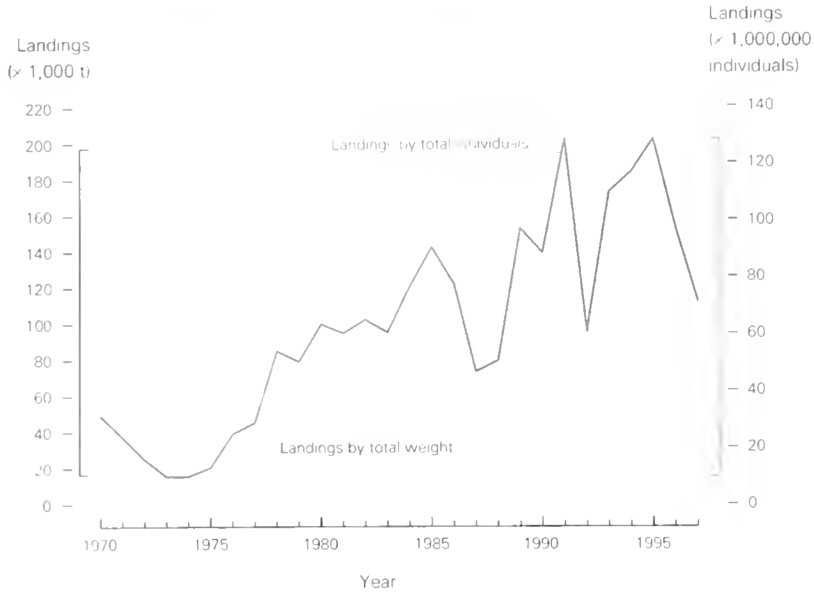


Figure 13-2
Alaska commercial landings of pink salmon, 1970–97, by metric tons (t) and individual fish.

Pink Salmon

Pink salmon are the most abundant species of Pacific salmon in Alaska (Figure 13-2), accounting for 50–60% of the total harvest each year. During the past 27-year period (1970–97), pink salmon comprised 56% of the average annual commercial salmon harvest (Figure 13-3). Pink salmon are mostly harvested by purse seines in the southeastern, southcentral, and Kodiak Island regions of the state. In Prince William Sound, hatcheries produce a large portion of the pink salmon catch.

Unique among the five species, pink salmon have a fixed life-history cycle whereby the species always matures and spawns at 2 years of age. This cycle is genetically fixed so that spawners in even-numbered years are always separate and distinct from spawners in odd-numbered years. Throughout much of its range the species has viable populations in both odd- and even-numbered years; however, in some areas pink salmon only occur in one or the other cycle year. In Bristol Bay and western Alaska, for example, pink salmon essentially occur only in even-numbered years, whereas in the Pacific Northwest they occur only in odd-numbered years.

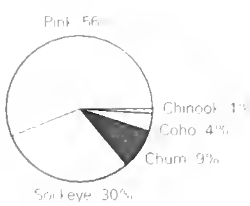


Figure 13-3
Alaska commercial salmon landings by numbers of fish, averaged over 1970–97.

Sockeye Salmon

Sockeye salmon (Figure 13-4), second in abundance, generally accounted for 30% of the harvest in recent years (Savikko, 1997). Sockeye salmon, however, provide greater dollar value to fishermen than all other commercially caught salmon in Alaska combined, usually yielding from 60–70% of the ex-vessel value of the annual harvest. The Bristol Bay sockeye salmon fishery in southwestern Alaska is the most valuable capture fishery for salmon in the world, often yielding $300–400 million (ex-vessel) per year.

Sockeye salmon are harvested by purse seine in the southeastern, Kodiak, and Chignik fisheries and by drift gillnet or set gillnet throughout the state. The largest fisheries for sockeye salmon occur in the Bristol Bay, Cook Inlet, Alaska Peninsula-Aleutian Islands, and Kodiak regions, while other significant fisheries for this species also occur in the southeast, Prince William Sound, and Chignik regions.

The most common sockeye salmon life history pattern dictates that juveniles rear in lakes for 1–2 years before migrating seaward as smolts. The large lake complexes on Bristol Bay rivers provide this necessary life history component and form a critical part of the important fishery in this region. The Bristol Bay fishery, based on drift and set gillnet catches, is concentrated in a narrow window of time from late June until mid July when millions of returning adult sockeye salmon pour into Bristol Bay rivers from the ocean.

The 1997 preseason forecast for sockeye salmon returning to Bristol Bay was estimated to be about 34,000,000 fish. Previous forecasts generally have been in reasonably close agreement with actual runs. During the previous 5-year period (1992–96), returns to Bristol Bay ranged from 29,600,000 to 44,400,000 fish and averaged 36,500,000 sockeye salmon per year (Savikko, 1997). The return to Bristol Bay in 1997, however, was only 18,900,000, with a fishery harvest of 12,300,000. This unexpectedly low return of sockeye salmon created a serious shortfall in the catch and incomes of fishermen and communities throughout a large region of southwestern Alaska dependent on this fishery.

Several hypotheses have been suggested to explain the 1997 shortfall of sockeye salmon returning to Bristol Bay. During May, June, and part of July of 1997 the region experienced unusually warm, calm weather that resulted in high water temperatures. One hypothesis suggested this caused high mortality and changes in migration behavior after returning salmon entered Bristol Bay. Other suggested causes of the shortfall include changes in freshwater or ocean rearing conditions that affected growth and survival of juveniles or immature adults, increased predation at sea, interception by other fisheries, disease, and overescapements on spawning grounds in recent years. The true cause of the shortfall, which may involve a combination of many factors, remains unknown. A paramount unanswered question, however, that arises from 1997 Alaska salmon returns, including those in Bristol Bay, is whether or not cyclic changes in oceanic environmental conditions have occurred that portends lower survivals and smaller returns for future runs.

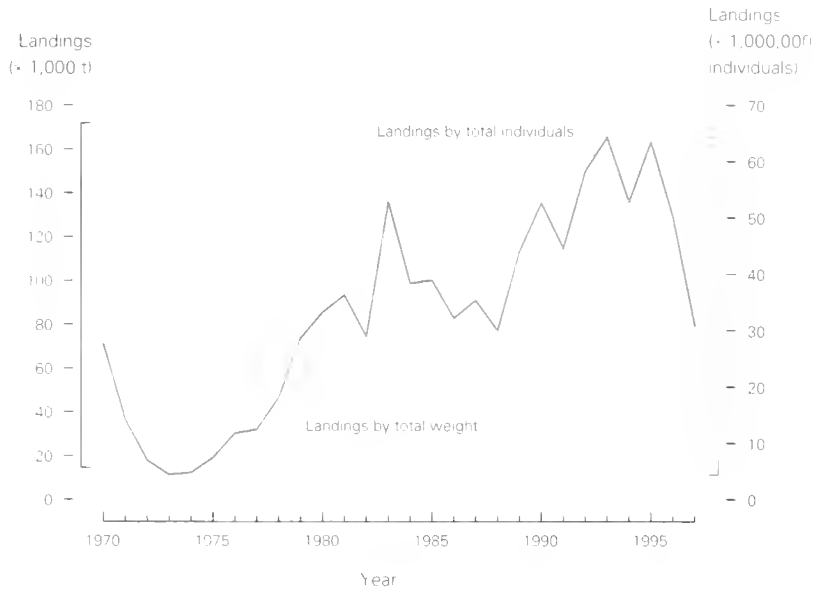


Figure 13-4
Alaska commercial landings of sockeye salmon, 1970–97, by metric tons (t) and individual fish.

Chum Salmon

Chum salmon (Figure 13-5) are harvested commercially by purse seines, drift and set gillnets, and in large western Alaska rivers by fish wheels. Statewide, over a 27-year period (1970–97), chum salmon have accounted for 9% of Alaska's salmon harvest (Figure 13-3). Over the past 5-year period (1993–97), the annual average chum salmon harvest across Alaska was 16,800,000 fish, with the 1997 harvest slightly below this average at 15,600,000 fish (Savikko, 1997). Currently, 60–70% of the commercially harvested chum salmon occur in Alaska's southeast region where hatcheries produce a significant portion of the catch.

Chum salmon runs in southwestern and western Alaska, similar to sockeye salmon, were below expectations in 1997 which added to the shortfall hardships in those regions. Management of chum salmon fisheries in western Alaska is complicated by another commercial fishery at False Pass in the Aleutian Islands. Western Alaska chum salmon may spend part of their ocean life in the Gulf of Alaska. These salmon, as maturing adults on their return migration, funnel through passes between the Aleutian Islands into the Bering Sea. The False Pass fishery, targeted primarily on sockeye salmon returning to Bristol Bay, must be managed to not overharvest chum salmon destined for the Kuskokwim and Yukon Rivers in western Alaska. Chum salmon in western Alaska are an important part of commercial fisheries in that region and a significant subsistence resource for local residents.

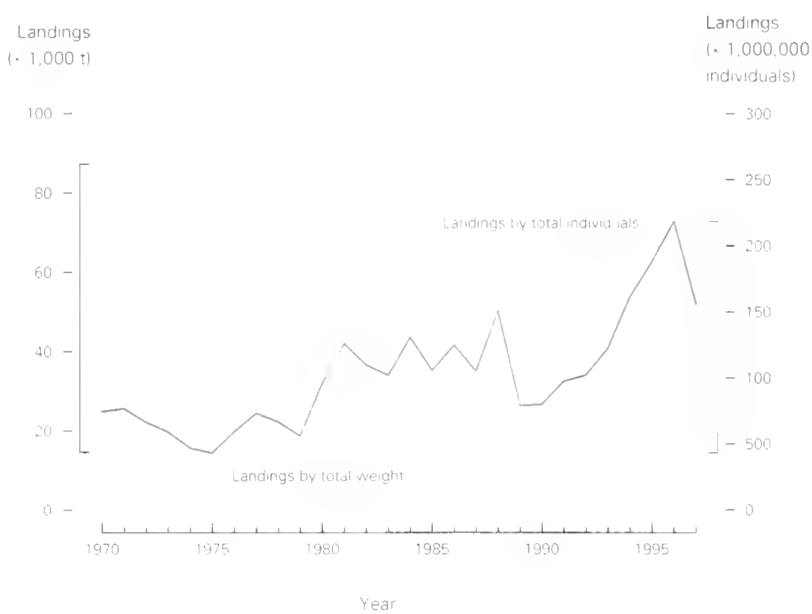


Figure 13-5
Alaska commercial landings of chum salmon, 1970–97 by metric tons (t) and individual fish.

Figure 13-6
Alaska commercial landings of coho salmon, 1970–97, by metric tons (t) and individual fish.

Coho Salmon

Commercial catches of coho salmon across Alaska in 1997, totaling 2,900,000 fish, were less than half the recent 5-year average harvest levels (Savikko, 1997) and similar to record low catches in the 1970's (Figure 13-6). This decline was most noticeable in the southeast region where marine survivals from both wild and hatchery smolts dropped significantly from recent trends. As recently as 1995 over 3,300,000 coho salmon were caught in the southeastern fisheries alone.

Coho salmon in Alaska are caught commercially by purse seines in the southeast and southcentral regions, by drift or set gillnets in all regions, and by hand and power troll gear in the southeast. Coho, along with sockeye and chinook salmon are popular target species in recreational fisheries throughout the state.

Chinook Salmon

The annual commercial harvest of chinook salmon in Alaska has averaged 500,000–700,000 fish in recent years (Figure 13-7). The statewide 10-year (1988–97) average annual harvest was 627,000 fish (Savikko, 1997). Chinook salmon, like coho salmon, are commercially harvested by purse seines in the southeast and southcentral regions, by drift or set gillnets in all regions, and by hand and power troll gear in the southeast. In addition, fishwheels harvest chinook salmon in western Alaska rivers for commercial sales and for subsistence uses.

In general, chinook salmon are the first species each year to begin spawning migrations into Alaska rivers. Only in a few Bristol Bay and western Alaska rivers are fisheries permitted to directly target these early returning runs of chinook salmon. However, in fisheries targeted on other salmon, chinook salmon are often taken incidentally. Sockeye salmon migrations into many larger river systems begin during the later portion of chinook salmon runs into the same rivers. In these cases, for example in certain Cook Inlet, and southeastern rivers, and in the Copper River near Cordova, fisheries that target sockeye salmon may catch significant numbers of chinook salmon. These fisheries may have a quota limiting the catch of chinook salmon.

The chinook salmon harvest in southeastern Alaska, where significant numbers of non-Alaska origin fish are caught, is normally regulated by a quota under provisions of the Pacific Salmon Treaty. This annual harvest quota is then reallocated among various fisheries by the Alaska Board of Fisheries, a regulatory body empowered to arbitrate which user group gets to catch how many salmon. For example, the troll fishery (both hand and power troll), which historically has been highly dependent on chinook salmon, is allocated the largest portion of the southeastern chinook salmon quota. Net fisheries in the region (purse seine and drift gillnet) primarily target pink, chum, or sockeye salmon but are provided a quota to take a limited catch of chinook salmon in pursuit of other target species. The remaining allowable quota is allocated to guided and unguided sport fisheries.

ISSUES

Value of Alaska Salmon

Although commercial harvests of Alaska salmon have been at high levels in recent years, the value of the catch has declined significantly due to a number of complex worldwide factors. Value of the record 1995 statewide catch (451,000 metric tons (t)) was $466,000,000 (ex-vessel), but this value was well below that of the 1992 harvest (312,000 t) valued at $546,000,000. A fluctuating but downward trend in value of Alaska's salmon harvest has persisted over much of the last decade (Figure 13-8). Along with the downward trend in value of Alaska salmon is a rising trend in total worldwide salmon production (Alaska Seafood Marketing Institute, 1993). Increases in world salmon production are due not only to record levels of wild salmon caught in Alaska, Japan, and Russia, but especially to the continued rapid growth in worldwide production of farmed salmon (Folsom et al., 1992). Wild salmon, in this context, also includes fish produced from hatcheries and ocean ranching programs.

Total world salmon production from capture and farmed fisheries in 1995 was about 1,500,000 t as each fishery reached record production levels. This 1995 production represents a continuation of recent trends for increased production in both fisheries and in lower prices paid to fishermen (Heard, 1996 and 1997). Decreases in prices paid for wild-caught salmon in Alaska also characterizes capture fisheries for salmon in Japan (Kaeriyama and Urawa, 1993). The largest quantities of farmed salmon are raised in Norway and Chile. In 1997, Norway's farmed Atlantic salmon production of 315,000 t (Bill Atkinson News Report, 1998) exceeded the total Alaska commercial salmon harvest of 282,800 t.

Recreational Fisheries

Recreational (sport) fishing for salmon in Alaska continues to grow. Part of this growth is due to the fact that many Alaska households use sport fishing as convenient method to collect wholesome seafood for the table. Some part of the total sport fish harvest of salmon in Alaska, therefore, might more appropriately be included in subsistence fishery statistics. But a larger part of the growth is due to increased guided recreational fishing by tourists visiting Alaska. Sport fishing for salmon in Alaska as a recreational outlet is an important pursuit for both residents and nonresidents alike. A total of 414,449 Alaska sport fishing licenses were issued in 1995, with 58% issued to nonresident anglers. More nonresident sport fishing licenses have been sold in Alaska than resident licenses since 1990 (Howe et al., 1996). Sport fishing for salmon is a vital part of the recent rapid growth in Alaska tourism.

Coho salmon were the most popular sport caught salmon in Alaska, representing 30.3% of

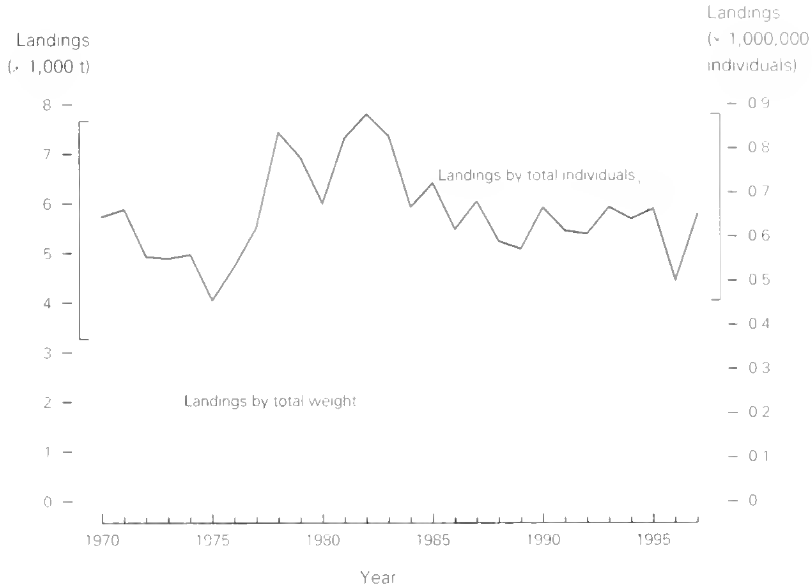


Figure 13-7
Alaska commercial landings of chinook salmon, 1970–97.

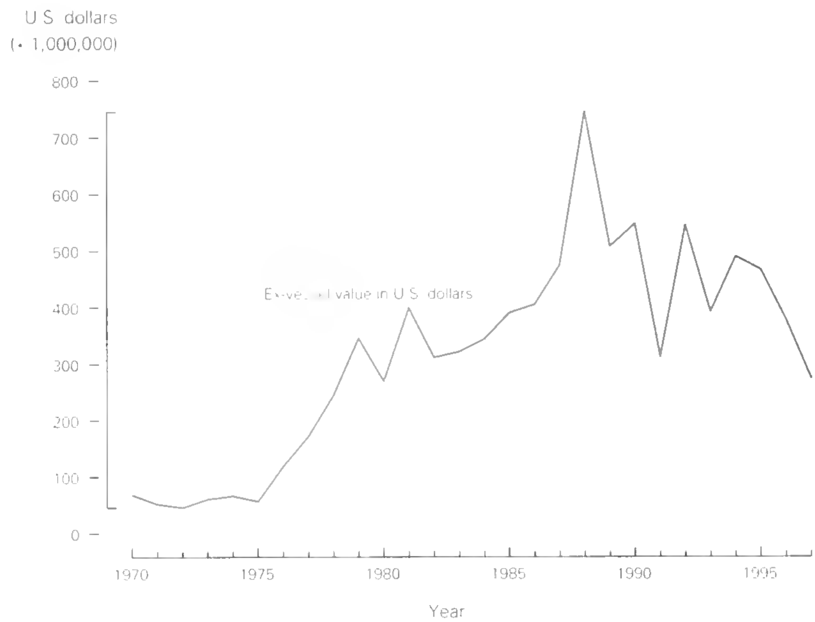
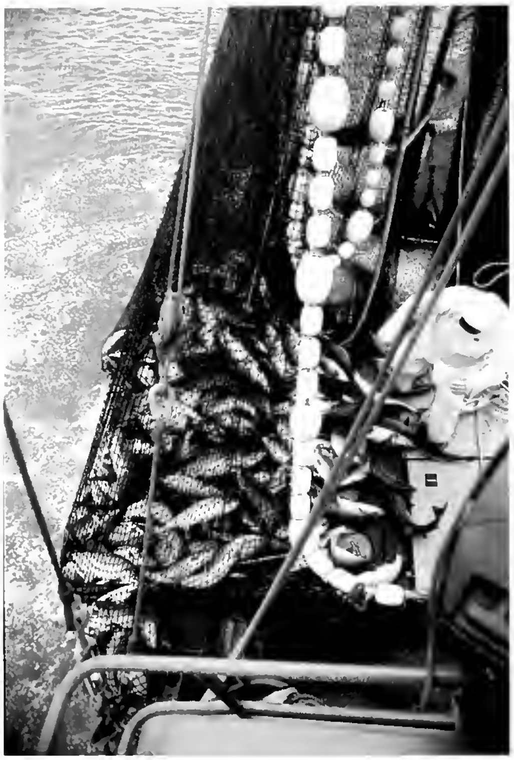


Figure 13-8
Ex-vessel value of Alaska commercial salmon landings, 1970–97.



Sockeye salmon in purse seine, off Chignik, on the south side of the Alaska Peninsula.

the 1,800,000 salmon caught by recreational fishermen in 1995 (Howe et al., 1996). Sockeye (22.5%) were the second most popular sport-caught salmon that year, followed by pink salmon (21.3%), chinook salmon (17.7%), and chum salmon (8.2%).

Bycatch and Multispecies Interactions

Bycatch of salmon by U.S. groundfish fisheries in the Bering Sea and the Gulf of Alaska remains a problem in fisheries management. Although the groundfish fisheries are prohibited from retaining any salmon they catch, about 60,000 chinook salmon were taken incidentally each year between 1992 and 1994 in these trawl fisheries. In that same period, about 173,000 other salmon (mostly chum salmon) per year were estimated as trawl bycatch. The problem is currently being addressed by the North Pacific Fishery Management Council through time-area closures and bycatch limits set for the groundfish fisheries.

Protecting Salmon Habitats

Responsible conservation of Alaska's salmon resource is a Federal responsibility shared with the state. Maintaining this renewable resource requires considered and planned use for the thousands of miles of riparian habitat in Alaska that support salmon production. Competing uses for this habitat include logging, mining, oil and gas development, and industrial and urban development. Although progress has been made in setting Federal and state land use guidelines, conflicts still occur. While working to change land use laws, natural resource managers continually face increasing demands from extractive industries to log, drill, or fill riparian habitats. An example is the continuing debate over the required size of clearcuts and buffer zones along anadromous fish streams. In its recent review of timber harvest in the Tongass National Forest, the U.S. Forest Service concluded that long-term application of current timber harvest procedures could lead to, or continue, declines in habitat productivity and eventual loss of salmonid stocks. The recent buy-back of Federal gas and oil leases in Bristol Bay is another example of long-term protection granted to the salmon resource.

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act to require the description, identification, conservation, and enhancement of essential fish habitat (EFH) in all fishery management plans throughout the United States. As a result of this legislation the EFH requirements for the Alaska salmon fishery management plan are now under development by North Pacific Fishery Management Council and the National Marine Fisheries Service (NMFS).

State resource managers deal with increasing demands of industrial developments while working to maintain productive natural habitats that support Alaska's wild salmon. To assist in meeting the need for a better understanding of the status of wild stocks, a cooperative study is underway between ADF&G, the Alaska Chapter of the American Fisheries Society, and various other agencies (including the NMFS) to provide a population status inventory of Alaska's salmon resources. The first phase of this program was recently completed for southeastern Alaska (Baker et al., 1996), and is now expanding to other regions of the state. In conjunction with this stock status survey, a correlative project, funded in part by the National Oceanic and Atmospheric Administration's Earth Science Data and Information Management program, is integrating available information on Alaska's salmon stocks into a geographic information format.

Hatcheries and Ocean Ranching

Alaska's salmon enhancement programs produce significant numbers of fish for commercial and sport harvest. While most hatcheries are now operated by private-sector regional aquaculture associations, the state manages to minimize catches of wild salmon in fisheries where large numbers of returning hatchery salmon are caught. Overfishing is of concern where wild stocks are in low abundance and spawning escapement goals may not be achieved. Prince William Sound is an area of particular concern where large returns of hatchery pink salmon mix with lower numbers of wild fish.

The present hatchery program in Alaska which began in 1974, contributed 29,400,000 salmon to commercial fisheries and 280,798 salmon to sport fisheries in 1996 (McNair, 1997). Major contributions to salmon fisheries from Alaska hatcheries vary considerably by species and region. Hatcheries in southeast made important contributions in 1996 to catches of sockeye, coho, chinook, and chum salmon; in Prince William Sound to catches of sockeye, pink, and coho salmon; in Cook Inlet to catches of chinook, coho, and sockeye salmon; and in Kodiak to catches of sockeye, coho, and pink salmon (McNair, 1997).

Interception Fisheries

Significant progress has been made to control the interception and incidental take of Alaska's salmon resources. First, a formerly legal high-seas salmon fishery by Japan, authorized by an international convention from 1952 to 1992, was terminated under the new Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean. Second, high-seas driftnet fisheries for squid by various countries that also intercepted U.S.-origin salmon stocks in the central North Pacific Ocean have been terminated by United Nations General Assembly Resolution 46/215. A remaining problem of salmon bycatch in U.S. groundfish fisheries in the Bering Sea and the Gulf of Alaska is actively being managed by the North Pacific Fishery Management Council through time-area closures and bycatch limits set for the groundfish fisheries. Interceptions of nontarget salmon species within state-managed salmon fisheries continue to be addressed by the Alaska Board of Fisheries. Negotiations continue between the United States and Canada, under the Pacific Salmon Treaty, to resolve long-standing interception issues, particularly in the northern British Columbia and Alaska boundary area, and in the Yukon River.

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Pacific Coast and Alaska Pelagic Fisheries

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Ball of Pacific herring.

Unit 14

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INTRODUCTION

Several stocks of small pelagic fish species support fisheries along the Pacific Coast from northern Mexico to Alaska. The major ones are Pacific sardine, northern anchovy, jack mackerel, chub (Pacific) mackerel, and Pacific herring. Sardine, anchovy, and the two mackerels are primarily concentrated and harvested off California and Baja California. Pacific herring are taken along the west coast from California to Alaska.

Sardine and anchovy are the most prominent of the fisheries from a historical perspective. These small pelagic fish, like Peruvian anchovy and Japanese sardine, tend to fluctuate widely in abundance. California sardines supported the largest fishery in the western hemisphere during the 1930's and early 1940's when total catches averaged 500,000 metric tons (t). Sardine abundance and catches declined after World War II (Figure 14-1), and the stock finally collapsed in the late 1950's. In the mid 1940's, U.S. processors began canning anchovy as a substitute for sardine. Consumer demand for canned anchovy, however, was low, and catches from the mid 1940's to mid 1950's averaged only 50,000 t. Catches declined and remained low before starting to increase in 1965. Together with catches from Mexico, the total catch increased to 350,000 t during 1975–80. Thereafter, U.S. catches declined due mainly to significant price reductions for fish meal. Low prices and market problems continue to prevent a significant U.S. reduction fishery for anchovy in recent years. The other small pelagic species also have a tendency to fluctuate widely in abundance.

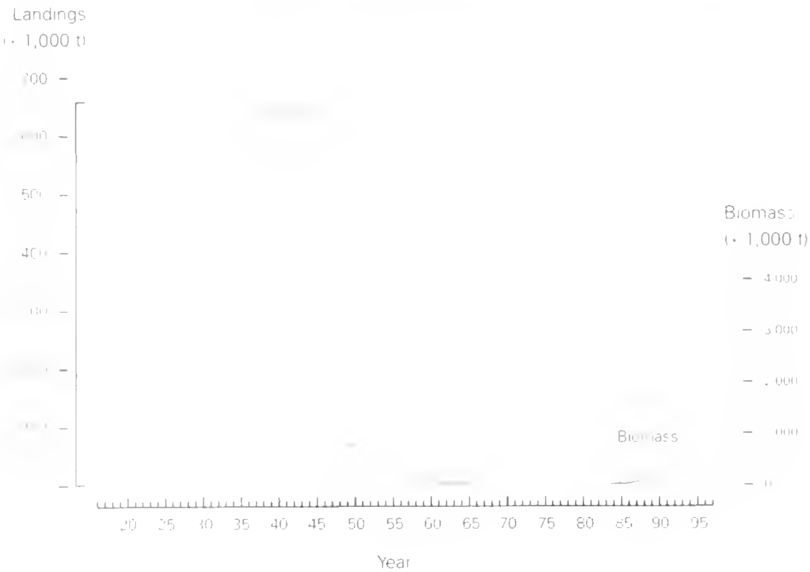

Figure 14-1
Landings and biomass of Pacific sardine, 1916–97, in metric tons (t). No biomass data are available for the time period before 1932 and for 1966–82.

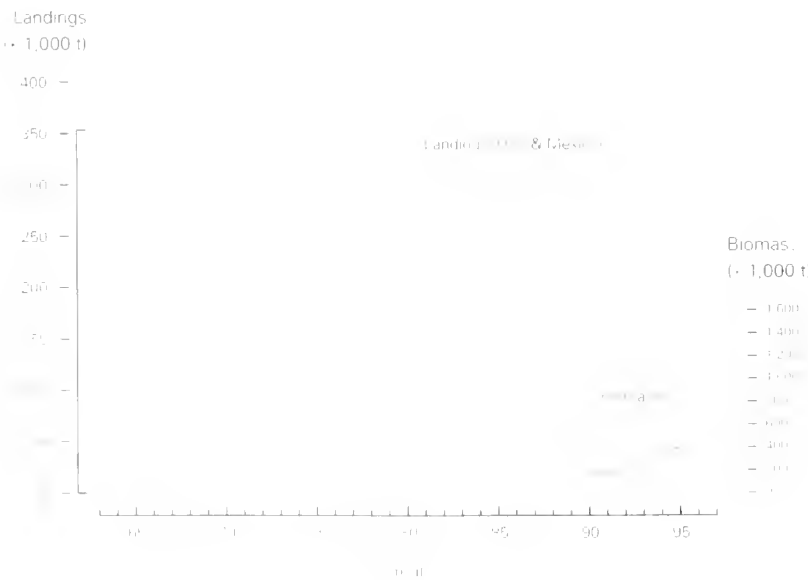

Figure 14-2
Landings and biomass of northern anchovies, 1963–97, in metric tons (t). No biomass estimates are available for 1995–97.

All these pelagic fishery resources are under management. The anchovy fishery is managed under the Northern Anchovy Fishery Management Plan by the Pacific Fishery Management Council. Pacific sardine, Pacific herring, and chub mackerel are managed by the State of California. Jack mackerel north of latitude 39° N are managed as part of the Pacific Coast Groundfish Fishery Management Plan. And the State of Alaska manages its inshore Pacific herring fishery.

PACIFIC COAST PELAGIC FISHERIES

Pacific Sardine

California's Pacific sardine abundance has gone through boom-and-bust cycles (Figure 14-1). The decline of the resource, from a biomass of more than 3,000,000 t in the 1930's to immeasurable low levels (a few thousand metric tons) in the 1970's, stimulated much debate as to whether fishing or an adverse natural environmental period was to blame. In retrospect, the intense fishing pressure on the resource at that time probably accelerated a long-term pattern of natural decline. The biomass of sardines remained negligibly low for about 40 years. Since 1986, sardine biomass has increased by 30–40% annually, and quotas have been allowed for commercial fishing. The biomass in 1997 was about 600,000 t.

In the past, sardines were harvested for fish meal, bait, and human consumption. Currently, there is no fish meal (reduction) fishery. Sardines are now taken for human consumption and bait. Commercial demand for sardines is strong and, as resource abundance grows, the fishery is expected to revive. Thus, the sardine resource is recovering rapidly. Current potential yield is 63,000 t or about 44% of the long-term potential yield (Table 14-1).

Northern Anchovy

Northern anchovy, fished off California and Mexico, are divided into several subpopulations. The central subpopulation of the resource is the one that supports most of the U.S. fisheries. Anchovy are harvested for reduction into fish meal, oil, and soluble protein products. Other uses include human consumption (fresh, frozen, canned, and paste), and as bait (live and frozen) for recreational fisheries.

Anchovy landings in California have fluctuated

Area and species	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Pacific Coast					
Northern anchovy	11,000	88,000	120,000	Under	Near
	(4,000)[1]	(62,000)[1]	(84,500)[1]		
Pacific sardine	69,000	63,000	145,000	Full	Near
	(35,000)	(32,000)[1]	(73,700)[1]		
Jack mackerel	2,000	100,000[2]	100,000[2]	Under	Above
Chub mackerel	20,000[1]	22,000[1]	28,000	Full	Near
Pacific herring[3]	6,000	6,000	7,000	Full	Near
Alaska					
Pacific herring					
Gulf of Alaska	11,500	15,900	Unknown	Full	Near
Bering Sea	34,000	39,300	Unknown	Full	Near
Total	153,500	334,200	455,200		
Total (U.S.)	112,500	277,200	348,400		

[1]U.S. (California) only
[2]Crude estimate
[3]Uses 1995 data only

Table 14-1
Productivity in metric tons and status of Pacific Coast and Alaska pelagic fishery resources.

more in response to market conditions than to stock abundance. Figure 14-2 shows the historical catch trend for the United States and Mexico. Landings by the United States have varied from less than 10,000 t to nearly 140,000 t. Since 1983, U.S. landings have been low (less than 10,000 t), and they have been used mostly for live bait and other nonreduction uses. The biomass trend for the anchovy resource (Figure 14-2) hit a peak of 1,400,000 t in 1985 and declined steadily to 126,000 t by 1994.

The well being of ecologically related species in the marine ecosystem is an important factor in management of the anchovy resource. The endangered brown pelican, for example, depends on anchovy as an important food source. Thus, the fishery management plan has specified a threshold for its optimum-yield determination to prevent anchovy depletion and provide adequate forage for marine fishes, mammals, and birds.

The anchovy resource is presently at a moderate level of abundance. Current potential yield is 88,000 t or 72% of the long-term potential yield (Table 14-1), but recent catches have been much lower (less than 10,000 t) due to a lack of commercial markets.

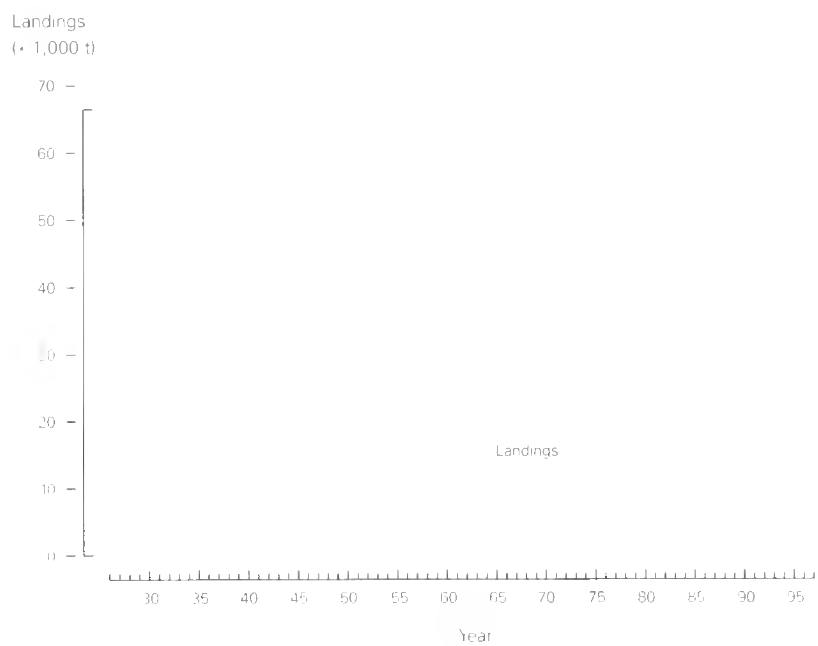

Figure 14-3
Landings of jack mackerel off California, 1926–97, in metric tons (t).

Jack Mackerel

Jack mackerel catches have fluctuated widely with changing market demands and the ability of the fleet to fish for other species which were more profitable or available, especially sardines and chub mackerel. In addition, the availability of jack

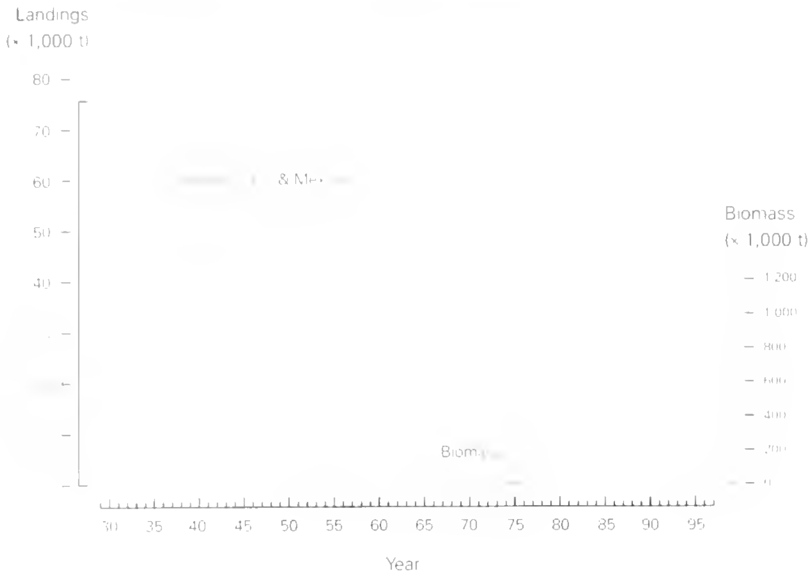

Figure 14-4
Landings and biomass of chub mackerel, 1929–97, in metric tons (t).

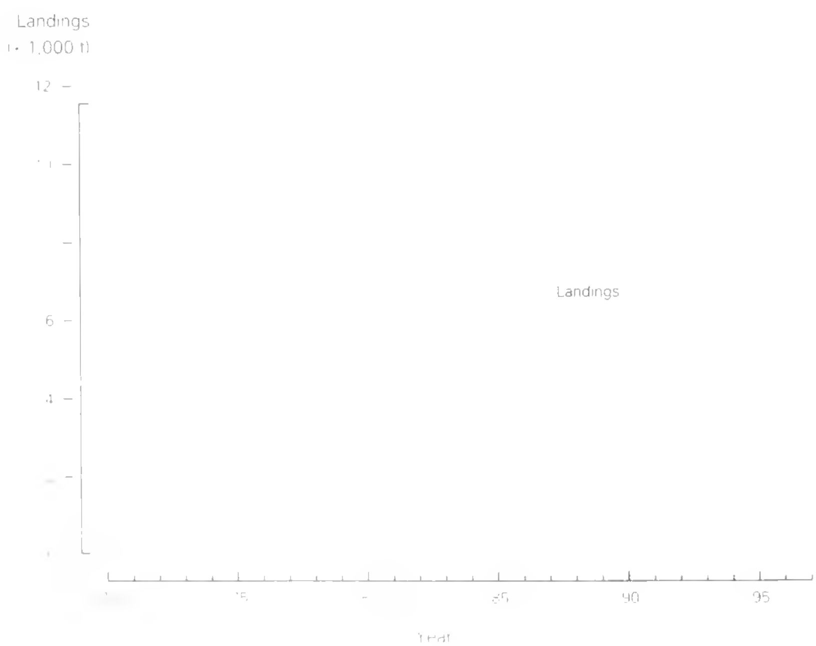

Figure 14-5
Commercial landings of Pacific herring, 1970–97, in metric tons (t).

mackerel can also be very erratic. Jack mackerel has two distinct behavior patterns during its life cycle: juveniles are found inshore off southern California and Baja California, while adult fish are distributed offshore and farther north, in some years as far as the Gulf of Alaska. Adult jack mackerel found offshore are sometimes caught incidentally by trawlers, particularly those targeting Pacific whiting.

The foreign trawl fisheries of the 1970's resulted in jack mackerel being placed in the groundfish fishery management plan, and a bycatch quota of 12,000 t/year (north of latitude 39° N) was set. Restrictions on fishing for other groundfish species, including Pacific whiting, were thus avoided. The recent history of jack mackerel commercial landings, mostly as incidental catch, is shown in Figure 14-3. In 1991, interest in jack mackerel increased, and the catch limit was raised to 52,000 t to allow a target fishery to operate. While this fishery has not yet materialized, signs of commercial interest continue. A purse-seine fishery for jack mackerel has continued at a low level. Currently, it has no catch limit. Jack mackerel have been occasionally important to the partyboat sport fishery off southern California. It is also fished recreationally off piers.

Assessment and management of jack mackerel are difficult because of limited data and its broad distribution. The most recent estimate of biomass was made in 1983. Spawning biomass was estimated at 1,500,000 t, and total biomass at 1,630,000–1,990,000 t. Its potential yield is little more than an educated guess at this time (Table 14-1).

Chub (Pacific) Mackerel

Chub mackerel has a worldwide distribution in temperate and subtropical seas. On the Pacific coast, it is most abundant south of Point Conception, Calif. It supported one of California's major fisheries during the 1930's–40's and again in the 1980's. It was second only to sardine during the heyday of the southern California sardine fisheries in the 1930's–40's. The peak catch reached 73,000 t in 1935 and declined steadily thereafter. In 1970, a moratorium was placed on the fishery after the stock collapsed.

A series of successful year classes in the late 1970's stimulated a recovery of the stock, and the fishery was reopened under a quota system in 1977. The resource is now harvested by three separate fisheries: the California commercial fishery, a sport fishery, and a Mexican commercial fishery. The recent U.S. harvest history is shown in Figure 14-4. From 1980 to 1989, the California recreational catch averaged 1,462 t/year.

The trend in chub mackerel biomass is also shown in Figure 14-4. Recent peak abundance was 754,000 t in 1982. Abundance has since declined to about 20,000 t by 1995 and has stabilized there. Analyses of fish-scale deposits in ocean bottom sediments off southern California indicate that the prolonged period of high chub mackerel biomass levels during the late 1970's and 1980's may have been unusual and would only be expected to occur, on average, about once every 60 years. In 1985, it was estimated that chub mackerel might sustain average yields between 26,000 and 29,000 t/year under management systems similar to that currently used to manage the stock by the State of California. The commercial catch is currently restricted by a quota of about 32,000 t. If the biomass dips below 18,000 t, commercial fishing will be stopped.

Pacific Herring

Pacific herring are fished primarily off California. The fishery in Puget Sound, Wash., is small by comparison. The fishery off California has peaked three times during this century: during 1916–19 near 3,600 t, during 1947–53 near 4,500 t, and above 10,000 t in 1982 (Figure 14-5). In the earlier years, herring were harvested for reduction into fish meal and for pet food and bait. Some were canned to supplement the declining supply of sardines. Canned herring proved to be a poor substitute for sardines, and the fishery for human consumption ended in 1954.

Since 1973, herring in California have been harvested primarily for their roe for export to the Japanese market. Landings declined in 1984 when El Niño caused a corresponding decline in the herring population. However, most stocks have recovered somewhat and so have catches. The herring roe fishery is limited to California's four largest herring spawning areas: San Francisco Bay, the Tomales-Bodega Bay area, Humboldt Bay, and the Crescent City harbor. San Francisco Bay has the largest spawning population of herring and supplies over 90 percent of the state's herring catch. The four spawning areas are managed separately by the California Department of Fish and Game, with catch quotas based on population estimates.

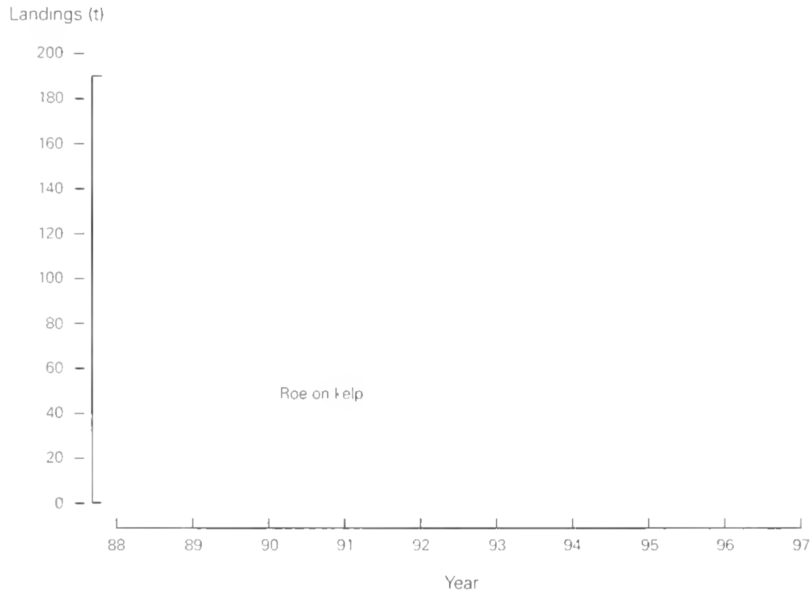

Figure 14-6
Landings of herring roe and kelp from the roe-on-kelp fishery in California, 1988–97, in metric tons (t).

Another lucrative phase of the herring industry is the roe-on-kelp fishery. Beginning in 1965, scuba divers harvested species of marine vegetation with herring eggs attached in Tomales and San Francisco Bays. This product is exported to Japan as a holiday delicacy. The fishery has evolved into the present roe-on-kelp fishery. Giant kelp is harvested from the Channel Islands off southern California, brought to San Francisco Bay, and suspended from 60×40 foot floating rafts. The rafts are towed to areas where herring spawning is expected to occur and are anchored. After spawning has ended, the kelp with herring eggs attached is removed from the rafts and packed in salt. Catches have been generally low (Figure 14-6) but valuable.

Allen Shimada, NMFS

Pacific herring and roe-covered kelp.

The herring spawning populations in Tomales and San Francisco Bays are estimated annually from hydroacoustic and spawning ground surveys. The spawning biomass has fluctuated widely in both areas since the 1983 El Niño through the more recent 1997–98 El Niño. The 1996–97 season estimates were a relatively low 1,331 tons in Tomales Bay and a relatively high 81,260 t in San Francisco Bay. Humboldt Bay supports a

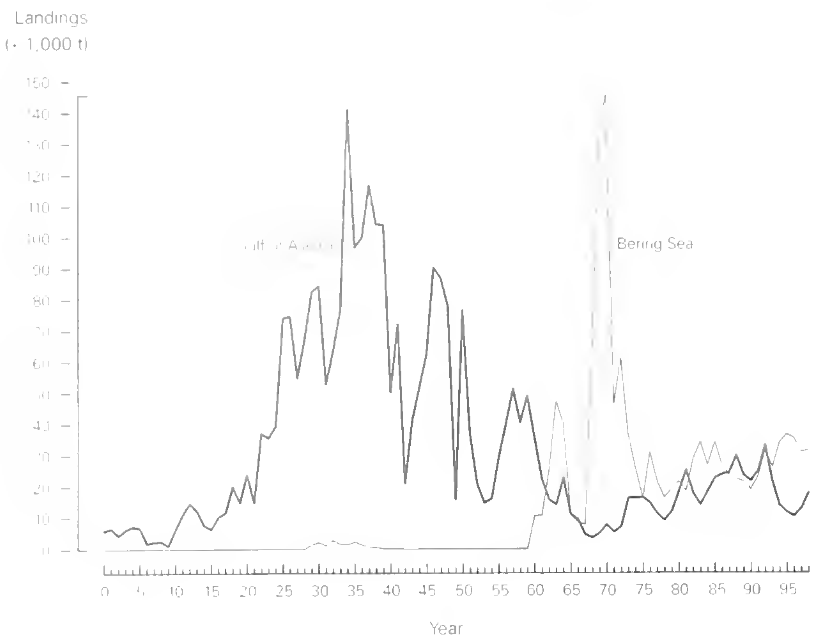

Figure 14-7
Landings of Pacific herring off Alaska, 1900–98, in metric tons (t) (1998 is an estimate of sac roe only).

smaller spawning stock, estimated in 1991 at 400 tons. Population estimates have not been made for the Crescent City herring stock, but observed spawning suggests that the population is large enough to support a minor fishery there.

ALASKA PELAGIC FISHERIES

Pacific Herring

Pacific herring is the major pelagic species that is harvested in Alaska. The fisheries occur in specific inshore spawning areas of the Gulf of Alaska and the Bering Sea. In the Gulf of Alaska, spawning fish concentrate mainly off southeast Alaska, in Prince William Sound, and around the Kodiak Island-Cook Inlet area. In the Bering Sea, the centers of abundance are in northern Bristol Bay and Norton Sound. This fishery occurs within state waters (3-mile limit), and it is therefore monitored and managed by the Alaska Department of Fish and Game by 20 separate fishery statistical areas.

Herring spawn every year after reaching sexual maturity at 3 or 4 years of age. The number of eggs varies with the age of the fish and averages 20,000. Average life span for these fish is about 8 years in southeast Alaska and up to 16 years in the Bering Sea.

Alaska's herring industry began as early as 1878 when 30,000 pounds were marketed for human consumption. The total value was $900. By 1934 the catch had reached a record 140,000 t. The Bering Sea fishery began in the late 1920's. A large foreign offshore fishery developed in the 1950's and peaked dramatically in 1970 at more than 145,000 t. It then fell off sharply to 16,000 t in 1975 (Figure 14-7). Since 1977 Bering Sea herring have been harvested primarily in inshore sac roe fisheries, and catches have since risen slowly but steadily, reflecting better stock conditions. A portion of the Bering Sea harvest is taken as bycatch in the groundfish fishery. Regulations now limit bycatch to about 1,000 t.

From catch records, it is evident that herring biomass fluctuates widely due to influences of strong and weak year-classes.[1] Currently the herring populations in Alaska remain at moderate levels and are in relatively stable condition, with the exception of Prince William Sound. Herring abundance levels typically increase abruptly following major recruitment events, then decline slowly over a number of years because of natural and fishing mortality. Prince William Sound herring continue to be depressed from a disease outbreak in 1993, but have recovered to above-threshold levels. In more recent years, statewide herring harvests have averaged about 45,000 t with a value averaging around $30,000,000. About 10% of the commercial harvest is taken for food and bait, and the rest is taken in the sac roe fisheries. In addition, there is a roe-on-kelp fishery that harvests about 400 t of product annually with a value of around $3,000,000. The 1998 sac roe fisheries was forecast to be about 45,900 t, with a stock status ranging from moderate to high, while the Prince William Sound status remains at a depressed level.

ISSUES

Transboundary Stocks and Jurisdiction

Mackerels, sardines, and anchovy are transboundary stocks exploited by both U.S. and

[1] A year-class comprises the new generation of young fish entering a stock in the same year.

Gathering roe on kelp, Summit Island, Togiak Bay, Alaska.

Mexican fleets, but no bilateral management agreement has yet been reached for coordinated management of the stocks. Harvest levels are increasing in Mexican waters, and the absence of a governing bilateral agreement is compromising management of the same stocks that both countries fish.

Underutilized Species

Jack mackerel is an underutilized species, while the Pacific sardine is increasing in abundance after decades at low levels. These species may support an increased harvest by U.S. fishermen in the near future.

PROGRESS

National Marine Fisheries Service scientists continue to work closely with state biologists and the Pacific Fishery Management Council in assessing and managing the stocks. Stock assessment models have been developed for northern anchovy, Pacific sardine, and chub mackerel. The new models are more reliable and precise than earlier ones. The models now use more data, including fish-spotter data from pilots employed by commercial fishermen, and the California Cooperative Oceanic Fisheries Investigations' long-term ichthyoplankton data base.

FOR FURTHER READING

California Cooperative Oceanic Fisheries Investigations (CALCOFI) Reports, volumes 36–39.

Hill, K. T., M. Yaremko, L. D. Jacobson, N. C. H. Lo, and D. Hanan. 1998. Stock assessment and management recommendations for Pacific sardine (*Sardinops sagax*) in 1997. California Department of Fish and Game Administrative Report 98-5.

Yaremko, M., J. T. Barnes, and L. D. Jacobson. 1998. Status of the Pacific mackerel resource during 1997 and management recommendations for the fishery. California Department of Fish and Game Administrative Report 98-3.

Pacific Coast Groundfish Fisheries

Canary rockfish.

Unit 15

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INTRODUCTION

The groundfish fishery off Washington, Oregon, and California is conducted across a diverse range of habitats and involves tens of species and several fishing gears. Domestic landings averaged about 30,000 metric tons (t) per year prior to the early 1970's (PFMC, 1997). A foreign fishery began in the early 1960's for Pacific ocean perch and Pacific whiting. The long-lived Pacific ocean perch stock is still recovering from the excessive foreign harvest that occurred during the 1960's, but the fishery for the more productive Pacific whiting stock evolved into a healthy joint venture, then to a wholly domestic fishery in 1991.

By 1977, when work by the Pacific Fishery Management Council on the Groundfish Fishery Management Plan began, domestic landings of all groundfish had increased to 60,000 t, and by 1982, when the fishery management plan was implemented, landings peaked at 116,000 t (PFMC, 1997). The recent yield of groundfish (other than Pacific whiting) has returned to an average of about 56,000 t.[1] Present yields may be sustainable for some species involved, but several of the stocks are depressed. Many stock assessments do not have sufficient data to be precise, and substantial natural fluctuations occur in some species.

Several assemblages of fish contributed to the $98,500,000 groundfish fishery in 1997 (Figure 15-1). The midwater trawl fishery for Pacific whit-

[1] Landings and value data since 1981 are available from the PacFIN data base, Seattle office of the Pacific States Marine Fisheries Commission, 7600 Sand Point Way NE, Seattle, WA, 98115.

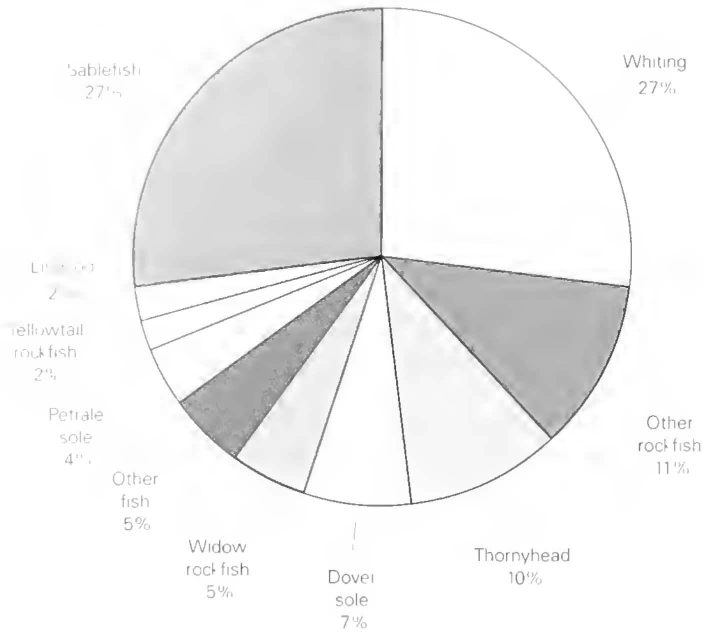

Figure 15–1
Relative components of Pacific Coast groundfish total value in 1997.

ing dominated the tonnage (Table 15-1), but Pacific whiting and sablefish contributed equally high values in 1997 (Figure 15-1). A deep-water trawl fishery for sablefish, thornyheads, and Dover sole now operates out to near 1,500 m depths. This trawl fishery and a longline and pot fishery for sablefish was worth $43,500,000 in 1997, with sablefish and thornyheads contributing about 63% of this total.

On the continental shelf and extending into the nearshore reef habitat is a trawl and hook-and-line fishery for tens of rockfish (*Sebastes*) species that was worth $16,800,000 in 1997. Widow rockfish contributed 27% and yellowtail rockfish contributed 10% of this total value. An associated species is lingcod with landings worth $1,700,000 in 1997 (PFMC, 1997). In addition, lingcod and some species of rockfish have substantial recreational harvests in some areas.

Catch of nearshore flatfish (Petrale sole, English sole, sanddab, sand sole, and starry flounder) was worth $6,100,000 in 1997, with 64% coming from Petrale sole. Fishing and processing participants in the groundfish fishery also commonly engage in fisheries for shrimp, halibut, Dungeness crab, salmon, and albacore tuna. In 1997, the groundfish fishery contributed 38% of the total $206,000,000 for these named fisheries (PFMC, 1997).

Management Situation

Recommendations for management of the Pacific Coast groundfish fisheries are developed by the Pacific Fishery Management Council. The Groundfish Fishery Management Plan calls for establishment of an annual acceptable biological catch and harvest guideline for major groundfish species (PFMC, 1997). Although brief, derby-style fisheries of a few weeks or days duration have been used for a portion of the Pacific whiting and fixed gear sablefish harvests, most elements of the fishery have a goal of year-round operations.

Achievement of a year-round fishing opportunity in the face of excessive fishing effort has been achieved by imposition of limits on individual vessels. These limits have evolved from trip limits for widow rockfish beginning in 1983, to monthly cumulative limits for each vessel for each of several species today. Inseason adjustment of these limits has been mostly successful in keeping the annual catch close to the harvest guideline while allowing year-round fishing opportunities. However, some abrupt changes to the limits have been disruptive to the industry, and the restrictive nature of these limits causes discard of excessive catches.

In an attempt to reduce discarding, fishermen are presently allowed to bring in up to 10% over their monthly limit and have the excess deducted from the other month in designated 2-month periods (PFMC, 1998). The expected level of discard is taken into account when setting the annual harvest guideline below the acceptable biological catch. Development of observer programs to estimate the amount of discard, biological studies to understand the mortality rate of discarded fish, and study of co-occurrence patterns among species is needed.

In 1994, a limited entry program was implemented for the groundfish fishery (PFMC, 1997). The transferable limited entry permits have endorsements for vessel size and primary gear in order to maintain the existing fleet composition. A formula for combining of permits from smaller vessels into a single permit for a larger vessel has allowed several large (>200 ft) catcher-processors to buy permits and participate in the Pacific whiting fishery. Implementation of the limited entry

Table 15–1

Productivity in metric tons and status of Pacific Coast groundfish.

Species and area	Recent average yield (RAY)[1]	Current potential yield (CPY)[2]	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY[3]
Pacific whiting[4,5]	291,067	290,000	336,000	Full	Below
Pacific whiting (U S)	207,971	232,000	268,000		
Sablefish	8,022	5,625	9,800	Full	Below
Lingcod[5,6]	2,890	1,532	3,100	Over	Below
Lingcod (U S)	1,966	960	1,943		
Pacific cod	515	3,200	Unknown	Under	Unknown
Flatfishes					
Arrowtooth flounder	2,257	5,800	Unknown	Under	Unknown
Dover sole	10,930	9,426	16,300	Full	Near
English sole	1,263	3,100	3,100	Under	Above
Petrale sole	1,810	2,700	2,700	Full	Near
Other flatfish[7]	2,278	7,700	Unknown	Unknown	Unknown
Rockfishes					
Bocaccio	863	654	~1,800	Full	Below
Canary rockfish	1,054	1,130	~1,250	Full	Below
Chilipepper rockfish	1,846	3,400	<4,000	Under	Near
Pacific ocean perch	800	2	1,100	Over	Below
Shortbelly rockfish	38	23,500	23,500	Under	Above
Thornyheads	6,514	4,103	6,600	Full	Near
Yellowtail rockfish[5]	5,232	4,886	<6,700	Full	Below
Yellowtail rockfish (U S)	4,073	3,539	4,853		
Widow rockfish	6,426	5,750	6,700	Full	Below
Other rockfish[6]	7,766	8,750	Unknown	Full	Unknown
Other groundfish	1,693	14,700	Unknown	Unknown	Unknown
Total (U S)	268,085	336,039	391,796		
Total (U S +Canada)	353,264	395,958	462,800		

[1]RAY is the average 1995–97 landed commercial catch as reported to the Pacific Fisheries Information Network (PacFIN) (Pacific States Marine Fisheries Commission, 45 SE 82nd Drive, Suite 100, Gladstone, OR 97027)

[2]CPY is taken from the Pacific Fisheries Management Council's Acceptable Biological Catch for 1998 (PFMC, 1997)

[3]Stock status compared to the stock size that would produce LTPY

[4]Includes tribal catch

[5]Stock as defined crosses Canadian border Estimates of Canadian catch are from Martin Dorn (personal communication, NMFS AFSC RACE, 7600 Sand Point Way, Seattle WA 98115) for Pacific whiting, Jack Tagart (personal communication, Wash Dept Fish & Wildl Fish Management Program Marine Resources Division, 600 Captial Way N , Olympia, WA 98501), for yellowtail, and the 1997 lingcod stock assessment (PFMC, 1997) Canadian catch in 1997 is assumed equal to 1996

[6]Recreational catch estimates were added to the commercial catch estimates 438 t lingcod, 200 t bocaccio and 1,980 t other rockfish including 600 t black rockfish

[7]Does not include halibut

Pacific whiting.

system has been beneficial in creating a well-defined set of participants, but it has not decreased the number of participants sufficiently to allow for increases in the monthly vessel limits. Nonpermitted vessels may participate in a small-scale, open access fishery.

Other major restrictions on the groundfish fishery include a minimum mesh size on trawls to allow escapement of undersized fish, and area/season restrictions on the whiting fishery to decrease bycatch of salmon.

Species and Status

The Pacific coast groundfish fisheries are generally managed with a constant proportional rate of harvest such that the expected level of egg production (or spawning biomass) per recruit will be 35 or 40% (for rockfish) of the unfished level. The exception is Pacific whiting, which has a more conservative and varying harvest rate in recognition of the extreme natural fluctuations in recruitment.

Because many groundfish species have longev-

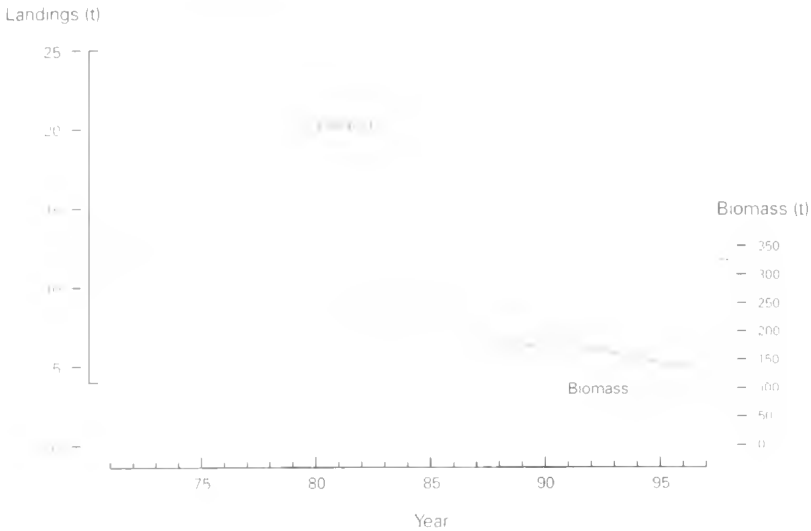

Figure 15–2

Total landings and estimated stock biomass (fish over 2 years of age) in metric tons (t) of sablefish off the U.S. Pacific Coast.

ity in the 40–100 year range, the annual exploitation rates that achieve the spawning biomass per recruit goal are often as low as 5–10%. Thus, it has taken many years for these low exploitation rates to reduce the stock abundance from the lightly exploited levels of the 1960's to the fully exploited levels of today (Figure 15-2). Reductions in recommended annual harvest amounts over the past decade for sablefish, widow rockfish, and some other species has been a direct result of this "fishing down" of the surplus biomass. In no case has the fishing down been smoothly along a constant rate of exploitation. Rather, imprecise stock assessments, insufficient staff to revise assessments frequently, and natural fluctuations in abundance contribute to changes in recommended harvest levels.

The groundfish stocks are generally fully utilized, although a few species such as shortbelly rockfish remain essentially underutilized because of a lack of market. Pacific whiting is fully utilized, but its abundance has been on a decline because of a lack of strong recruitment since the 1984 year class.

The four species in the deep-water fishery are near full utilization. Within this set, sablefish abundance may be below the level needed to produce the long-term potential yield, due in part to a recent series of weak year classes. Dover sole abundance is slightly increasing as a result of an estimated above-average 1990 year class and reduced catch levels in 1994–96. The abundance of shortspine thornyheads appears to be below its target level, and the deeper living, smaller bodied longspine thornyhead has not yet been fished down to its target level. However, the assessments for all four of these species have considerable uncertainty, and the sablefish and shortspine thornyhead assessments have been subject to a high level of scrutiny and criticism from the fishing industry.

Within the set of rockfish, widow rockfish is estimated to be below the target level of abundance, based on estimates of low recent recruitments to the fishery. Off California, the chilipepper rockfish stock is declining with the passing of the extremely large 1984 year class, while bocaccio is at a low stock level with reduced recruitment levels since the 1977 year class (PFMC, 1997). Off Oregon and Washington, the canary rockfish is estimated to be below or close to the level needed to produce the long-term potential yield, based on an estimated downward trend in recruitments during 1987–95.

In that same area, yellowtail rockfish stock biomass also apparently continues to decline, but there is substantial uncertainty in the recent stock estimates. Pacific ocean perch appears to be only slowly rebounding from overharvest that occurred in the 1960's. The current level of catch, intended as bycatch in other groundfish fisheries, is close to the overfishing level. Black rockfish, an important recreational species off Oregon and Washington, appears fully utilized and probably is near its target level of abundance.

An assessment of eight additional rockfish species indicated that some species have catches much greater than their current potential yield, while others may be underutilized due to market restrictions. However, the precision of all these rockfish

Kelp greenling

assessments appears low, given the amount of available information. For other species of rockfish, no estimates of abundance and exploitation rates are available.

A recent lingcod assessment in the northern area indicated that harvest over the past decade has equaled or exceeded the overfishing level since 1990. The stock has continued to decline due to the high exploitation rates and steadily declining recruitment since 1980. Among the other flatfish species, English sole appears to be at a high level of abundance due to large recent recruitments, and Petrale sole is near its target level of abundance and yield.

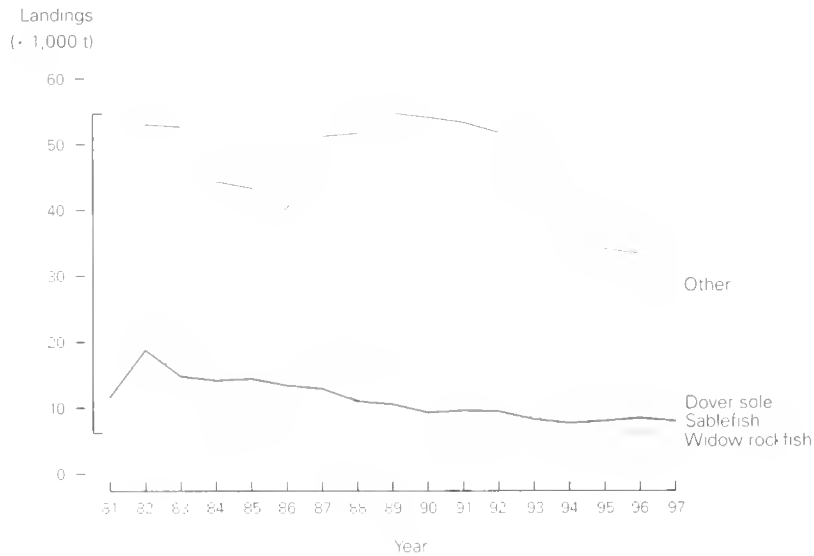

Figure 15–3
Pacific Coast commercial groundfish landings in metric tons (t), excluding Pacific whiting

Recreational Fisheries

The non-salmon recreational fishery harvests a diverse collection of nearshore fishes, including many species of groundfish managed by the Pacific Fishery Management Council. Coastwide sampling of the recreational fishery resumed in 1993 after a 3-year break. Valuation of the recreational fishery for groundfish is important, but more difficult than estimating the magnitude of the catch. In some cases, proxy values from the recreational fishery for salmon have been used in estimating the economic impact of changing regulations for the recreational groundfish fishery.

Among the groundfish species, the recreational component is particularly important for lingcod and some species of rockfish. In 1995, the recreational catch of rockfish off California was estimated at 2,800,000 fish[2]. This may represent approximately 1,400 t, so it was an important component of the estimated 8,400 t of rockfish (excluding thornyheads and widow rockfish) harvested in California in 1995.

Off Washington and Oregon, the charter boat fishery has relied on black rockfish to offset declining opportunities to fish for salmon. In recent years, the recreational catch of black rockfish has been about 300 t in each of these states. Commercial catch of black rockfish has been less than one-third of that amount. The Pacific Fishery Management Council has supported initiatives to provide long-term protection for this recreational fishing opportunity by recommending spatial segregation between recreational and commercial fisheries for black rockfish, and by imposing restrictive trip limits and bag limits on the commercial and recreational fisheries, respectively.

Landings

The landed catch of most species is well-monitored through a system of state fish landing receipts and collation of computerized copies of these receipts into the centralized Pacific Fisheries Information Network (PacFIN) database. Unfortunately, funding for biological sampling of the landings is inadequate, so the species composition of mixed rockfish landings is not well known, and size and age composition data are not adequate for many species.

The combined U.S.-Canada harvest of Pacific whiting reached a record level of 358,900 t in 1994 (of which 252,700 t were caught in U.S. waters). The increase in 1994 was due to a new stock assessment based on an expanded and improved survey. However, the stock's spawning biomass continued to decline due to reduced recruitment, resulting in lower available total yields in 1995–97 (Table 15-1).

The landed catch of non-whiting groundfish has generally declined since 1989, reaching ap-

[2]Marine Recreational Fisheries Statistics Survey data. NMFS Office of Science and Technology, Fisheries Statistics and Economics Division, Silver Spring, MD 20910.

Lingcod.

proximately 54,000 t in 1997. Several major stocks such as Dover sole, sablefish, and widow rockfish contributed to this decline (Figure 15-3) as the stocks were fished down and year classes entering the fisheries were estimated to be at low levels (PFMC, 1997). Table 15-1 documents the recent average yield (1995–97) for those species that contributed substantially to the landings, or were identified with a specific landings target (acceptable biological catch and/or harvest guideline) by the PFMC.

ISSUES AND PROGRESS

Balancing Between Competing Users

Management of the Pacific coast groundfish fisheries involves old and new allocation issues. The Pacific whiting available yield is allocated first between the United States and Canada and then between shoreside and at-sea deliveries within the United States. The two countries have not come to full agreement on any allocation scheme. Thus, the United States now sets its harvest guideline at 80% of the overall acceptable biological catch, and Canada sets its harvest guideline such that it will be 30% of the combined harvest guidelines. This resulting overharvest has contributed to the stock's decline in recent years.

The sablefish harvest guideline is allocated between a Native American fishery, an open access fishery, limited entry trawl, and limited entry fixed gear. The allocation between limited entry and open access is by a fixed percentage for each species as established in the fishery management plan, but the level of allocation to open access has the potential to become more contentious for lingcod and some rockfish. Direct allocation between recreational and commercial fisheries has not occurred; however, management actions on black rockfish have been designed to preserve recreational fishing opportunities for this species. Recent lingcod management has reduced both the commercial and recreational catches to achieve the increasingly lower total harvest allowed.

Indirect allocation between high capacity and low capacity participants affects many management issues. For Pacific whiting, the direct allocation between a brief at-sea fishery and a protracted fishery for shoreside deliveries is partly a consequence of this issue. For fixed-gear sablefish, the debate in recent years has been between an ever-shortening derby-style fishery, movement to an individual transferable quota fishery (which could favor high capacity participants), or movement to a protracted trip-limit fishery (which could favor low capacity participants). For trawlers, the decline in trip limits over the past decade has had the greatest impact on the vessels that already invested in advanced harvesting capability, yet did not greatly deter other vessels from increasing their capability.

Bycatch considerations have not much entered into allocation arguments, partly because the lack of a comprehensive at-sea observer program has hindered collection of data on the magnitude of bycatch. For example, past arguments over trawl versus fixed gear allocation of sablefish hinged on intractable questions regarding whether sablefish was a target fishery for trawlers or an unavoidable bycatch as they targeted other species. More recently, an estimate of Pacific halibut bycatch in the groundfish trawl fishery has increased the potential for this to become a new allocation issue. Both of these issues need better estimates of the amount of discards and the survival rate of discarded fish.

Ecosystem Considerations

Accurate, long-term predictions of potential yield will require a substantial increase in our knowledge about competitive and predatory interactions in the biological system that includes Pacific Coast groundfish, and about climate effects on this community. The target exploitation rate for most groundfish species is designed to achieve a large fraction of maximum potential yield, while reducing the abundance of spawners by about two-thirds, in expectation that this will not reduce the mean recruitment level. However, we have been monitoring some of these stocks for not much more than the span of just one of their generations. Only decades of monitoring the stock's performance will ascertain the long-term feasibility of these targets, and the degree of natural fluctuation that will occur while maintaining these targets. Unfortunately, there is little historical data, and the current level of stock assessment data is not adequate to precisely track changes in abundance for more than a few species. In addition, only a low level of effort is directed towards food habits studies that may help predict how the interactions among species may change as the abundance of several major species is reduced below unfished levels.

Models of long-term potential yield depend on assumptions of constant average environmental conditions or an ability to predict changing conditions. There is evidence of a decline in zooplankton abundance within the California Cooperative Oceanic Fisheries Investigations' 40-year time series (McGowan et al., 1998), as well as of an ocean warming during the late 1970's (Francis and Hare, 1997). Dover sole in southern areas and bocaccio rockfish and lingcod exhibit declines in mean recruitment during this same period. Better understanding of potential linkages between fish recruitment and long-term changes in the ocean climate are key to improved 5- to 10-year forecasts of fishery potential yield.


Allen Shimada NMFS

Mixed catch of rockfish, sablefish, and Dover sole off Oregon coast.

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Western Pacific Invertebrate Fisheries

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Unit

16

NMFS SOUTHWEST FISHERIES SCIENCE CENTER, HONOLULU LABORATORY

Honolulu
Hawaii

Blunt slipper lobster. Hanauma Bay, Oahu, Hawaii.

INTRODUCTION

The Northwestern Hawaiian Islands (NWHI) lobster fishery is the major commercial marine invertebrate fishery in the western Pacific. A very small-scale, primarily recreational, fishery for lobster also exists in the Main Hawaiian Islands (MHI), American Samoa, Guam, and the Northern Mariana Islands. A deepwater shrimp resource is found throughout the Pacific islands but is relatively unexploited. A resource of deepwater precious coral (gold, bamboo, and pink corals) exists in Hawaii and possibly other western Pacific areas. A short-lived (1974–79) domestic fishery operated off Makapu'u Point in Hawaii, but there has been no significant precious coral harvest for 20 years. However, interest in the fishery has recently resurfaced, and one Federal permit was issued in 1997.

Management Situation

The NWHI lobster fishery, which began in 1977, harvests spiny and slipper lobsters and is governed by the Western Pacific Regional Fishery Management Council under a fishery management plan. The MHI lobster fishery is managed by the state of Hawaii, although a few offshore banks are included in the Fishery Management Plan for the Crustacean Fishery of the Western Pacific Region.

This plan was implemented in 1983 and has since been amended nine times. Many of the earlier amendments were in response to requirements to eliminate lobster trap interactions with the endangered Hawaiian monk seal (Amendments 2 and 4), protect spiny and slipper lobster reproductive potentials (Amendments 3 and 5), and specify overfishing definitions (Amendment 6). The most significant change in the plan occurred in 1992. In response to continuing declines in

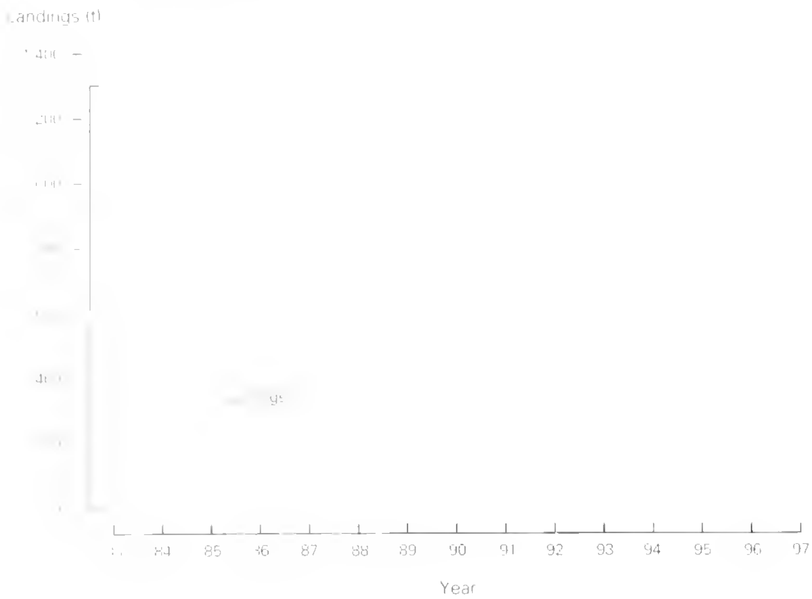


Figure 16-1

Hawaiian lobster landings (spiny and slipper lobsters) for 1983–97, in metric tons (t). The fishery was closed in 1993 and the seasons shortened in 1994 and 1995.

commercial lobster catch per unit of effort, the plan was amended (Amendment 7) to include an annual 6-month closed season (January–June), limit entry into the fishery, and establish an annual catch quota. The plan was amended again in 1996 (Amendment 9) to implement a quota system based on a constant harvest rate that allows only a 10% risk of overfishing in any given year and allows the retention of all lobsters caught.

Precious corals occurring in the U.S. Exclusive Economic Zone also are managed under a fishery management plan implemented in 1983 by the Western Pacific Regional Fishery Management Council. Very limited quotas are allowed under regular permits, and experimental permits are required for unassessed coral beds.

Fishery Landings

The combined landings of spiny and slipper lobster in 1997 were 330,000 pounds whole weight (150 metric tons (t) valued at $1,900,000) and consisted of 175,000 spiny lobster and 135,000 slipper lobster. The fishery initially targeted spiny lobster, but by 1984 gear modifications and improved markets led to an increase in slipper lobster landings. Landings peaked in 1985 at 1,300 t (worth $6,000,000), and generally declined from 1986 to 1995. (The fishery was closed in 1993 and had shortened seasons in 1994 and 1995.) Catches of slipper lobster were significant for a brief period, 1985 to 1987, and fell into a general decline from 1989 to 1996. Overall landings increased in 1996 and 1997 due to recovery of the population following several years of closures and shortened seasons and changes in the fishery management plan, which allowed the retention of juvenile and egg-bearing lobsters (Figure 16-1).

Most of the lobster catch is processed at sea and landed as frozen tails. In recent years, the opening of several foreign markets has led to an increase in live landings. Nonetheless, most lobsters are still landed as processed frozen tails.

Since 1983 the commercial fishery has fished plastic traps. Approximately 10 strings of 100 traps each are fished overnight at depths generally ranging from 15 to 35 fathoms (27–64 m). Historically, traps set at the deeper depths caught slipper lobster while the shallower sets caught spiny lobster. In recent years, slipper lobsters have been caught at shallow depths presumably due in part to the "fishing down" of spiny lobsters and availability of suitable lobster habitat. Current, recent, and long-term potential yields for these species are given in Table 16-1.

SPECIES AND STATUS

Lobster

The populations of spiny and slipper lobster declined dramatically from the mid 1980's through

Table 16-1

Productivity in metric tons and status of Western Pacific Region lobster fishery resources

	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
[illegible]	09	160	222	Full	Above

the mid 1990's. Much of this decline has been attributed to the combined effect of a shift in oceanographic conditions affecting recruitment and fishing mortality in the mid 1980's. The spawning potential ratio (SPR), which is used to measure the status of the stocks, has ranged between 74 and 88% over the past three seasons (1995–97).

Overfishing is defined in the fishery management plan in terms of recruitment[1] overfishing. The criterion used to assess overfishing is the SPR: the ratio of the spawning potential of a cohort[2] in a fished condition relative to that in an unfished condition. The fishery management plan defines the 20% level as a minimum SPR threshold, below which the stock is considered overfished, and establishes a warning SPR threshold at 50%, indicating the need for additional conservation measures. The NWHI lobster fishery is managed with a constant harvest rate such that there is only a 10% chance in any given year that the fishing mortality will exceed the mortality associated with the minimum SPR threshold. Since 1994, SPR values have been substantially above the minimum threshold level, indicating that the levels of fishing effort exerted during the 1994–97 commercial fishing seasons, and resulting fishing mortality and exploitation rate, would not cause long-term recruitment overfishing under equilibrium conditions (Table 16-2).

Coral

Because there has been no fishery on precious corals over the past 20 years, little solid evidence is available on recovery of the population from the low levels which existed when the Magnuson-Stevens Act was first passed in 1976. However, recent video analysis suggests that the unfished beds have recovered much of their potential and that new beds have been identified. Nonetheless, it also appears that illegal foreign fishing in some remote areas during the 1980's had a very significant impact on some beds. In 1997, one company obtained a permit to fish precious coral at Makapu'u, Oahu, under a 2-year quota for 2,000 kilograms (kg) of pink coral and 600 kg each for bamboo and gold coral. Harvesting began in early 1998. Historical landings of precious corals are shown in Figure 16-2.

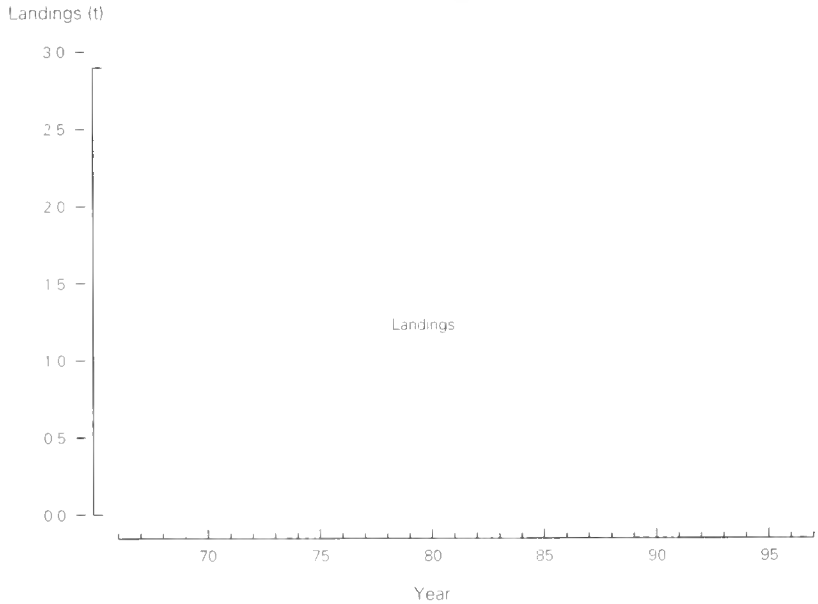


Figure 16-2
Landings of precious coral in metric tons (t), 1966–97.

ISSUES

Bank-specific Status of Lobster Stocks

The proportion of fishing effort and reported catch at each bank within the NWHI region has varied both spatially and temporally throughout the 20-year history of this fishery. While as many as 16 banks have been fished on an annual basis, the majority of fishing effort has been directed at four banks: Maro Reef, Gardner Pinnacles, St. Rogatien, and Necker Island (Figure 16-3). The observed spatial-temporal shifts in fishing effort between banks is attributed to declines in the spiny lobster catch per unit of effort; as spiny lobsters were fished down and catch rates at one bank fell below a minimum economic threshold, fishing effort shifted to a more productive bank. In recent years, fishing has generally been limited to Necker Island, where there has been a relatively higher concentration of spiny lobsters.

Year	SPR (%)
1994	74
1995	88
1996	80
1997	74

Table 16-2
Annual estimates of spawning potential ratio (SPR) for NWHI lobsters.

[1]Recruitment is the process of new generations of young fish or animals entering the stock.
[2]Recruits from the same year are called cohorts.

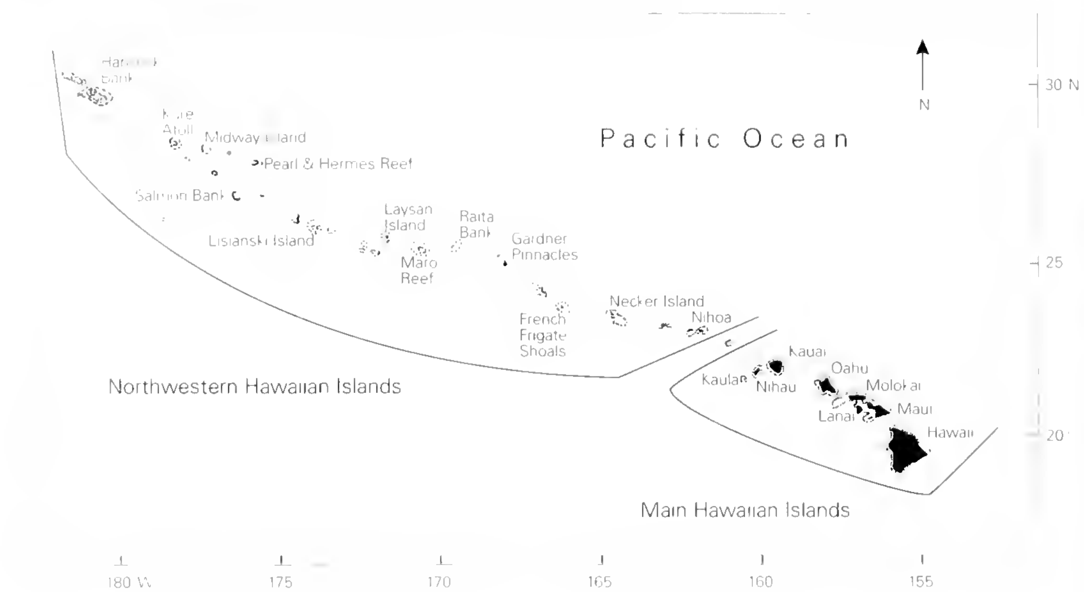


Figure 16-3
The Main Hawaiian Islands (MHI) and Northwestern Hawaiian Islands (NWHI)

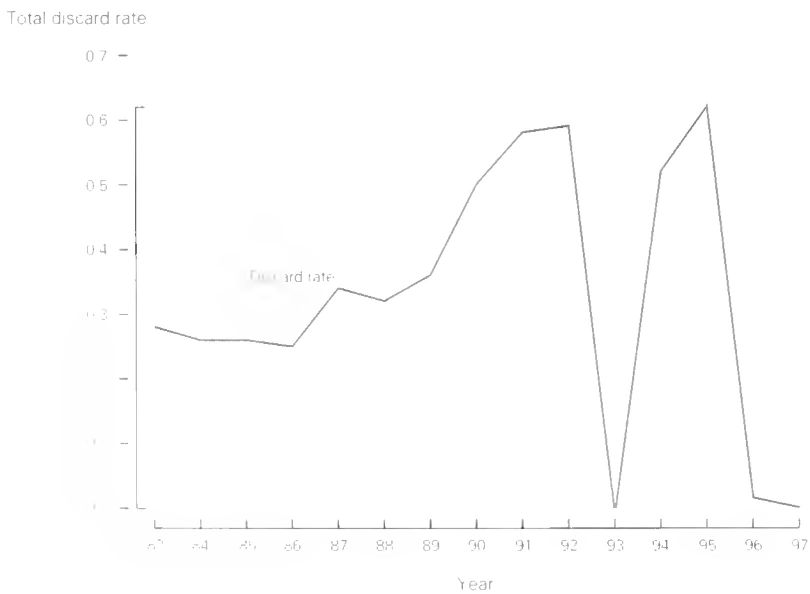


Figure 16-4
Lobster discard rate (ratio of lobsters discarded to total lobsters caught), 1983–97. The season was closed in 1993. The effect of new regulations took place in 1996.

Lobster Discards

In the 1980's, problems were identified related to high catch rates of then sublegal-sized lobsters and associated discard mortality caused by top-level predators (sharks and jacks) and on-deck handling. Escape vents were mandated in 1987 to release small lobsters on the bottom or during trap hauling. Nonetheless, from 1983 through 1995 the lobster (spiny lobster and slipper lobster combined) discard rate (the reported ratio of lobsters discarded to total lobsters caught) generally increased, rising from 0.28 in 1983 to 0.62 in 1995 (Figure 16-4). Although the escape vents reduce the number of small lobsters in each trap (based on research results), the average size of lobsters in the population declined during this period.

After 1995, the discard rate decreased significantly due to a relaxation of the minimum legal size requirement in favor of an optional retain-all policy. Implementation of the retain-all policy was based on research conducted by the National Marine Fisheries Service's Honolulu Laboratory to determine the effects of on-deck exposure on the mortality of sublegal and egg-bearing lobster. Handling mortalities for two on-deck handling methods (dry and wet) and a variety of exposure times were estimated to be as high as 77% for spiny lobsters and 44% for slipper lobsters, depending on the duration of exposure after being brought on deck.

Scientific Information and Adequacy of Assessments

Despite the multispecies nature of the NWHI lobster fishery and regulatory measures, most of the biological research has been directed at spiny lobster. Future research is needed to address knowledge shortfalls of slipper lobster biology. Estimates of the exploitable population of lobsters in the NWHI have been based solely on commercial catch and effort data from the NWHI lobster fishery as a whole. This approach neglects the fact that fishermen target areas with higher concentrations of lobsters, and may lead to estimates of exploitable biomass that are biased. More accurate assessments will require the integration of fishery-independent data into assessments in an effort to fine-tune the parameter estimates and assessment of exploitable biomass on a bank-specific basis.

Factors Affecting Abundance

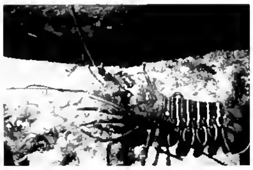
In predicting the response of the NWHI lobster population to fishing harvest, it must be noted that research to date has identified a dynamic change in the spatial and temporal structure of the NWHI lobster population. One major fishing area, Maro Reef, continues to be characterized by low spiny lobster abundance. Based on oceanographic research, size class and genetic structure analysis, and trends in catch per unit of effort, it appears that recruitment in the NWHI spiny lobster population differs between the southeastern and northwestern segments of the archipelago and remains depressed in the northwestern segment relative to the 1975–85 level. Numerous hypotheses have been advanced to explain population fluctuations of lobsters in the NWHI, including environmental, biotic (e.g. habitat and competition), and anthropogenic (e.g. fishing). Each hypothesis by itself offers a plausible, however simple, explanation to a rather complex phenomenon operating in a system of very high dimensionality. It is likely that population fluctuations of lobsters in the NWHI will be more accurately described by a mix of the hypotheses presented, each describing a different set of mechanisms.

Multispecies Interactions

The long-term effects of fishing on ecosystems are not well understood, and cautious management controls are required. The removal of one species, or complex of species, could result in species composition shifts. Although both spiny and slipper lobsters are harvested in the NWHI lobster fishery, spiny lobster is the primary target at most banks. As large numbers of spiny lobster were being removed from banks in the NWHI, the abundance and spatial distribution of slipper lobster on these banks apparently increased; areas traditionally defined as spiny lobster habitat appear now to be occupied by slipper lobster.

Progress

Much progress in assessing the status of exploited lobster stocks of the Western Pacific Region has been made in the past several years. Shoreside sampling of the commercial landings was started in 1996 and has provided valuable information for characterizing the size-structure composition of the commercial landings. Likewise, sampling of the commercial catch by at-sea observers was conducted in 1995 and 1997, providing information to characterize the commercial catch, as well as spatial heterogeneity of lobster abundance and size composition. These data were used to enhance the annual NWHI lobster fishery-independent survey and provide a more representative basis for future stock assessments.



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Hawaiian spiny lobster, Oahu, Hawaii.

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Western Pacific Bottomfish and Armorhead Fisheries

Robert L. Humphreys Jr. NMFS

Pelagic armorhead and soft coral on summit of Hancock Seamount, north of Midway Island

Unit 17

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INTRODUCTION

The western Pacific bottomfish fishery geographically encompasses the Main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), Guam, the Northern Mariana Islands, and American Samoa (Table 17-1). In contrast, the pelagic armorhead is harvested from the summits and upper slopes of a series of submerged seamounts along the southern Emperor-northern Hawaiian Ridge. This chain of seamounts is located just west of the International Dateline and extends to the northernmost portion of the NWHI.

The Guam, Mariana Islands, American Samoa, and MHI fisheries employ relatively small vessels on 1-day trips close to port; much of the catch is taken by either part-time or sport fishermen. In contrast, the NWHI species are fished by full-time fishermen on relatively large vessels that range far from port on trips of up to 10 days. Fishermen use the handlining technique in which a single weighted line with several baited hooks is raised and lowered with a powered reel. The bottomfish fisheries are managed jointly by the Western Pacific Fishery Management Council and territorial, commonwealth, or state authorities.

The commercial seamount fishery for armorhead was started by bottom-trawl vessels of the former Soviet Union in 1968. During 1969, Japanese trawlers entered this fishery, and by 1972 the catch per unit of effort (CPUE) (based on Japanese data) peaked at some 54 metric tons (t)/hour (Figure 17-1). The United States has never been a participant. By the end of 1975, the two foreign fleets had harvested a combined cumulative total

Table 17-1

Productivity in metric tons and status of western Pacific bottomfish and pelagic armorhead

Species and area	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Bottomfish					
MHI	249	111	254	Over	Below
NWHI	184	222	288	Under	Near
American Samoa	18	34	34	Under	Near
Guam	24	25	25	Full[1]	Near
CNMI	17	78	78	Under	Near
Pelagic armorhead					
Hancock Seamount	0	0	2,123	Over[3]	Below
Total	492	470	2,802		

[1]Approaching full utilization level

[2]Commonwealth of the Northern Mariana Islands

[3]Fishing moratorium currently in effect within U.S. EEZ (Hancock Seamounts); fishery considered overfished at seamounts outside U.S. EEZ

of some 1,000,000 t of pelagic armorhead. Facing a steady decline in CPUE after 1972, the former Soviet fleet left the fishery after 1975. The combined catch index for all seamounts has remained depressed since the late 1970's. The inclusion in 1977 of the southernmost seamounts (Hancock Seamounts) into the U.S. Exclusive Economic Zone (EEZ) allowed for a small portion of the fishery to be managed in a limited way. A preliminary fishery management plan was developed that year which provided for limited foreign harvesting at the Hancock Seamounts under a permit system during 1978–84. However, catches remained low, and all fishing ceased after 1984. Under the Fishery Management Plan for the Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region, a 6-year fishing moratorium was imposed on the Hancock Seamounts in 1986. The moratorium was extended for two additional 6-year periods, the latest starting in 1998 and ending in 2004.

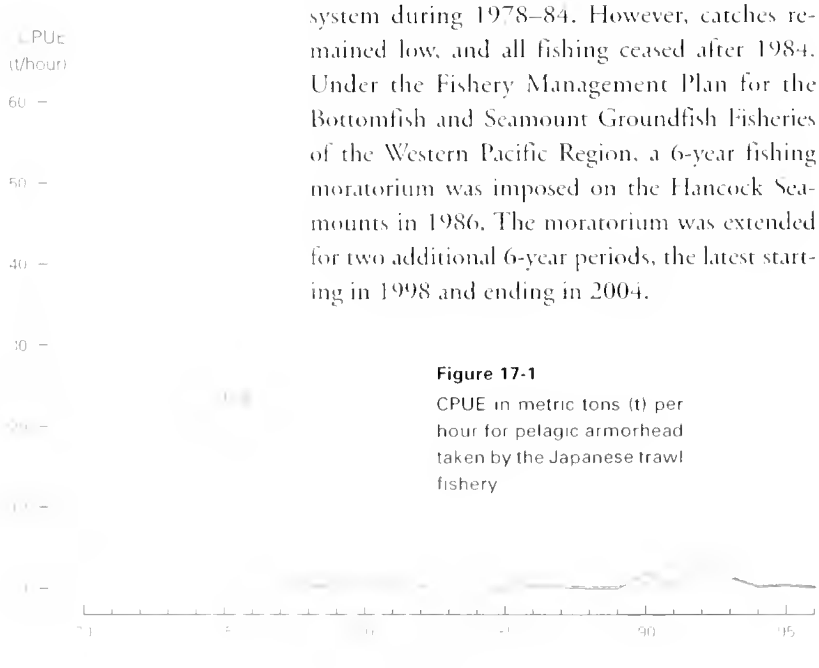


Figure 17-1

CPUE in metric tons (t) per hour for pelagic armorhead taken by the Japanese trawl fishery

SPECIES AND STATUS

Bottomfish

In Hawaii, the bottomfish species fished include several snappers (ehu, onaga, opakapaka), jacks (ulua, butaguchi), and a grouper (hapu'upu'u), whereas in the more tropical waters of Guam, Mariana Islands, and American Samoa, the fishes include a more diverse assortment of species within the same families as well as several species of emperors. These species are found on rock and coral bottoms at depths of 50–400 m. Catch weight, size, and fishing effort data are collected for each species in the five areas. However, the sampling programs vary in scope between the areas. About 90% of the total catch is taken in Hawaii, with the majority of the catch taken in the MHI as compared to the NWHI (Figure 17-2).

Stock assessments, though somewhat limited, indicate that the spawning stocks of several important MHI species (ehu, hapu'upu'u, onaga, opakapaka, and uku) are at only 5–30% of original levels. Onaga and ehu presently appear to be the most stressed among MHI bottomfish species.

Pelagic Armorhead

The seamount groundfish fishery has targeted just one species: the armorhead. Since 1976, this bottom trawl fishery has been almost exclusively conducted by Japanese trawlers fishing the seamounts in international waters beyond the Hancock Seamounts. The fishing grounds comprising the Hancock Seamounts represent less than 5% of the total fishing grounds. The long-term potential yield (Table 17-1) is 2,123 t, but recovery to these former levels has not occurred.

Standardized stock assessments were conducted during 1985–93. Research cruises were focused on Southeast Hancock Seamount, and the armorhead stock was sampled with bottom longlines and calibrated against Japanese trawling effort. Catch rates vary but have not shown the increases expected after the fishing moratorium was implemented (Figure 17-3). Furthermore, the increase in the 1992 seamount-wide CPUE (Figure 17-1) caused by high recruitment was apparently short-lived, as CPUE declined appreciably in 1993 and thereafter. Closure of only the small U.S. EEZ portion of the pelagic armorhead's demersal habitat may not be sufficient to allow population recovery, because these seamounts remain the only part of the fishery currently under management.

ISSUES

Scientific Advice and Adequacy of Assessments

Adequacy of the biological and catch data collected is a primary management concern for the western Pacific bottomfish fishery. For example, the reproductive biology of many of the important species in Guam, Mariana Islands, and American Samoa is unknown, and spawning stock biomass cannot be computed.

Transboundary Stocks and Management Jurisdictions

The primary issue for the armorhead seamount fishery is how to implement some form of management on an international basis to provide conditions more conducive for stock recovery. The recruitment event of 1992 and subsequent stock decline (probably from overharvesting) reinforce the need to implement some form of management if this fishery is to recover to early 1970's levels.

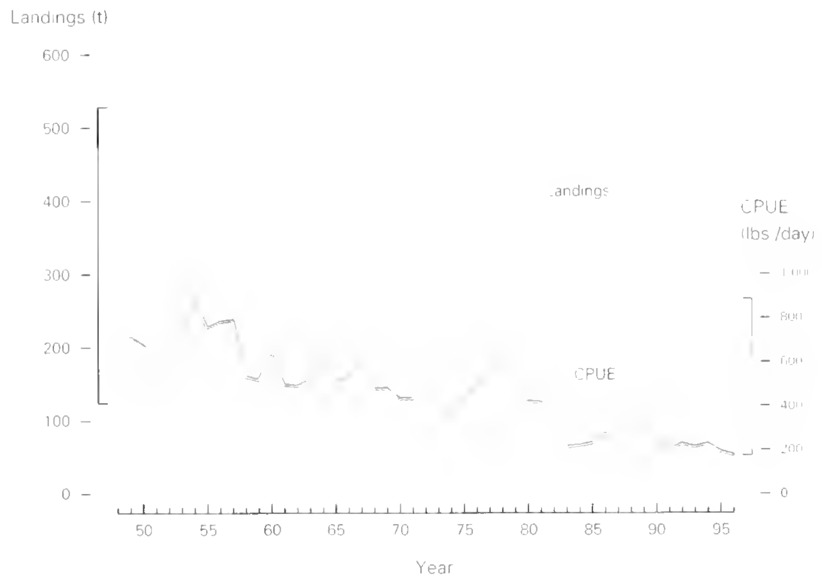
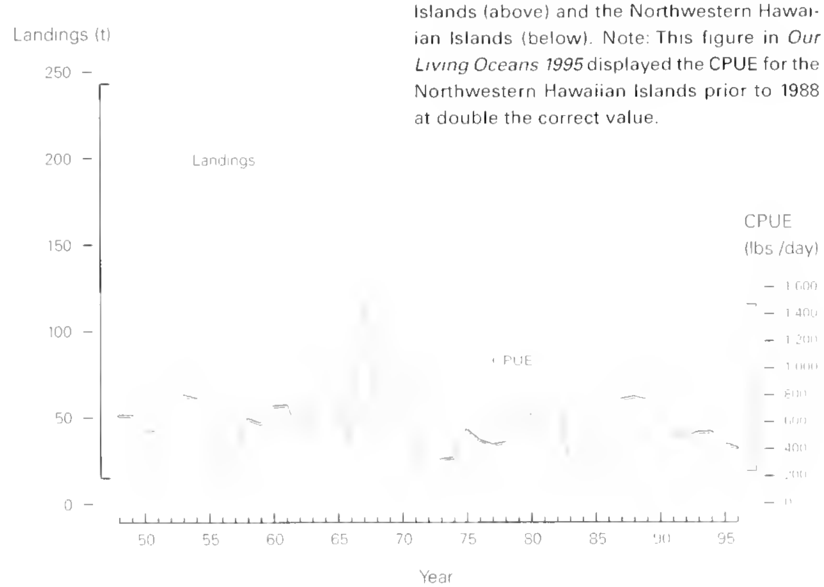


Figure 17-2
Bottomfish landings in metric tons (t) and CPUE in pounds per day at the Main Hawaiian Islands (above) and the Northwestern Hawaiian Islands (below). Note: This figure in *Our Living Oceans 1995* displayed the CPUE for the Northwestern Hawaiian Islands prior to 1988 at double the correct value.



Management Concerns

The spawning biomass of several important MHI bottomfish species (ehu, hapu'upu'u, onaga, opakapaka, and uku) appears to be at about 5–30% of original levels. Thus, overutilization is a concern, and the Western Pacific Fishery Management Council has recommended that Hawaii take

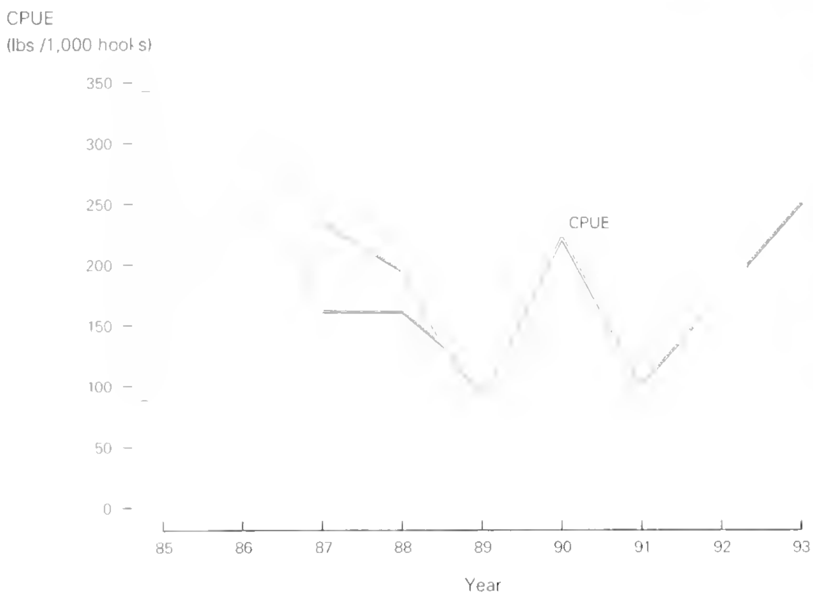


Figure 17-3
Pelagic armorhead CPUE from bottom longline sampling during research cruises. Biannual samples were taken from 1985–88, and annual samples thereafter. No samples were taken in 1992.

action to prevent overfishing because the fishery and the bottomfish habitat are predominantly within state waters. During the past 2 years, the State of Hawaii conducted a series of meetings with fishery managers, scientists, and fishermen to develop a management plan for the state's bottomfish fishery. In 1998, the state established a new administrative rule that governs bottomfishing in state waters and includes restrictions on fishing gear and fishing areas.

Progress

Researchers continue to identify nursery habitat for juvenile snappers and groupers in Hawaii, and age and growth curves have been extended to include early juvenile stages. Improvements have been made in collection of more complete catch-and-effort data from the NWHI fishery. Fishery discard patterns and interactions with sharks and protected species have also been examined.

No progress toward cooperative international management is foreseen for the pelagic armorhead. Cooperative exchanges of fishery data with scientific colleagues in Japan have provided annual commercial catch data by seamount. Recently acquired biological data of importance for future management considerations indicate that armorhead undergo a 2-year pelagic phase prior to recruitment into the fishery and that the seamount populations comprise a single stock.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Bigeye trevally, Hanauma Bay, Oahu, Hawaii.

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Pacific Highly Migratory Pelagic Fisheries

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Yellowfin tuna.

Unit 18

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INTRODUCTION

The fishes in this group range the high seas and often are outside U.S. fisheries management jurisdiction. Some species are sought vigorously by both commercial and sport fishermen. The status of many is either uncertain or unknown.

During 1976–80, the eastern tropical Pacific tuna fishery expanded and was dominated by the U.S. fleet. Fishing became less profitable in the 1980's, and many U.S. fishermen quit or moved to the central-western Pacific, leaving Mexico, with more than 50 purse seiners, the dominant fleet in the eastern tropical Pacific. In the next decade, the U.S. fleet declined to about 7 vessels in 1993-97 in response to domestic regulations that addressed dolphin mortality concerns. Purse seiners (all countries) in the eastern tropical Pacific in 1997 numbered about 189. Until 1980, the Inter-American Tropical Tuna Commission (IATTC) regulated the international fishery with catch quotas. Since then, IATTC regulations have been suspended because Mexico with its dominant fleet is not a Commission member. Currently, there is no international tuna management in the eastern tropical Pacific; each coastal nation regulates fishing within its own exclusive economic zone (EEZ).

Also, since there is not yet an overall resource management program in the central-western Pacific, the South Pacific Forum Fisheries Agency (FFA), which represents the South Pacific island nations, has instituted a licensing program for foreign (distant-water) fishing fleets through access agreements. The U.S. fleet is currently limited to 55 purse seiners in the region under an access agreement called the South Pacific Regional Tuna

Table 18-1

Productivity in metric tons and status of Pacific highly migratory pelagic species.

Species	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Yellowfin tuna (central-western Pacific)[1]	335,451	600,000	600,000	under	above
Yellowfin tuna (eastern-tropical Pacific)	257,333	300,000	unknown	full	near
Skipjack tuna (central-western Pacific)[1]	950,527	2,000,000	2,000,000	under	above
Skipjack tuna (eastern-tropical Pacific)[1]	135,967	135,967	135,967	under	near
Albacore (North Pacific)[1]	73,667	80,000	80,000	under	near
Albacore (South Pacific)	36,733	36,733	36,733	unknown	near
Bigeye tuna	132,615	160,000	160,000	full	near
Blue marlin[2]	23,278	23,278	23,278	over	below
Black marlin[2]	2,621	2,621	2,621	unknown	near
Striped marlin[2]	11,649	11,649	11,649	under	near
Sailfish and shortbill spearfish[2]	4,360	4 360	4,360	unknown	near
Swordfish	29,794	29,794	25,000	unknown	near
Wahoo[3]	160	160	160	unknown	near
Dolphinfish[3]	23,020	23,020	23,020	unknown	near
Pelagic sharks[3]	32,243	32,243	32,243	unknown	unknown
Total	2,049,418	3,439,825	3,435,031		
U S Subtotal[4]	253,606	253,116	253,116		

[1] 1995–97 average
[2] 1993–95 average
[3] 1994–96 average
[4] U S subtotal is U S landings of tunas, swordfish, and billfish for 1993–95, 1995–97 data are unavailable

Treaty. The FFA opened multilateral talks in 1994 for the purpose of developing a conservation and management treaty for tropical tuna species and South Pacific albacore. These talks are continuing at an accelerated pace.

Currently, there is no international management regime for the pelagic species in the North Pacific. An informal arrangement has existed between Japan and the United States for assessing the status of North Pacific albacore (scientists from Canada, Taiwan, and the Republic of Korea also participate.) Recently, the United States and Japan, through a bilateral agreement, established the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean to monitor North Pacific fisheries as a precursor for a management regime.

The temperate-water bluefin tuna is not considered here, as most catches have been relatively minor and taken off California in recent years. This species is taken incidentally while purse seining for other species (anchovy and mackerel; yellowfin and skipjack tunas). It is also taken sporadically by the Hawaii-based longline fishery on the northern swordfish grounds.

U.S. billfish harvests (except for swordfish) have been dwarfed by foreign harvests (mostly from longline fisheries). There is no international authority managing these species in the Pacific, although they are under consideration in the FFA talks. U.S. management authority for billfish and tuna in the EEZ rests with the Western Pacific Regional Fishery Management Council for central and western Pacific waters, and with the Pacific Fishery Management Council for North American waters. In the past, the latter has delegated management to the State of California for swordfish, striped marlin, and some sharks. Currently, there is renewed interest by the Pacific Fishery Management Council in developing billfish, tuna, and shark management plans.

Species and Status

Highly migratory pelagic species include tropical tunas (yellowfin, bigeye, and skipjack), albacore, marlins, spearfish, sailfish, swordfish, sharks, and other large fishes. Most are caught commercially, but some, especially marlins, support important recreational fisheries as well.

Tropical Tunas

Longline gear is used to catch yellowfin and bigeye tunas across the Pacific, whereas the purse seine is the primary gear in the eastern and the western tropical Pacific for capture of yellowfin and skipjack tunas. Purse seine fishing is conducted generally between latitude 20°N and 20°S. Longline fishing extends to higher latitudes (e.g. to 40°N). Other gears used in the central-western Pacific fisheries include ring net, handline, troll, and pole-and-line. Purse seiners, dominated by U.S. and Japanese fleets but with substantial fleets from Korea and Taiwan, take 30–50% of the yellowfin tuna catch in the central-western Pacific. In 1996, the total number of purse seiners in the central-western Pacific was more than 200, including 40 U.S. seiners. Virtually all skipjack tuna is taken by pole-and-line and purse seine. Most of the bigeye tuna catch is taken by longline gear.

Mexico is the primary fishing nation in the eastern tropical Pacific. Others include the United States, Vanuatu, Venezuela, and some other coastal nations. Major fishing fleets in the central-western Pacific come from the United States, Japan, Republic of Korea, Philippines, and Taiwan. Current, recent, and long-term potential yields for the various species are given in Table 18-1.

More skipjack tuna are caught than any other tuna species. The recent annual yield of Pacific skipjack tuna taken by U.S. and foreign fleets is 950,527 metric tons (t) from the central-western Pacific and 135,697 t from the eastern tropical Pacific (Figure 18-1); recreational catches are small. The species is believed to be underutilized, with the long-term potential yield for the central-western stock between 4,000,000 and 6,000,000 t. The annual dockside ex-vessel revenue of the U.S. and foreign Pacific skipjack tuna catch is about $869,000,000, and for yellowfin tuna it is well in excess of $474,000,000. These figures are based on a conservative dockside price of $800/t for both species. The recent average yield of yellowfin tuna for the entire Pacific is about 592,784 t (Table 18-1), distributed about equally between the eastern tropical and the central-western Pacific (Figure 18-2). Recent assessments of yellowfin tuna

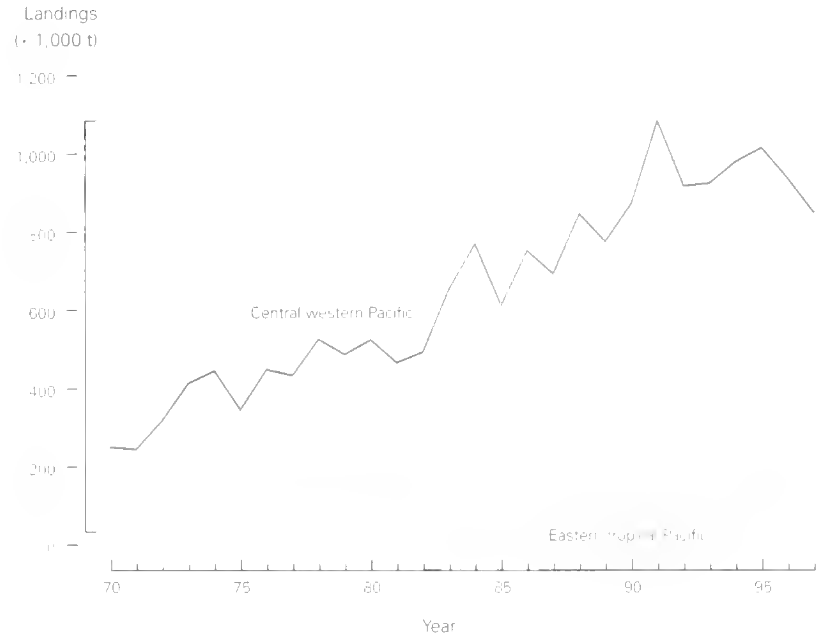


Figure 18-1
Landings of skipjack tuna in the Pacific Ocean region, 1970–97, in metric tons (t).

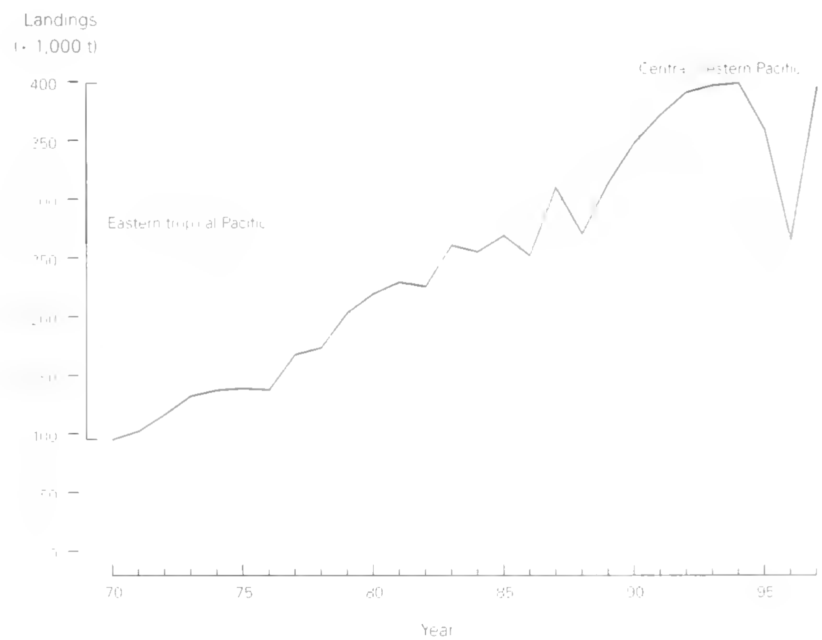


Figure 18-2
Landings of yellowfin tuna in the Pacific Ocean region, 1970–97, in metric tons (t)

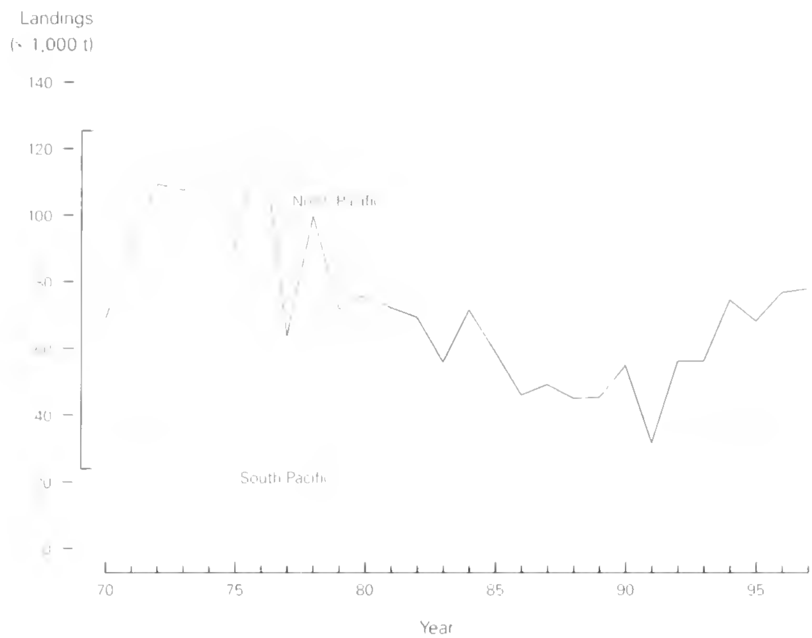


Figure 18-3
Landings of albacore tuna in the Pacific Ocean region, 1970–97, in metric tons (t).

indicate that the long-term potential yield for the eastern tropical Pacific is about 300,000 t, making this resource fully utilized. The long-term potential yield for the central-western Pacific is estimated at 600,000 to 670,000 t, indicating the stock is underutilized.

The recent average yield of bigeye tuna for the entire Pacific is about 133,000 t (Table 18-1) generating ex-vessel revenues of about $1 billion, with most of the catch taken by foreign longline fisheries. Bigeye tuna is mostly sold for raw consumption as Japanese-style "sashimi" and brings the highest dockside price of any tropical tuna (about $7,000/t). The best available estimates of long-term and current potential yield are about 160,000 t (Table 18-1), and the current level of fishing effort is the highest recorded to date. Recent catches and catch rates have been lower than seen during the 1990–92 period, and the stock may be fully utilized.

Albacore

Albacore is fished from the northern limits of the North Pacific Transition Zone to about latitude 15°N, and from Japan to North America. In the South Pacific, it is fished from about latitude 15°S to the southern limits of the Subtropical Convergence Zone and from South America to Australia.

In the North Pacific, albacore is fished primarily by longline, pole-and-line, trolling, and until 1992, drift gillnet. Longline gear is used in the lower latitudes and accounts for about 20–25% of the current catches. The surface fisheries (pole-and-line, troll) operate in the higher latitudes of the North Pacific Transition Zone and account for 75–80% of the catches. The U.S. fishery extends from the middle of the Pacific Ocean to the North American coast and uses between 500 and 2,000 vessels. Based on a dockside price of $2,200/t, the annual ex-vessel revenue of the North Pacific albacore catch is about $145 million.

South Pacific albacore is fished primarily by longline and trolling. As in the north, longliners operate nearer the equator than trollers. Surface gear is fished in the Tasman Sea and in the Subtropical Convergence Zone at about longitude 160°W. In 1996, about 50 U.S. trollers fished the South Pacific.

Pacific albacore (both the north and south stocks) has a long history of exploitation (Figure 18-3). Recent development of a large surface fishery in the South Pacific, in addition to the longline fishery, has changed the previous stock assessments from fully exploited, under a longline-only fishery, to unknown. No long-term potential yield has yet been estimated, but a comprehensive assessment is needed due to the opposing effects of a rapid expansion of the troll fishery in the late 1980's and termination of the driftnet fishery in 1991.

In the North Pacific, total catches, catch rates, and fishing effort in the U.S. troll fishery and the Japanese pole-and-line fishery declined until the early 1990's then began increasing through 1996 (Figure 18-3). Current assessments estimate long-term potential yield between 80,000 and 104,000 t. This follows a period of higher stock utilization at or above the long-term potential yield in the 1970's. This early high production, coupled with a drift gillnet fishery from 1980 to 1992 (for which statistics are incomplete), probably overutilized the stock. It appears that the stock has recovered from the earlier period of overfishing; however, increasing catches may once again threaten the stock.

Swordfish

Swordfish are distributed throughout the temperate, subtropical, and tropical waters of the Pacific. Much of the Pacific-wide catch is taken by the Japanese longline fishery directed at tunas, some is taken by the U.S. swordfish longline fishery, and the rest is taken by surface gears such as harpoons, handlines, coastal drift gillnets and, until 1993, high-seas drift gillnets. Coastal fisheries occur off the United States, Japan, Taiwan, Mexico, Chile, and Australia. Catches have increased throughout the 1980's and 1990's (Figure 18-4), averaging about 30,000 t in recent years (Table 18-1).

The stock structure and status of Pacific swordfish stocks are unclear. Several studies suggest more than one Pacific stock. The most recent assessment assumed a single Pacific stock and suggested that the stock was somewhat underutilized. However, this assessment was limited to data through 1980. More recent statistics on catch and effort are not available, but as total catch has increased so has the crude estimate of long-term potential yield. The recent average yield for 1993–95 exceeds the estimated long-term potential yield (Table 18-1).

From 1989 to 1993, production from the U.S. domestic longline fishery in Hawaii increased rapidly, reaching 5,942 t and an ex-vessel revenue of $26,100,000 in 1993. Catches declined to 2,504 t in 1996. The 1995 production represents 9% of the total Pacific production and 50% of the central-eastern North Pacific production.

The production from the U.S. domestic gillnet and harpoon fisheries located primarily off California increased markedly from 1975 to 1985, when a peak catch of 2,400 t was landed. The fishery currently has a recent average annual yield of 1,124 t for about $5,000,000 in ex-vessel revenue.

Other Billfishes and Pelagics

Species included here are the blue, black, and striped marlins; sailfish, shortbill spearfish, wahoo, dolphinfish, and several oceanic sharks (requiem, thresher, hammerhead, and mackerel). They generally range from North America to Asia and between the North and South Pacific convergence zones. They are generally more abundant near is-

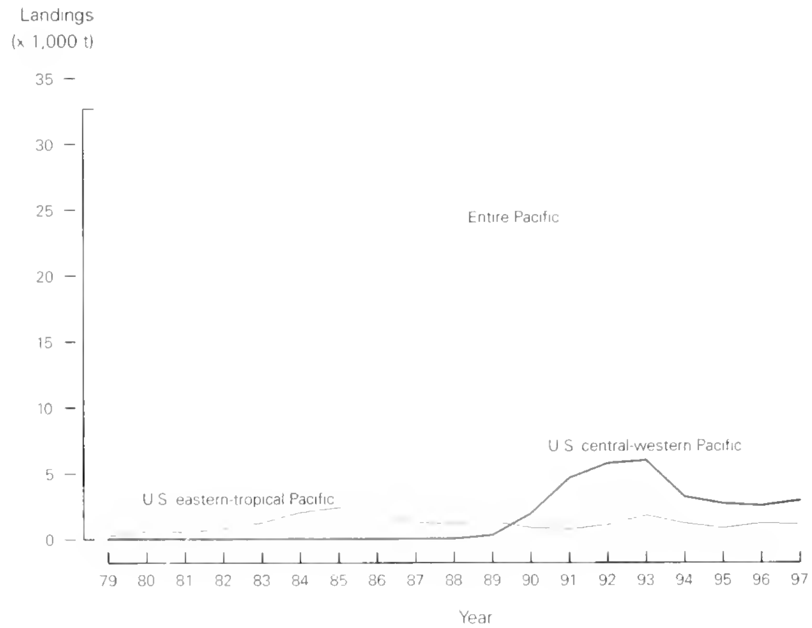


Figure 18-4
Landings of swordfish in the Pacific Ocean region, 1979–97, in metric tons (t). Pacific-wide data unavailable for 1997.

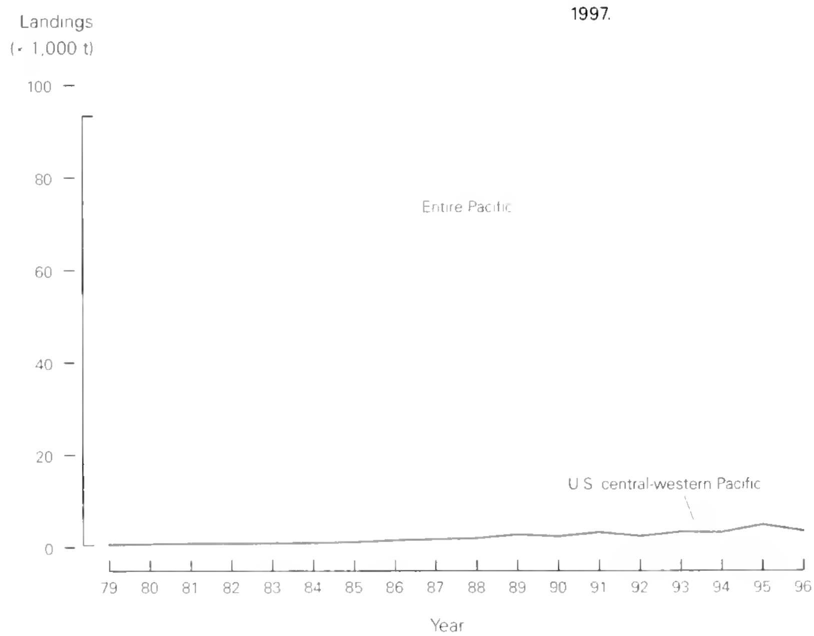
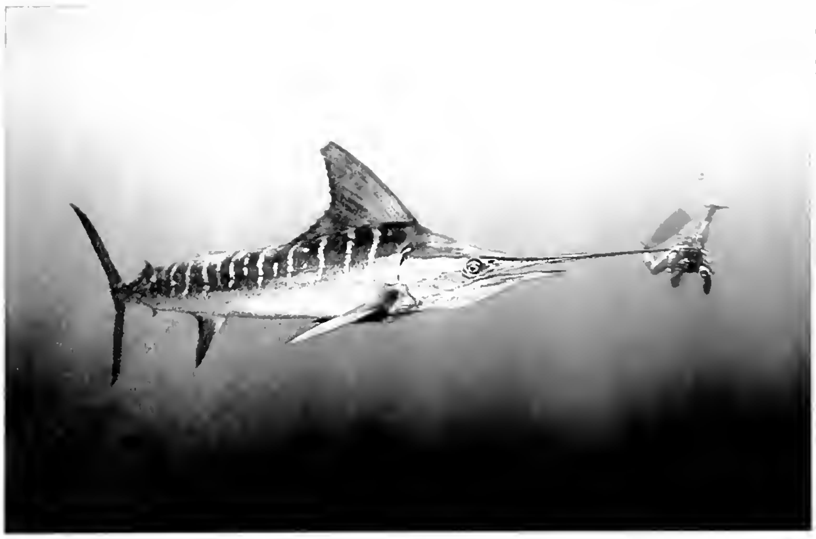


Figure 18-5
Landings of billfish and sharks in the Pacific Ocean region, 1979–96, in metric tons (t). Data for 1997 not available.



Striped marlin.

lands, continental slopes, seamounts, and oceanic fronts, and many are important to local economies. They are caught by foreign and U.S. recreational and commercial fishermen.

U.S. commercial fishermen in the western and central Pacific primarily use longline, troll, and handline gear to catch marlins, spearfish, wahoo, and dolphinfish. Recreational fishing gears include rod-and-reel and handline. Sharks are taken by longline in the central North Pacific and by harpoon and drift gillnet off North America.

Because of the many species in this "other" category, no accurate dollar value can be calculated for the annual catch. However, the U.S. catch of blue and striped marlin is worth about $2,000/t ex-vessel, and the U.S. catch of wahoo and dolphinfish is worth more than $4,000/t.

Three species dominate the reported catches of "other pelagics": blue and striped marlins and sharks (Figure 18-5). Catches in this category by U.S. fisheries for the central and western Pacific increased steadily through the 1980's, leveling out in the 1990's. Pacific-wide shark catches in the carcharhinid and requiem shark categories reported to the Food and Agriculture Organization of the United Nations total about 22,000 t/year, but pelagic shark catches are reported by only a few nations. The total Pacific harvest of pelagic sharks is unknown.

The status of most species' stocks is unknown or uncertain. Assessments using data through 1985 indicated that striped marlin were utilized slightly below their long-term potential yield, and blue marlin were fished above their long-term potential yield; however, new data are needed to confirm or dispute these findings. The condition of virtually all shark species remains unknown.

ISSUES

Management Concerns

There are two primary issues for the management of pelagic species in the Pacific. The first is the development and implementation of comprehensive international plans for gathering and reporting fishery statistics; the second involves setting up conservation and management regimes to encompass all interests and ensure sustainable fisheries. Both the South Pacific Forum Fisheries Agency treaty talks and the recently begun Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean appear to be addressing these concerns. The poor quality of some data and the lack of current data in several fisheries prevent conducting accurate and up-to-date stock assessments, developing informed management options, and preparing pragmatic advice for rational exploitation and conservation of the resource.

Another major issue affecting virtually all fisheries to some extent is the bycatch taken during fishing operations. Bycatch is defined as the capture or mortality of nontarget species and target species which are not retained (discards). Some examples of bycatch include catches of small tuna discarded by purse seine fisheries; takes of seabirds, including endangered species, and sharks discarded by longline fisheries; the impact of chase and encirclement on dolphins in the eastern tropical Pacific purse seine fishery; and the indiscriminate catch, killing, and discarding of nontarget species in purse seine operations around fish aggregating devices and other floating objects. Both U.S. and foreign fisheries are involved in bycatch issues.

Within the U.S. EEZ of the central-western Pacific, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands, the Western Pacific Regional Fishery Management Council has developed, and the Secretary of Commerce has approved, a fishery management plan for pelagic species. The plan specifically addresses concerns about the expanded Hawaii longline fleet and the potential for interactions among longliners, trollers, and handliners by placing a cap on the number of permits issued to longliners and establishing nearshore zones closed to longlining. At the Council's behest, the National Marine Fisheries Service implemented a mandatory logbook and reporting system in the region's domestic longline fleet to collect statistics for fishery monitoring. Research is under way to analyze the fishery statistics and to evaluate the effectiveness of the longline fleet limits. Also affecting data collection is the recently enacted High Seas Fishing Compliance Act, which requires licensing and logbooks for all U.S. vessels fishing on the high seas.

Although they fish the same swordfish resource as the Hawaii-based vessels, longline vessels operating out of California and Alaska have not been subject to the management regulations developed by the Western Pacific Regional Fishery Management Council. Until their elimination in 1993, high-seas drift gillnet fisheries had taken a dominant share of the North Pacific albacore catch. Recent developments indicate that the Pacific Fishery Management Council is considering development of regulations in the U.S. west coast EEZ, and presumably in common with high-seas regulations governing the western Pacific. In the South Pacific, the interaction between the established foreign longline albacore fishery and the surface fishery (predominantly from the United States) needs attention, particularly if allocation of available yield between the fisheries becomes an issue. A domestic longline fishery for albacore has started in American Samoa. A similar but larger fishery in Western Samoa has raised gear conflicts and competition issues.

The North Pacific albacore stock appears to have been overutilized in the 1970's and 1980's, possibly due to high surface fishery catches and decadal changes in ocean productivity. In the 1990's, the stock appears to have recovered, aided by reduced catches and a productivity increase. However, it appears that the stock may not support catches as high as those taken in the early 1970's. Creation of an international arrangement to manage the stock is another issue that needs attention, particularly if the fishing nations want to reap the benefits of a recovered stock and prevent another overfishing cycle.

Scientists recognize that at least one billfish species, the Indo-Pacific blue marlin, is depleted over its range, but no international management mechanism exists to rebuild the stock. Similarly, thresher and mako sharks taken in the U.S. west coast drift gillnet fishery may need protection from overexploitation. The Pacific Fishery Management Council has the jurisdiction to address this need.

The potential take of endangered Hawaiian monk seals, endangered and threatened sea turtles, and seabirds is also of concern. The monk seal problem has been addressed by the Western Pacific Regional Fishery Management Council through a strict prohibition of longlining within a 50-mile area surrounding the Northwestern Hawaiian Islands. Sea turtle and seabird takes are monitored using data gathered by fishery observers on longline vessels.

Scientific Advice and Adequacy of Assessments

Population levels of the billfishes and other species are generally unknown or out of date: There is no comprehensive international mechanism to collect and share fishery data on the Pacific-wide stocks, including those portions of the stocks that range in U.S. waters, although the Interim Scientific Committee for Tuna and Tuna-like Species is addressing the issue. Basic biological data (beyond catches) are also lacking or grossly inadequate for most of these species. This limits determination of the current condition of the stocks. Bycatch in all fisheries is another issue.

The impacts of the U.S. longline fleet on swordfish and other resources in the EEZ around Hawaii and in the central Pacific are unknown, but the catches are being monitored, and research is under way to better assess the stocks.

Progress

Research has been focused on selected issues, and progress has been made for several species. However, on the whole, the number of species and issues remains more than can be addressed, given

Tagging a blue shark off southern California.

current agency resources.

For central-western Pacific tunas, informal international scientific meetings are annually convened by the South Pacific Forum Fisheries Agency to assemble fisheries statistics, evaluate fishery developments and assess the condition of the stocks. For tuna and tuna-like species in the North Pacific, the Interim Scientific Committee has been established, and initial meetings have been held regarding some species and fishery statistics. For many central and South Pacific fisheries, multilateral treaty discussions may eventually lead to needed management arrangements.

Management of the domestic fisheries has been successful in eliminating gear conflicts among longline, troll, and handline fisheries. Limited entry and area closures in the Hawaii-based longline fishery have limited the growth of the fishery and reduced nearshore longline catches of tuna, billfish, and other pelagic species important to troll and handline fisheries, thus reducing the potential for fishery interaction. At the same time, the total yield of the Hawaii-based longline fishery has increased during the 1990's due to an expansion of fishing effort, modifications of the seasonal limits of the area closures, and changes in areas of operations. Area closures implemented in the Northwestern Hawaiian Islands to prevent interaction of the longline fleet with the endangered Hawaiian monk seal have been fully successful.

FOR FURTHER READING

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Alaska Groundfish Fisheries

Unit 19

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NMFS Alaska Fisheries Science Center

Seattle Washington

Trawl codend emptying walleye pollock, eastern Bering Sea.

INTRODUCTION

The groundfish complex is the most abundant of all fisheries resources off Alaska, totaling more than 21,000,000 metric tons (t) of exploitable biomass and contributing more than 2,000,000 t of catch each year. Another 1,000,000 t of underutilized sustainable potential yield is available.

Prior to the Magnuson Fisheries Conservation and Management Act of 1976, the only groundfish species of significant domestic catch and value was Pacific halibut. All other groundfishes were at or near full utilization by foreign fisheries. The Magnuson Act extended Federal fisheries management jurisdiction to 200 nautical miles and stimulated the growth of a domestic Alaska groundfish fishery that rapidly replaced the foreign fisheries. Much of the groundfish catches are exported, particularly to Asia, and such trade contributes prominently as a major source of revenue for U.S. fishermen.

SPECIES AND STATUS

Pacific Halibut

The Pacific halibut is found from the Bering Sea to California, with the center of abundance in the Gulf of Alaska. The resource is managed by a bilateral treaty between the United States and Canada and through research and quota recommendations from the International Pacific Halibut Commission (IPHC). Pacific halibut, considered as one large interrelated biological stock, is regulated by subareas through catch quotas, time-area restrictions, and (lately) by individual vessel quotas. The commercial fishery has a long tradition dating back to the 1880's. There is a growing recreational fishery as well.

Most components of the halibut fishery had a very successful year in 1997. The resource was healthy, and the total catch was near record levels, totaling 53,720 t. The breakdown by fishery was:

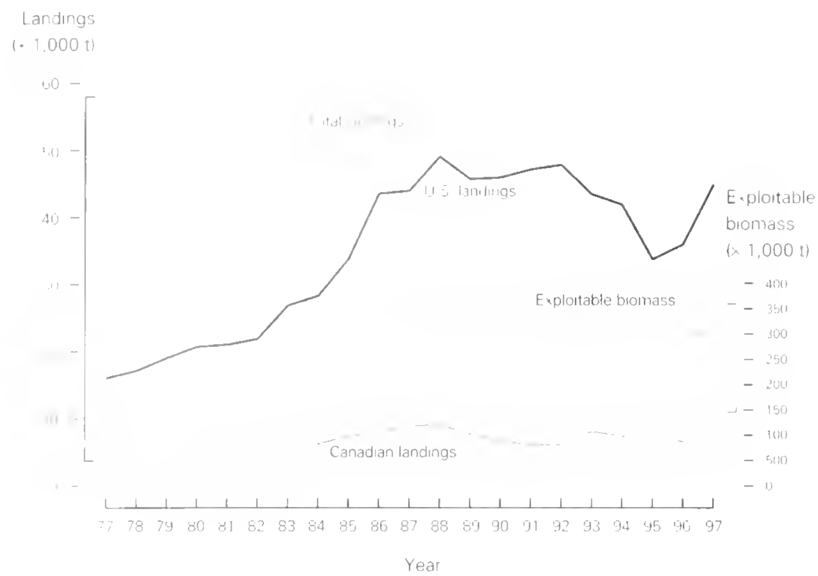


Figure 19-1

Landings and abundance of Pacific halibut in metric tons (t).

commercial fisheries (39,240 t), recreational fisheries (5,050 t), personal use (325 t), bycatch in other fisheries (7,975 t), and mortality due to fishing by lost gear and discards (1,130 t).

The nature of the commercial fisheries has changed dramatically in recent years. Both Canadian and Alaskan halibut fisheries have moved from an open-access fishery with short fishing seasons to an individual fishing quota (IFQ) fishery of nearly 8 month's duration. In addition, IFQ share allocations have also been implemented for Treaty Indian, commercial, and recreational fisheries for the Washington-California region. Under such a tight allocation of quota shares, there has been a decline in overall size of the fishing fleet. Vessels licensed to fish in Canada remained at 435, while 2,000 vessels fished in the U.S. fisheries in 1997, down from 3,400 vessels in 1993.

The assessment of Pacific halibut stocks was radically revised in 1996 due to a revelation that changes in individual growth rates have affected fishing selectivity by the gear. The new approach (Sullivan and Parma, 1998) takes a model for growth, additional information from surveys and bycatch observations, and brings in commercial catch-at-age and catch-per-unit-effort (CPUE) data to determine the current and historical status of the population. The approach also considers uncertainties with selectivity by age versus length that resulted in two biomass estimates for each year. The IPHC concluded that the true biomass lies between the two estimates. However, for the purpose of being precautionary, the lower of the biomass estimates for the main range of Pacific halibut (Gulf of Alaska, Canada, and Washington-California) is shown in Figure 19-1.

The exploitable portion of the Pacific halibut stocks apparently peaked at 360,000 t in 1988 (Figure 19-1). The population has since declined slightly to a rather constant biomass level of 298,000–305,000 t over the past 5 years. The long-term average reproductive biomass for the resource was estimated at 130,000 t (Parma, 1998). Long-term average yield (equivalent to the long-term potential yield) was estimated by Parma (1998) at 29,750 t, round weight. The species is fully utilized. The recent average yield (1995–97) was 38,180 t for the United States and 7,710 t for Canada, for a combined total of 45,890 t for the entire Pacific halibut resource. This recent average yield was 6% higher than the estimated long-term potential yield, which reflected good condition of the underlying resource. The values for recent average yield and current potential yield shown in Table 19-1 are for all catches—commercial, recreational, bycatch, and waste.

Table 19-1

Productivity in metric tons and status of Pacific halibut resources

Area	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Bering Sea	8,930	11,280	Not applicable	Full	Near
Gulf of Alaska	29,250	31,575	Not applicable	Full	Near
U.S. Pacific Coast	570	865	Not applicable	Full	Near
Canadian Pacific Coast	7,710	8,020	Not applicable	Full	Near
Total resource	46,460	51,740	51,740	Full	Near
U.S. total	38,750	43,720	31,610	Full	Near

Bering Sea and Aleutian Islands Groundfish

The average Eastern Bering Sea and Aleutian Islands groundfish catch during 1995–97 was about 1,780,000 t (Table 19-2, Figure 19-2). The total catch in 1997 was 1,740,000 t, valued at $405,000,000 (ex-vessel). The dominant species harvested were walleye pollock (1,090,000 t valued at $231,000,000), Pacific cod (240,000 t valued at $116,000,000), and yellowfin sole (150,000 t valued at $26,000,000).

Groundfish populations have been maintained at high levels since implementation of the Magnuson-Stevens Fishery Conservation and Management Act. Their long-term potential yield totals about 3,500,000 t. The current potential yield of 2,500,000 t for 1998 is slightly below the long-term potential yield. This potential, however, has not been fully utilized because catch quotas cannot exceed the 2,000,000 t optimum yield limit set in the groundfish fishery management plan.

Walleye Pollock: Pollock produce the largest catch of any single species inhabiting the U.S. Exclusive Economic Zone. The three main stocks, in decreasing order of abundance, are: eastern Bering Sea stock, Aleutian Basin stock, and the Aleutian Islands stock. The eastern Bering Sea stock, sustained by the strong 1989 and 1992 year classes, is near the target biomass (i.e. the level that produces the long-term potential yield) and fully utilized. The Aleutian Islands stock is believed to be slightly below the target level and increasing.

Until 1992, another large fishery targeted the portion of the Aleutian Basin stock residing outside of the U.S. and Russian exclusive economic zones in the "Donut Hole" of the central Bering Sea. Historical catches from this stock were apparently too high (well over 1,000,000 t throughout the late 1980's) and not sustainable. The abundance of the Aleutian Basin stock was consequently greatly diminished, and all fishing ceased in 1993.

Pacific Cod: Pacific cod abundance remained high and stable throughout the 1980's. Although a string of below-average year classes (those spawned in 1986–88) led to a downturn in abundance during the early 1990's, this trend has been

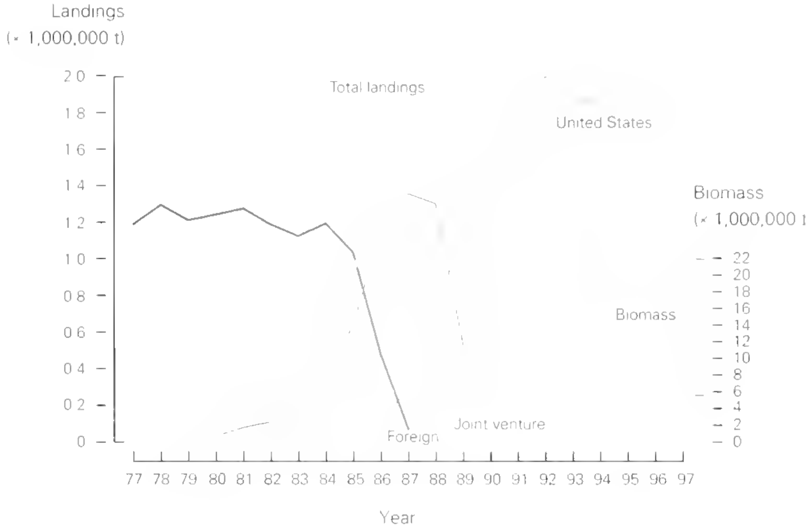


Figure 19-2

Landings and abundance trends in metric tons (t) for Bering Sea and Aletutian Island groundfish.

Table 19-2

Productivity in metric tons and status of Bering Sea and Aleutian Islands groundfish resources.

Species	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Walleye pollock	1,140,400	1,140,000	1,800,000	Full	Near
Pacific cod	247,800	210,000	328,000	Full	Near
Yellowfin sole	145,300	220,000	277,000	Under	Near
Greenland turbot	7,400	15,000	18,500	Under	Below
Arrowtooth flounder	11,300	147,000	230,000	Under	Above
Rock sole	56,500	312,000	449,000	Under	Above
Other flatfish	38,100	164,000	253,000	Under	Above
Sablefish	1,600	1,300	2,160	Full	Below
Pacific ocean perch	13,600	13,800	20,640	Full	Above
Other rockfish	5,800	6,200	8,300	Under	Above
Atka mackerel	83,800	134,000	64,300	Under	Near
Other fish	24,000	136,600	27,800	Under	Above
Total	1,775,600	2,499,900	3,478,700		

Table 19-3

Productivity in metric tons and status of Gulf of Alaska groundfish resources.

Species/area	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
Walleye Pollock	71,202	130,000	169,000	Full	Below
Pacific cod	68,602	77,900	56,700	Full	Above
Flatfish	36,294	293,920	169,000	Under	Unknown
Sablefish	15,957	14 120	23,700	Full	Below
Atka mackerel	873	600	Unknown	Unknown	Unknown
Slope rockfish	14,863	24,670	Unknown	Full	Below
Thornyhead rockfish	1,162	2,000	3,750	Full	Above
Pelagic shelf rockfish	2,605	5,000	Unknown	Unknown	Unknown
Demersal shelf rockfish	364	560	Unknown	Full	Unknown
Total	211,922	548,770	452,980		

reversed due to a subsequent string of above-average year classes (those spawned in 1989–91). The cod stock is now considered to be healthy, though declining slightly in abundance, and fully utilized.

Flatfishes: All flatfish species are underutilized and, with the exception of Greenland turbot, appear to be at above-average abundance levels. The underutilization of flatfish results from the fishery management plan requirement to maintain overall groundfish catches within the 2,000,000 t optimum yield cap and a desire to prevent excessive incidental catches of Pacific halibut and king and Tanner crabs.

Bill Barss ODFW

Yelloweye rockfish.

Yellowfin sole is the most abundant of the flatfishes. Within the overall groundfish complex, yellowfin sole ranks second in abundance behind walleye pollock. In terms of harvest, yellowfin sole ranks third among the groundfish complex behind pollock and Pacific cod. Greenland turbot, the only flatfish stock below target abundance levels, shows a continued decline from the high levels during the early 1980's due to poor spawning success.

Among the other flatfish species, abundance continues to be high and stable. Rock sole is now the second most abundant of the flatfishes and the third most abundant of all groundfish species, having increased steadily throughout the survey time series (i.e. since 1975).

Sablefish: Sablefish (or blackcod) is a valuable species caught mostly with longline and pot gear in depths greater than those fished by trawlers. Sablefish is considered to be a single stock from the Bering Sea and Aleutian Islands region to the Gulf of Alaska. The population declined substantially in 1990, perhaps due to migrations into the Gulf of Alaska and a general retraction of the stock's range. Recent recruitment has been relatively weak, and the stock is considered below its long-term average level. Sablefish is fully exploited (within the context of allowing stock-rebuilding to occur).

Rockfish: Rockfishes are assessed and managed as two major groups: Pacific ocean perch and other rockfish. The former's abundance dropped sharply owing to intensive foreign fisheries in the 1960's and remained low into the early 1980's. In recent years, catch levels have been set well below current potential yield to help rebuild the stocks. The Pacific ocean perch group appears to have recovered and is currently harvested at full utilization levels (within the context of risk-averse management).

Atka Mackerel: The Atka mackerel stock lives mainly in the Aleutian Islands region. Previously, current potential yield for this species had been set conservatively low because of uncertainty regarding its abundance. However, trawl surveys conducted by the Alaska Fisheries Science Center in 1986 and 1991 have confirmed a higher abundance than was previously realized, and a gradual increase in the rate of exploitation was phased in from 1992. This stock is considered at its average level, declining slightly, and fully utilized.

Other Species: In recent years, other species have represented 1% or less of the total groundfish catch. Sculpins and skates probably constitute most of this resource, but the abundance of pelagic squids, smelts, and sharks is largely unknown. The current potential yield has been set at the average catch level.

Gulf of Alaska Groundfish

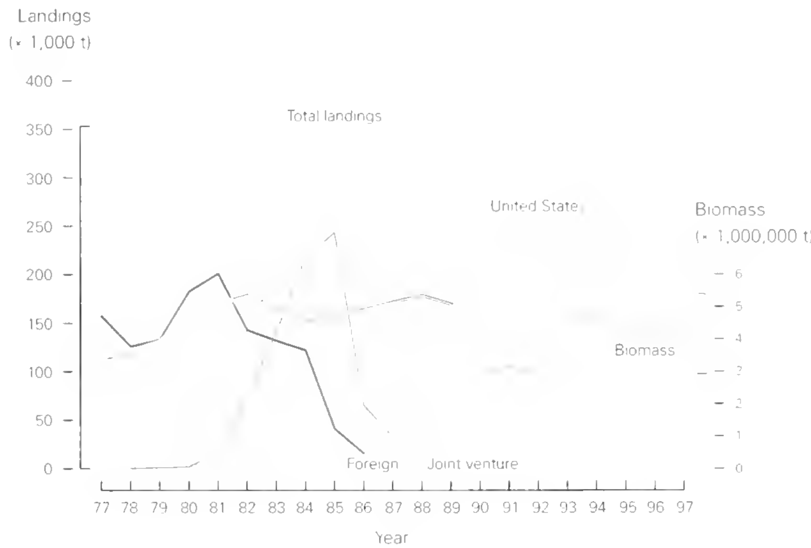


Figure 19-3
Landings and abundance trends for Gulf of Alaska groundfish.

Groundfish abundance in the Gulf of Alaska increased since 1977, peaking at 5,300,000 t in 1982. Abundance since then has remained relatively stable, fluctuating between 4,500,000 and 5,300,000 t. The estimated long-term potential yield (451,440 t, Table 19-3) for Gulf of Alaska groundfish has not been updated since last reported (NMFS, 1996). The current potential yield for the groundfish complex totaled 548,770 t which reflects a high abundance of some stocks relative to their long-term potential yields. The recent average yield of the complex is 211,922 t. The wide disparity between the current potential yield and the recent average yield is due to underutilization of some groundfish species, particularly for flatfish, that could not be fully harvested without exceeding incidental catch limits of Pacific halibut set by the North Pacific Fisheries Management Council.

Gulf of Alaska groundfish catches have ranged from a low of 129,640 t in 1978 to a high of 352,800 t in 1984 (Figure 19-3). The groundfish catches are dominated by pollock, followed by Pacific cod, flatfish, and rockfish. Groundfish catches since 1989 have fluctuated around 200,000 t. The 1997 groundfish catch of 225,000 t was valued at $144,000,000 (ex-vessel value). Sablefish comprised about 55% ($79,000,000). Other major revenue-producing species in 1997 were pollock ($19,000,000), Pacific cod ($33,000,000), and flatfishes ($7,000,000).

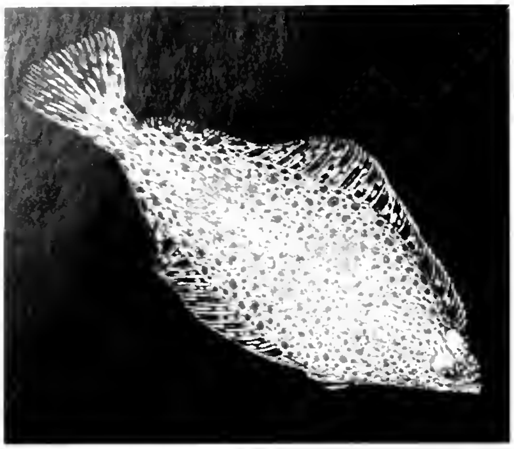
Pollock: Pollock abundance has been increasing in recent years due to strong recruitment from the 1994 year class. The western-central Gulf of Alaska pollock total allowable catch is further apportioned among three areas and three seasons. This temporal and spatial apportionment of the pollock quota was implemented to accommodate Steller sea lion concerns; pollock are a major prey item of Steller sea lions in the Gulf of Alaska. Pollock are considered fully utilized.

Pacific Cod: Pacific cod are abundant and fully utilized. The Pacific cod stock has been declining for the past several years due to a lack of significant recruitment. However, recruitment from the 1995 year class may reverse this trend in the near future. A risk-averse exploitation rate has been applied to Pacific cod in light of uncertainty about the natural mortality rate and the proportion of the population not sampled by the survey gear.

Flatfish: Flatfish are in general very abundant, largely due to great increases in arrowtooth flounder biomass. Flathead sole, rex sole, and arrowtooth flounder are managed as separate categories, and the rest of the flatfish are managed as deep-water or shallow-water groups. Flatfish are underutilized due to halibut bycatch considerations.

Sablefish: Sablefish are approaching their lowest observed population level and are projected to stabilize just above this lowest level in the near future. Sablefish have been on a slowly declining trend due to a lack of strong recruitment. They are fully utilized. Sablefish have been harvested under an individual fishing quota system since 1995. This has significantly changed the dynamics of the fishery.

Rockfish: For management purposes, rockfish in the Gulf of Alaska are divided into four assemblages or species groups: slope rockfish, pelagic shelf rockfish, thornyhead rockfish, and demersal shelf rockfish. Slope rockfish are at low levels of abundance and fully utilized. Within this group, Pacific ocean perch, shortraker and rougheye rockfish, and northern rockfish are managed as separate categories. The principal species of the slope group, Pacific ocean perch and shortraker and rougheye rockfish, are highly valued. Slope rock-



Juvenile sole.

fish, particularly Pacific ocean perch, were intensively exploited by foreign fleets in the 1960's. In recent years, Pacific ocean perch have started to rebound from the heavy exploitation of three decades ago due to good recruitment from a series of year classes. Thornyhead rockfish are highly valued and believed to be at average levels of abundance. Dusky rockfish is the dominant species in the pelagic shelf rockfish group, but its abundance estimate is variable due to problems assessing this species with current trawl survey methodology. Demersal shelf rockfish assessment and management are focused on the target species, yelloweye rockfish. Traditional population assessment methods (e.g. trawl surveys) are not considered useful for surveying demersal shelf rockfish because of their affinity for rough terrain. They are currently being assessed using a manned submersible. While estimates of abundance have been calculared, there is insufficient historical information to determine trends. Rockfish in general are conservatively managed due their long life spans and consequent sensitivity to overexploitation.

Atka Mackerel: The Atka mackerel stock occurs mainly in the Aleutian Islands region. Its abundance in the Gulf of Alaska is much lower and highly variable. The resource supported a large foreign fishery in the Gulf through the mid 1980's but disappeared thereafter. Targeting on the species resumed in the Gulf in 1990, as the population increased. The absolute abundance of the stock has been difficult to estimate by trawl gear since it is a shallow, schooling species that tends to reside on rough and rocky bottoms. Due to extreme variance in survey catches, it has been concluded that stock abundance cannot be determined from trawl survey data. Because there is no reliable estimate of Atka mackerel biomass and this species has exhibited vulnerability to fishing pressure in the past, Atka mackerel are managed as a bycatch-only species. Quota levels are set at low levels which preclude a directed fishery but accommodate bycatch needs in other fisheries.

ISSUES AND PROGRESS

Transboundary Stocks and Jurisdiction

Some of the U.S.-origin eastern Bering Sea pollock migrate into the Russian zone of the northern Bering Sea, intermingle with Russian stocks, and are subject to Russian exploitation. Such exploitation is of concern to the United States as it could impact U.S. stocks and management. While this transboundary issue is a subject of continuing U.S.-Russia scientific studies and discussions, a coordinated exploitation and management scheme has not yet been reached. At this time, the United States can only indirectly consider the possible impact of Russian fishing on the U.S. stocks in setting exploitation strategies.

A former unregulated pollock fishery that occurred in the "Donut Hole" area of the central Bering Sea has not been a problem since the implementation of the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea. Under this Convention, signed by the Russian Federation, Japan, Poland, China, the Republic of Korea, and the United States, a central Bering Sea pollock fishery has not been authorized because of low biomass of the Aleutian Basin pollock stock. In fact, the moratorium on pollock fishing in the central Bering Sea was voluntarily imposed from 1993 as negotiations on the Convention were proceeding.

Bycatch and Multispecies Interactions

Pacific halibut, king, Tanner, and snow crabs, salmon, herring, and shrimp are considered prohibited species for groundfish fisheries. Their incidental take by the groundfish fisheries must be recorded and returned immediately to the sea up to specified amounts set by regulation. While the

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Pacific halibut sportfishing, Shelter Island, near Juneau, Alaska.

problems of incidental take may be biological because of the overharvest by groundfish fisheries, they are mostly allocative in nature. Bycatch limits on such incidentally caught species have been set to mitigate the problem and have generally constrained further expansion of the groundfish fisheries. When any bycatch limit is reached, the groundfish fisheries could get closed, often before all of the available groundfish quota is taken.

The North Pacific Fishery Management Council has also been testing an incentive program to control bycatch. This is an individual vessel incentive program where bycatch rates are established for the fleet and regulated by individual vessels. It is designed to give a vessel more control over its own fishing destiny by holding it directly accountable for its bycatch rates. The program has resulted in some success and is undergoing evaluation and change.

Marine mammal interactions with fish and fisheries are a growing concern to resource management. Fisheries compete for fish that marine mammal and other species, including seabirds, depend on for food in the marine ecosystem. The impact of fish removals on Steller sea lions has been postulated as an important factor for declining sea lion populations. The Steller sea lion is listed as threatened (eastern Pacific population) and endangered (western U.S. Pacific population) under the Endangered Species Act and continues to decline. Since sea lions feed on pollock and other fish species, groundfish fisheries are being regulated to reduce impact on them. In December 1998, the National Marine Fisheries Service (NMFS, 1998) issued a biological opinion under the Section 7 Consultation of the Endangered Species Act that the Bering Sea and Aleutian Islands and the Gulf of Alaska pollock fisheries are likely to jeopardize the continued existence of the western population of Stellar sea lions and adversely modify its critical habitat. As a result of this jeopardy determination, the NMFS has proposed some reasonable and prudent alternatives to disperse the intensity of pollock fisheries in the critical habitat of sea lions and enact additional 10–20 nautical mile no-trawl zones around sea lion rookeries and haul-out areas.

As the domestic groundfish fisheries are now fully developed and overcapitalized, allocation disputes between user groups have also been a continuing problem. These problems include inshore versus offshore, fixed gear versus trawler, and other user conflict issues. The North Pacific Fishery Management Council has been addressing the problems as they arise and developing fishery management plan amendments to mitigate them. Recent amendments have made explicit allocations to inshore and offshore sectors of the industry as well as specific percentage allocation of target and bycatch amounts to specific gear types. The NMFS promulgated regulations to implement an individual fishing quota program for sablefish and Pacific halibut in 1995. Under this program, vessel owners are allocated transferrable quota shares of sablefish and Pacific halibut to use at their discretion. More efficient use of the resources are expected under this system.

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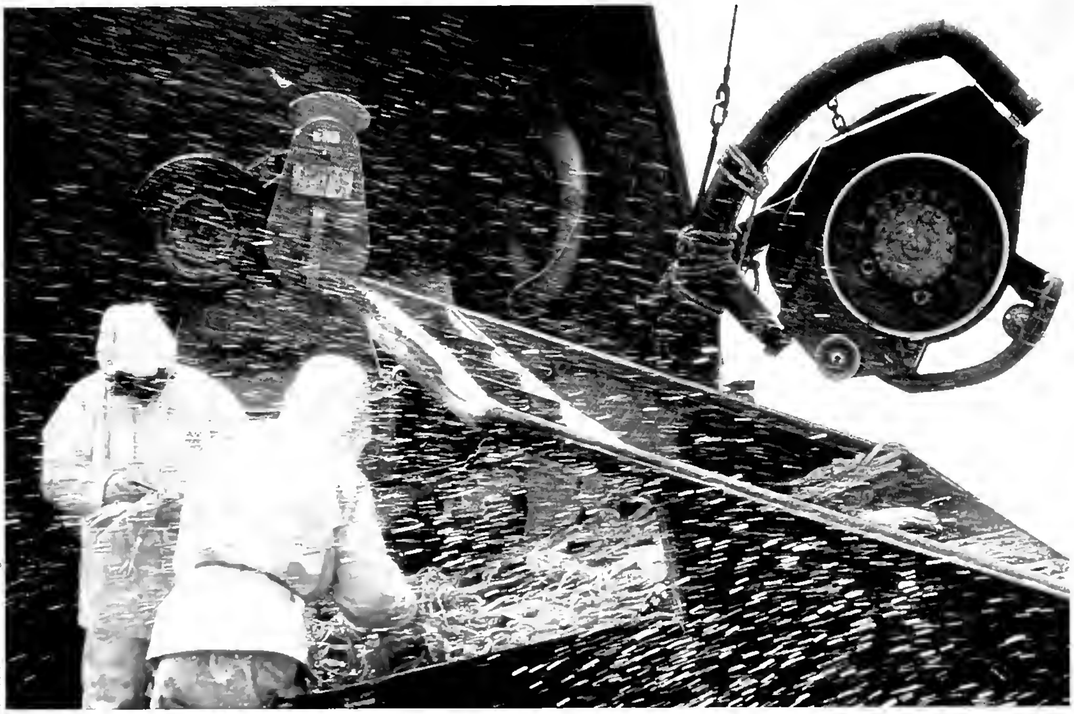
Alaska Shellfish Fisheries



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Sorting snow crab, eastern Bering Sea.

Unit 20

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INTRODUCTION

Alaska's major shellfish fisheries developed in the 1960's in the Gulf of Alaska, subsequently expanding to the Bering Sea and Aleutian Islands region. Shellfish landings in 1997 generated an ex-vessel value of $151,000,000 (preliminary). The most important of these are the king and snow crab fisheries at $144,000,000. There was no fishery for Tanner crab in the Bering Sea in 1997 due to low stock abundance. Shrimp resources remain depressed, and sea snails are only lightly harvested. These and other miscellaneous invertebrate landings contributed about $7,000,000 to ex-vessel revenue in 1997.

King and Tanner crab fisheries are managed primarily by the State of Alaska, with advice from a Federal fishery management plan for the Bering Sea and Aleutian Islands stocks. The sea snail resource falls under management of a Federal preliminary fishery management plan. Shrimp and other nearshore fisheries are managed by the Alaska Department of Fish and Game.

SPECIES AND STATUS

Crab

Three king crab species (red, blue, and golden or brown) and two Tanner crab species (Tanner crab and snow crab) have traditionally been harvested commercially off Alaska. Since the last report (National Marine Fisheries Service, 1996) exploratory fisheries on new deep-water stocks of scarlet king crab, grooved Tanner crab, and triangle Tanner crab have begun, producing only minor landings to date. Yield values from these fisheries are presented in Table 20-1. Information on current and long-term potential yield is lacking for king and Tanner crabs; thus default values were derived from historical average landings. Long-term potential yield is represented by catch

Table 20-1

Productivity in metric tons and status of Alaska shellfish fisheries resources

[illegible]	Recent average yield (RAY)	Current potential yield (CPY)	Long-term potential yield (LTPY)	Fishery utilization level	Stock level relative to LTPY
[illegible]	2,857	2,857	21,751	Full	Below
[illegible]	39,053	39,053	37,202	Full	Above
[illegible]	7,170	7,170	36,481	Full	Below
[illegible]	1,637	1,637	14,722	Full	Below
[illegible]	1,414	1,414	3,062	Under	Unknown
Total	52,131	52,131	113,218		

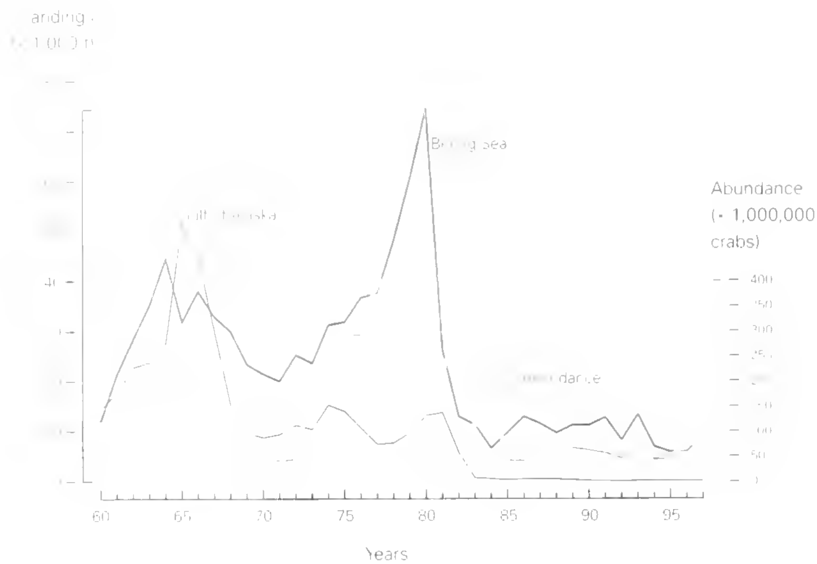

Figure 20-1

Landings in metric tons (t) and abundance trends of king crabs in the Gulf of Alaska and Bering Sea.

Opposite page: Oregon triton

averages; current potential yield is set equal to recent average yield, calculated as the most recent three-year average. Stock status is determined by comparison of the short-term average catches against long-term production. The recent average yields for king (7,170 metric tons (t)) and Tanner (2,857 t) crabs are below their respective long-term potential of 36,481 and 21,751 t. By contrast, the recent average yield for snow crab of 39,053 t is above its long-term potential yield of 37,202 t. Alaska crab resources are fully utilized.

The ex-vessel value for king crabs in 1997 was $56,000,000, $3,800,000 for Tanner crabs (Southeast Alaska only), and $88,000,000 for snow crabs. Landings in 1997 were: king crab (9,200 t), Tanner crab (862 t), and snow crab (53,220 t). Almost all this production came from the Bering Sea, where value and landings for king crab were ($43,000,000 from 6,720 t). All snow crab landings came from the Bering Sea, and these dominated the total crab landings, comprising 58% of value and 82% of catch (Alaska Department of Fish and Game, 1998).

The fleet fishing for Alaska crab is comprised of 200–250 vessels, many of which are based in the Pacific Northwest. Crabs are captured with baited pots, and most of the catch is landed in Dutch Harbor, Alaska. Catches are restricted by quotas, seasons, and size and sex limits, with landings limited to large male crabs. Fishing seasons are set at times of the year which avoid molting, mating, and soft-shell periods, both to protect crab resources and to maintain product quality.

Catch and abundance trends (Stevens et al., 1998) for king crabs are shown in Figure 20-1. After a 1964–66 peak, declines were evident. Until 1967, Japanese and Russian fisheries dominated Bering Sea landings, but those fisheries were phased out by 1974. In the Bering Sea, domestic catches peaked at 74,000 t in 1980 and then dropped precipitously in 1981. Since then, the catches have remained low. Gulf of Alaska catches peaked in 1965, then varied at a relatively low level for a decade before dropping lower still in 1983. Almost all Gulf of Alaska king crab fisheries have been closed since 1983.

Tanner and snow crab trends (Stevens et al., 1998) are shown in Figure 20-2. The 1965–75 period was a developmental phase. During 1975–85, the catch peaked at about 75,000 t in 1979 and then declined. Since 1984 the catch increased, reaching an all-time high of 168,000 t in 1991, and then decreased into 1997. Abundance trends for Bering Sea stocks indicate that the Tanner crab stock declined from a relatively high level in the late 1970's to a low in 1985. The stock recovered and then declined again subsequent to 1989, and is currently at a low level. From a low in 1985, snow crab rebounded sharply, producing the high catches of 1991.

Shrimp and Sea Snail

The northern pink shrimp is the most important of the five species making up Alaska shrimp landings. The domestic shrimp fishery in western Alaskan waters is currently at a low level. Shrimp abundance is also too low in the Bering Sea to support a commercial fishery. The western Gulf of Alaska has been the main area of operation. During the 1970's, when the fishery was more productive, 50–100 vessels trawled for shrimp at Kodiak Island and along the Alaska Peninsula.

Shrimp landings in the western Gulf during 1960–90 (Figure 20-3) show that catches rose steadily to about 58,000 t in 1976 and then declined precipitously. Since 1988, negligible amounts have been landed, almost all of it coming from Southeast Alaska. Ex-vessel revenue from the western shrimp fisheries averaged $4,000,000 annually, and yielded a peak revenue of $14,000,000 in 1977. Bering Sea shrimp catches by Russia and Japan peaked at 32,000 t in 1963, declining gradually thereafter, until the fishery ended in 1973. As with crabs, the potential yields of shrimp stocks in Alaska are not well understood, and they have been equated to average catches. Shrimp are managed by regulating catch levels according to stock abundance. In addition, spring "egg hatch" closures are used to protect breeding stocks.

The Japanese pot fishery for snails, conducted from about 1972 until ending in 1987, peaked at about 13,000 t in 1974. Annual catches averaged about 4,800 t during the period of the fishery. The snail stocks of the Bering Sea are underutilized because they are only lightly harvested, with five vessels participating in the Bering Sea during 1996. Recent average yield and current potential yield equal the 1994–97 average catch, and the long-term potential yield equals the 1972–97 average.

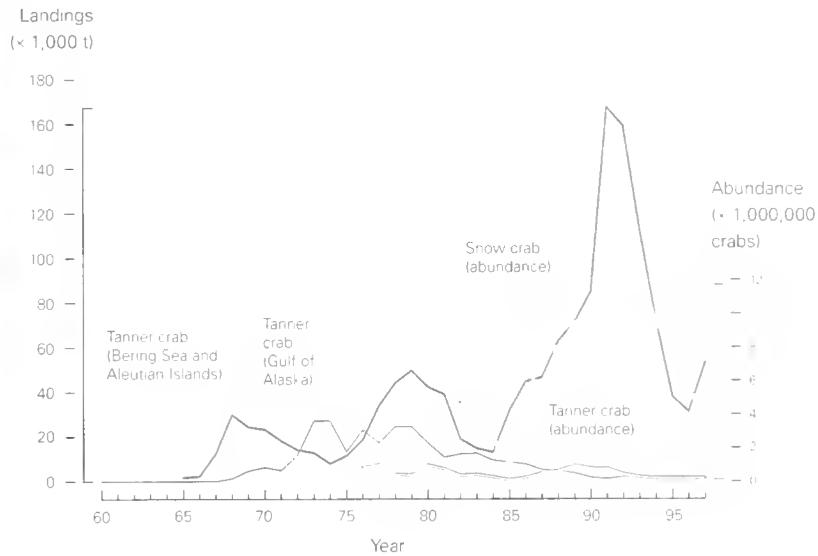

Figure 20-2
Landings in metric tons (t) and abundance trends of Tanner and snow crabs in the Gulf of Alaska and Bering Sea.

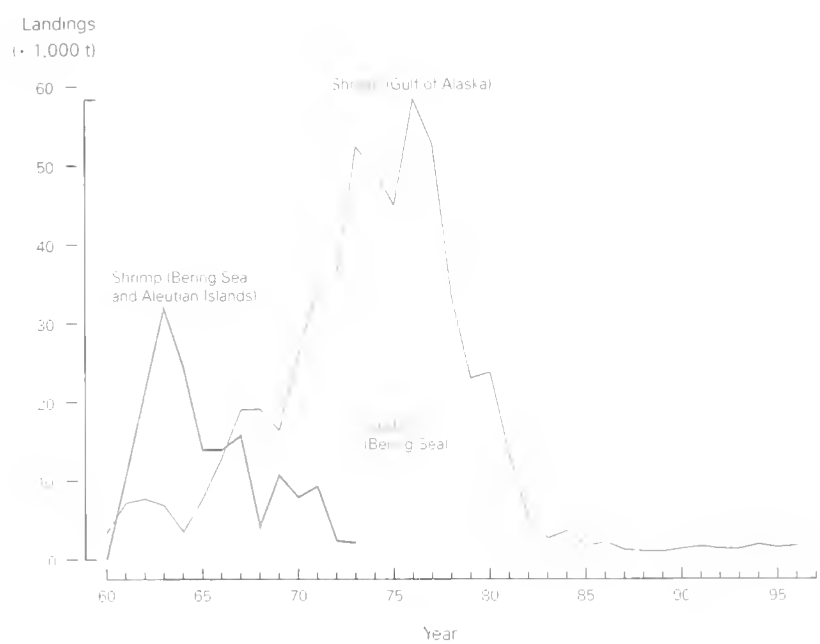

Figure 20-3
Landings in metric tons (t) of shrimp and snails in the Gulf of Alaska and Bering Sea

Snow crab.

ISSUES AND PROGRESS

Bycatch and Multispecies Interactions

In general, crab and shrimp resources are depressed throughout Alaska. The red king and Tanner crab stocks in Bristol Bay are particularly low. The red king crab fishery was closed in 1994 and 1995, following assessment of the spawning stock, which has declined to a low level. During the 1996 Tanner crab fishery only 800 t was landed, and the fishery was closed in 1997.

The bycatch of crabs in trawl and pot fisheries continues to be a major issue. Not only is bycatch an allocation problem, but unknown mortalities from discards of females and subadult crabs from pot and trawl catches could have an impact on the crab stocks. When crab abundance is low, the unknown bycatch mortality, if high enough, could impose unacceptable risks to stock recovery.

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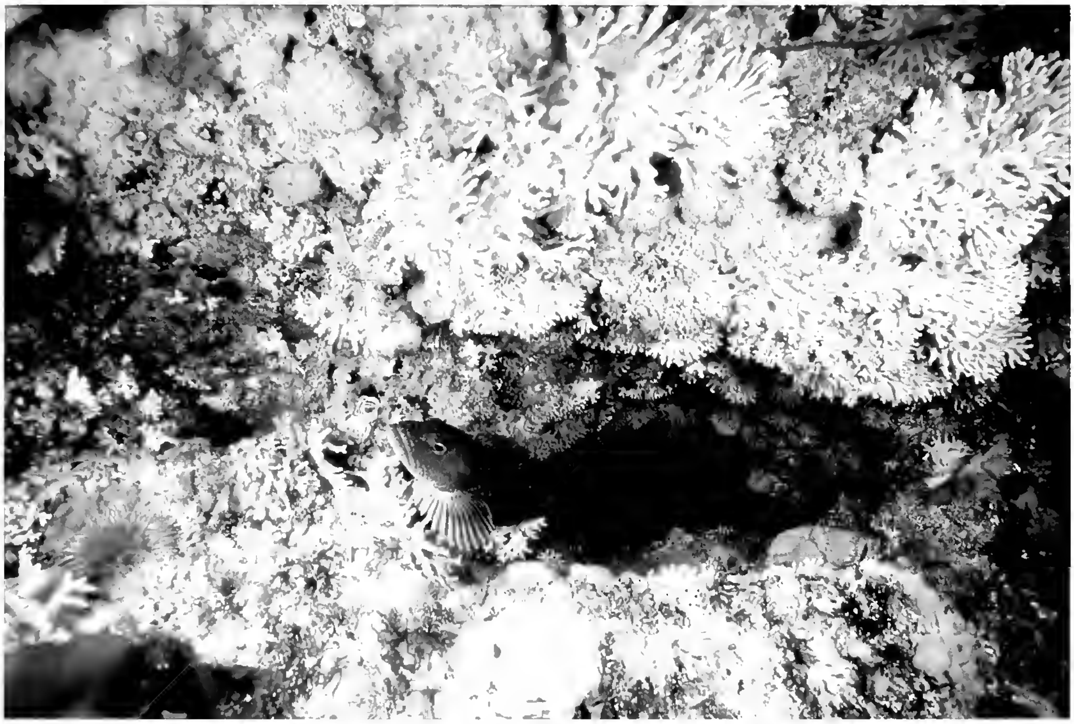
Nearshore Fisheries



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Lingcod in coral off California coast.

INTRODUCTION

For the purposes of this report, "nearshore fishery resources" are those coastal and estuarine species found in the 0–3 nautical mile zone of coastal state waters, and for which the National Marine Fisheries Service (NMFS) has no direct management role.

Nearshore resources vary widely in species diversity and abundance. Many are highly-prized gamefish. Others are small fishes used for bait, food, and industrial products. The invertebrate species of greatest interest include crabs, shrimps, abalones, clams, scallops, and oysters. Recent average yields from coastal state waters were at least 310,402 metric tons (t) (Table 21-1). This amount excludes landings of large-scale nearshore fisheries like anchovy, sardine, herring and the invertebrate resources described in earlier chapters.

Because the composition of the nearshore fauna is very diverse and management authority is shared among the many coastal states and other local bodies, *Our Living Oceans 1999* does not attempt a detailed treatment of their status. However, this unit presents information on the more significant species of national interest. For more comprehensive assessments of individual species, readers should refer to reports published by state natural resource agencies

NORTHEAST REGION

The 1995–97 recent average yield for the northeastern U.S. nearshore species was at least 74,450 t (Tables 21-1 and 21-2). This estimate is conservative and reflects mostly commercial landings; however, recreational harvest estimates for many, especially the invertebrates, are lacking. The 1997 dockside revenue from the commercial landings was an estimated $206,000,000. Nearshore recreational value, though not available, is con-

Table 21-1

Recent average landings of nearshore resources by regions, in metric tons.

[illegible]	Recent average yield (RAY)	Commercial RAY	Recreational RAY
Northeast	74,450	72,550	1,900[1]
Southeast	93,540	91,534	3,767[2]
Pacific	133,090	n/a	n/a
Western Pacific	1,420	n/a	n/a
Alaska	10,200	9,700	500
Total	312,700		

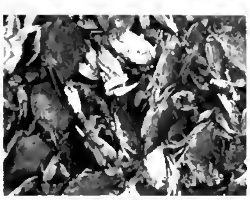
[1]Only for tautog and white perch; recreational harvest estimates unavailable for invertebrate species.
[2]Southeast Recreational RAY includes finfish only. Numbers are estimates based on surveys.

Table 21-2

Productivity in metric tons and status of northeast nearshore fishery resources.

Species/group	Recent average yield (RAY)[1]	Fishery utilization level	Stock level relative to LTPY[2]
Blue crab	42,000	Full	Near
Sea urchin	11,400	Over	Below
Atlantic hardshell clam	3,400	Over	Below
Oyster	3,000	Over	Below
Blue mussel	2,600	Unknown	Near
Horseshoe crab	2,100	Unknown	Unknown
Tautog	1,700	Over	Below
Other shads and herring	1,700	Over	Below
White perch	1,200	Unknown	Unknown
Jonah crab	1,100	Unknown	Unknown
Softshell clam	1,000	Full	Below
Rock crab	900	Unknown	Unknown
Conch	850	Unknown	Unknown
Sea cucumber	740	Unknown	Unknown
American eel	480	Unknown	Unknown
Sea worm	240	Unknown	Unknown
Periwinkle	30	Unknown	Unknown
Bay scallop	10	Over	Below
Total	74,450		

[1]1995–97 average (including recreational landings).
[2]LTPY = Long term potential yield.



Left page: blue crab; right page: commercial catch of blue crab.

sidered to be substantial.

There was an outbreak of *Pfiesteria piscidida*, a single-celled microorganism related to the dinoflagellates responsible for red tide, in the Chesapeake Bay region in the summer of 1997. This outbreak, possibly due to increased nutrients in the water caused by pollution, resulted in some fish kills as well as health problems for a small number of swimmers, divers, and fishermen in some isolated estuarine and coastal areas in Maryland and Virginia, and ranging as far south as North Carolina. As a consequence, some areas were temporarily closed to fishing, swimming, and boating activities.

Landings of blue crab are the most important of the nearshore harvests for the Northeast Region (Table 21-2). Commercial landings in 1997 were 45,500 t, 21% less than in 1996, with an ex-vessel value of about $83,000,000. Abundance in Chesapeake Bay, the region's main producer, was above average in the 1980's, but decreased somewhat in the 1990's and is currently at about the

National Wetlands Research Center, USGS

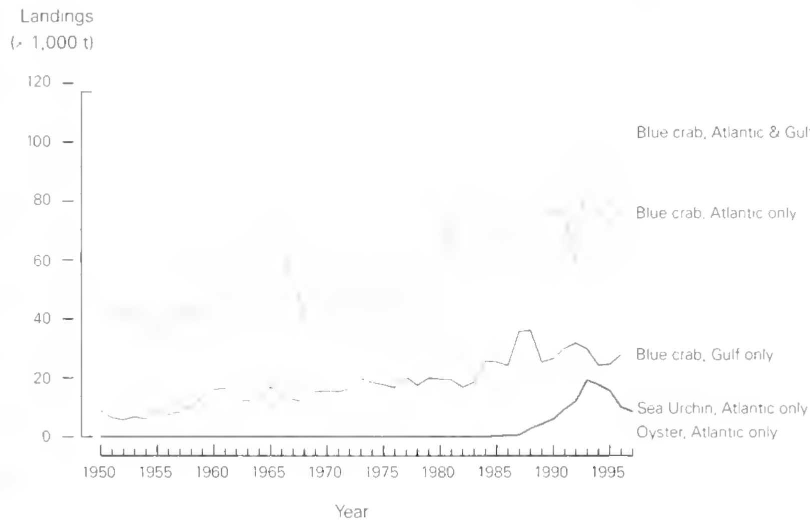


Figure 21-1
Landings of blue crab from the Gulf and Atlantic Coasts, and sea urchin and oyster from the Atlantic Coast, in metric tons (t).

long-term average level (Rugolo et al., 1997). Harvest levels in Chesapeake Bay, which comprise about 85% of the region's total, declined nearly 40% from a high in 1993 to 1996, but improved about 25–30% in 1997. In contrast, blue crabs have been unusually abundant in Delaware and Raritan Bays, where landings have increased.

Sea urchins, second highest in northeast nearshore species landings (recent average yield of 11,400 t), have been subjected to increasing fishing pressure ever since a major fishery began in Maine waters in 1987 to supply the fresh roe market in Japan. Landings increased from about 700 t in 1987 to a high of 19,200 t in 1993, but have declined to only 8,500 t in 1997. Abundance, as measured by catch-per-unit-effort, has steadily declined. At the peak of the fishery there were 2,800 harvesters delivering product to 85 buying stations along Maine's coast (Robert Morrill, Personal Communication[1]) As local areas are intensively harvested by divers, traps, rakes, and drags, the fishery has expanded to other areas. In the 1997–98 fishing season (September–April) in Maine, harvesting was restricted to 120 days because of concerns about the continued decline in abundance and the need for conservation.

Oysters, one of the most valuable nearshore species (commercial landings valued at nearly $40,000,000 in 1997), have increased slightly in abundance in Delaware and Chesapeake Bays. Harvest levels had reached all-time lows in recent decades in both areas (Figure 21-1) because of substantial mortalities caused by the diseases MSX and Dermo. Long Island Sound continues to be the region's largest oyster producer. In 1997, MSX caused mortalities of around 30% in some Connecticut beds, but production should be sustained because large supplies of live oysters easily exceed the quantity that markets will take. In most areas, oyster supplies in estuaries still exceed the current market demand. The James River is the most consistent oyster-producing habitat in Virginia, and abundance has increased there about 25% in the past 4 years. Improved abundance in traditional oyster-producing areas which had earlier suffered major declines due to disease will be dependent to a large extent on the successful development of improved broodstock of disease-resistant native eastern oysters, restocking programs, and habitat enhancement.

Landings and abundance of hardshell clams from the traditional harvesting grounds have risen in Narragansett Bay, Long Island Sound (Connecticut) and Raritan Bay, but have declined

[1]Robert C. Morrill, NMFS, Suite 212, Marine Trade Center, 2 Portland Fish Pier, Portland, ME 04101.

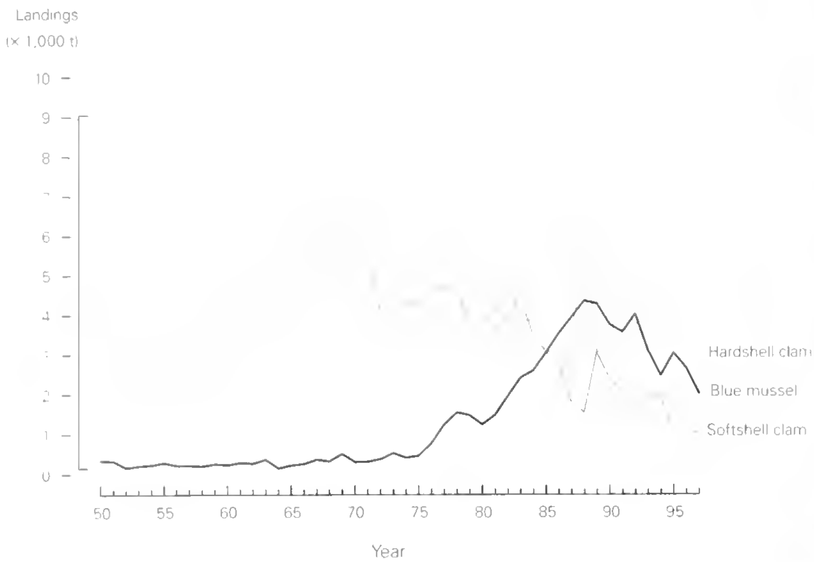


Figure 21-2
Landings of hardshell clam, shoftshell clam, and blue mussel from the Gulf and Atlantic Coasts, in metric tons (t).

sharply in Great South Bay and Barnegat Bay. In recent years, hard clam hatchery production has been substantial along the U.S. east coast in response to the increased market demand for littlenecks (the smallest and most expensive market category). Current levels of landings are about half of the early 1950's level (Figure 21-2). Ex-vessel value of landings has been around $35,000,000 in recent years.

Softshell clam landings, which have declined since the late 1960's (Figure 21-2), continue to decline in the largest producing areas, Maine and Maryland. For yet unexplained reasons, the clams have failed to reproduce in quantity in eastern Maine, a large producer of clams in the past, and diseases (sarcomas and *Perkinsus*) may be the principal reason for the decline in stocks in Maryland. Clam abundance in Massachusetts, which now produces slightly more clams than Maine, has remained about level due to consistently good annual sets of seed and programs to depurate (cleanse) clams harvested from contaminated grounds. Current landings, around 1,000 t, are valued at about $8,000,0000–$10,000,000.

Abundance of blue mussels in nearshore areas of Maine and Massachusetts, which produce nearly all the landings for the region, has declined slightly in recent years. During the 1980's and early 1990's, landings increased markedly (Figure 21-2). Supplies and both market demand and prices have been good and steady in recent years.

William B. Folsom, NMFS

Processing steamed clams, Kent Narrows, Maryland

The bay scallop is the most sensitive commercial mollusk to environmental perturbations, and its abundance remains low throughout the region because of the presence of adverse algal blooms, declines in abundance of eelgrass, and other problems. Rhode Island and eastern Long Island, which once produced large quantities of bay scallops, now have sparse stocks because dense algal blooms or "brown tide" kill the scallops. Scallop abundance and landings in Massachusetts have declined slightly in the past year or two, but are well below the levels experienced in the late 1970's and early 1980's as a result of lost habitat and increased numbers of predators.

Conchs or whelks are harvested from Massachusetts through New York with pots and in Virginia with dredges. Landings and the sizes of conchs landed have both declined slightly in response to steady harvesting from Massachusetts through New York, but landings have been stable in Chesapeake Bay (Virginia). Periwinkles, harvested only in Maine, have declined in abundance because of intense harvesting. Increased numbers of fishermen are now, for the first time, using dredges and rakes to harvest periwinkles to supplement their incomes. In addition, smaller periwinkles are being marketed.

Landings of Jonah and rock crabs have remained fairly stable, with abundance unknown but thought to be fairly high. Abundance of slow growing horseshoe crabs has declined in Delaware Bay, the site of greatest concentration.

A renewed interest in horseshoe crabs as bait for the American eel and conch pot fisheries, and use of horseshoe crab blood by the biomedical industry, elevated commercial catches from 412 t in 1990 to about 2,800 t by 1997. An interstate fishery management plan was adopted by the Atlantic States Marine Fisheries Commission (ASMFC) in October 1998 in recognition of the importance of horseshoe crabs and their eggs to the coastal ecosystem as food for migrating shorebirds, finfish, and sea turtles, and in concern over the growing exploitation rate (ASMFC, 1998). The ASMFC fishery management plan mandates conservation measures in the Mid-Atlantic area and monitoring programs throughout the species' Atlantic coastal range

Sea worms, dug principally in Maine, have continued to decline both in abundance and in average size because of heavy harvesting. These worms are highly sought as bait by marine recreational fishermen from Massachusetts to South Carolina.

A new fishery for sea cucumbers began in Maine several years ago to supply Asian markets. At present, only one processor and three fishing vessels are involved in that fishery. Landings peaked at about 1,300 t in 1996 and were only 61 t in 1997. Abundance appears to be relatively steady.

Of the finfish included in this unit, only tautog has been assessed. Recreational fishing accounts for about 85% of the total landings, which have continued to decline in recent years. Abundance remains at record low levels.

SOUTHEAST REGION

Relatively few fisheries from the southeast are highlighted in this unit, as many of the truly nearshore fisheries of the region have been covered under Units 7, 9, 10, and 11. In the southeast as in the northeast, the recent average yields reported here are underestimated, because they can generally be based only on commercial landings. Recreational landings, which may be considerable, are generally unavailable for the invertebrates that dominate the southeast nearshore fisheries. Bycatch mortality is not estimated, or is incompletely estimated, for many species.

Blue crabs dominate the nearshore catch by weight. Recent landings have fluctuated around 60,000 t (Figure 21-1, Table 21-3). Oyster harvests have trended downward over the last decade, but recent landings have been steady with a recent average yield of 10,440 t. Calico scallop has been important in the landings in the past (20,000 t in 1984), but recent landings have averaged 1,184 t.

Mullet landings in the region have been affected by a ban on nets over 500 square feet in

Horseshoe crab stranding, Lewes, Delaware.

Casting a mullet net, Everglades City, Florida

Table 21-3

Productivity in metric tons and status of southeast nearshore fishery resources.

Species	Recent average yield (RAY[1])	Commercial RAY[1]	Recreational RAY[1]	Fishery utilization level	Stock level relative to LTPY[2]
Blue crab	59,876	59,876	Unknown	Unknown	Unknown
Mullet	12,558	11,537	1,021	Unknown	Unknown
Oysters	10,440	10,440	Unknown	Unknown	Unknown
Other herring & Spanish sardine	6,040	5,980	60	Unknown	Unknown
Flounder (southern & Gulf)	1,514	609	905	Unknown	Unknown
Bait shrimp	1,264	1,264	Unknown	Unknown	Unknown
Calico scallops	1,184	1,184	Unknown	Unknown	Unknown
Ballyhoo, bigeye scad, flyingfish	664	644	20	Unknown	Unknown
Total	93,540	91,534	Unavailable		

[1]RAYs are for 1994–1996. Recreational data are estimates based on surveys.
[2]LTPY = Long-term potential yield

Florida's waters. This ban took effect July 1, 1995. Recent average yield is down to 12,558 t, but more telling are the landings for 1996, which were reported at 9,484 t. Commercial landings outweigh the recreational catch by slightly more than 10:1. Herrings (not including American shad, alewife, or blueback herring) and Spanish sardine recent average yields total 6,040 t in the southeast, almost all from commercial landings. Bait fisheries for species such as ballyhoo and bigeye scad (goggle-eye) exist primarily in south Florida, with a net fishery for bigeye scad in the Florida panhandle. A major portion of the bigeye scad were landed in Palm Beach County prior to the state-issued net ban. Present landings in that area are a result of a live-bait fishery and have a high value. Ballyhoo landings from the Palm Beach area also dropped, but those in the Florida Keys have been steady. Flying fish are often landed with the ballyhoo.

PACIFIC COAST

On the Pacific Coast, California contributes the most commercial landings of nearshore species at an estimated 93,954 t (Table 21-4), followed by Oregon (22,198 t) and Washington (14,637 t). The total value of the fisheries, much of which is related to marine recreational angling, is difficult to estimate but is thought to be sizable. Although not a direct measure of economic value, an estimated 2,000,000 California anglers spend $800,000,000 yearly on about 6,000,000 fishing trips to catch nearly 30,000,000 saltwater fish—most in nearshore waters—and add more than $1.8 billion to the U.S. economy. In addition to the many commercial nearshore species, marine anglers also land species that have been reserved exclusively for sport—such as striped bass, sturgeon, kelp bass, and California corbina.

Nearshore species also support an expanding California live-fish fishery valued at more than $3,600,000 in 1996, with estimated statewide landings of 562 t. The 65 target species include California halibut, California sheephead, white croaker, and other nearshore finfish, and are caught primarily by hook-and-line and trap gear. Live and premium quality fresh (dead) fish are sold as specialty items to local restaurants. The growing demand for live-fish species has increased fishing pressure on other commercial nearshore species and resulted in a limited-entry program for the live-fish trap fishery in southern California.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Intertidal zone, Pacific Coast.

Shrimp—Shrimp supports nearshore commercial fisheries throughout the Pacific region. They also provide opportunity for recreational fishing, especially near urban centers as in Puget Sound, Washington. The most common species harvested are Pacific (pink), ocean, spot, sidestripe, and bay shrimps. In recent years, landings appear to be on a slight increase from a cyclic low (Figure 21-3). Ridgeback, pink, and spot prawns are taken in California by trawl and trap vessels. Spot prawns support a very lucrative commercial live-prawn fishery. Landings of ridgeback and spot prawns increased 39% in 1996, to 511 t.

Crab—Dungeness crab is the most abundant crab harvested along the Pacific coast. Commercial fisheries operate along all the west coast states, with Oregon and northern California providing the bulk of the landings. Some recreational crabbing also occurs and is an important recreational and subsistence fishery to many ethnic groups. Like other crustacean resources, Dungeness crab abundance is highly variable. In recent years, abundance seems to be on the increase from a low cycle. The productivity and status of the other crab resources, which tend to be localized, are largely unknown. In 1996, amendments to the Magnuson-Stevens Fishery Conservation and Management Act gave authority to the States of California, Washington, and Oregon for their crab fisheries in Federal waters and also recommended that the Pacific Fishery Management Council develop a fishery management plan for Dungeness crab. After explor-

Table 21-4

Productivity in metric tons and status of Pacific nearshore fishery resources.

Area and species	Recent average yield (RAY)[1]	Fishery utilization level	Stock level relative to LTPY[2]
California			
California market squid	68,863	Unknown	Unknown
Sea urchins	10,062	Full	Near
Shrimp	4,853	Full	Near
Dungeness crab	5,315	Full	Near
Other crabs	526	Full	Unknown
Bonito, Pacific	312	Unknown	Unknown
Smelt	913	Near full	Unknown
Elasmobranchs	889	Unknown	Unknown
California halibut	341	Under[3]	Near
Sea cucumbers	314	Unknown	Unknown
Spiny lobster	264	Full	Unknown
Abalones	91	Over	Below
Croakers	238	Unknown	Unknown
Barracuda, Pacific	146	Unknown	Unknown
Bivalves	666	Unknown	Unknown
Other nearshore fishes and invertebrates	207	Unknown	Unknown
Total	94,000		
Oregon			
Clams	50	Under	Near
Oysters	69	Full	Near
Dungeness crab	5,899	Under	Near
Shrimp	7,193	Full	Below
Sea urchin	431	Over	Near
Elasmobranchs	546	Under	Near
Sturgeon	104	Full	Below
Other fish and invertebrates	345	Under	Unknown
Total	14,637		
Washington			
Geoduck clam	1,102	Full	Near
Other clams	2,956	Full	Near
Oysters	3,223	Full	Near
Other bivalves	445	Unknown	Below
Dungeness crab	9,747	Full	Near
Shrimp	3,275	Full	Near
Sea cucumber	355	Full	Near
Sea urchin	595	Full	Near
Elasmobranchs	2,140	Full	Near
Sturgeon	114	Full	Near
Other fish and invertebrates	501	Full	Below
Total	24,453		
Total	133,090		

[1]California RAYs are averaged from 1994–96 except abalone (1995–97). Washington and Oregon RAYs are 1995–97. All bivalve landings are in whole weights except Washington and Oregon oysters (meat weights). California data are from NMFS (Statistics and Economics Division, 1315 East-West Highway, Silver Spring, MD 20910) extracts of California Department of Fish and Game commercial catch statistical reports. California bivalve data are from the PacFIN data base (maintained by the Pacific States Marine Fisheries Commission 45 SE 82nd Drive, Suite 100, Gladstone, OR 97027). Abalone data are from Bill Jacobson (NMFS SW Regional Office, 501 West Ocean Blvd, Long Beach, CA 90802). Washington and Oregon data came from the Washington and Oregon Departments of Fish and Wildlife, respectively.

[2]LTPY = Long-term potential yield

[3]Considered underutilized since the gillnet fishery directed for this species ended January 1994 south of Pt. Arguello where 86[illegible] of the gillnet catch had been taken.

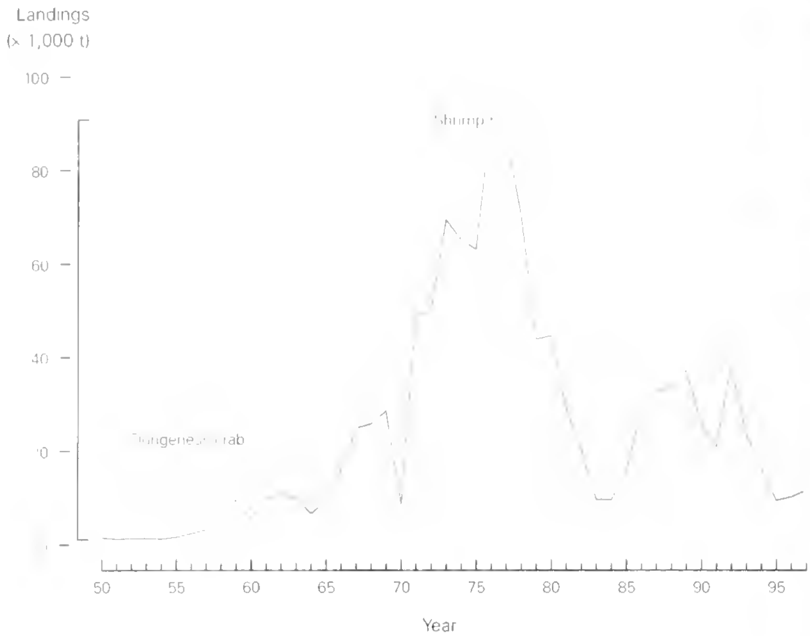

Figure 21-3
Commercial landings of Dungeness crab and several species of shrimp from the combined region of Washington, Oregon, and California, in metric tons (t).

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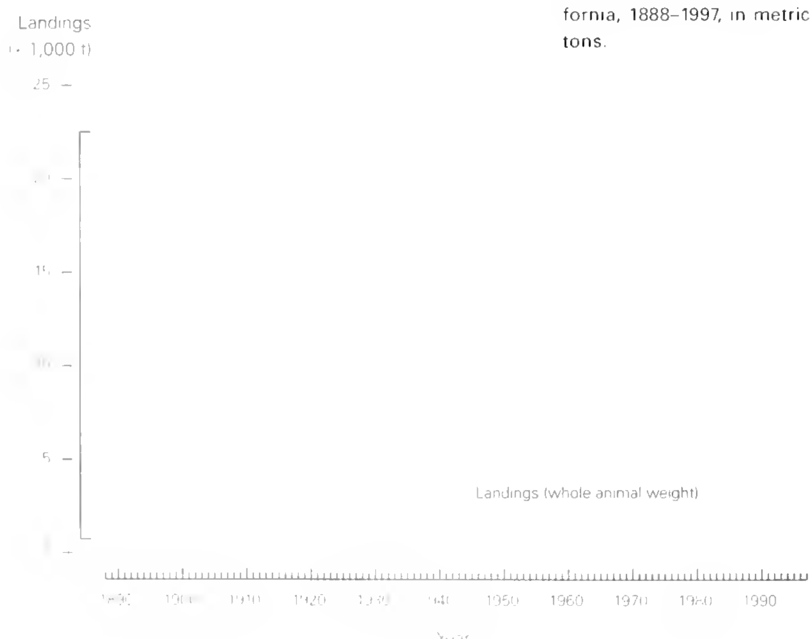


Figure 21-4
Landings of abalone in California, 1888–1997, in metric tons.

ing various management alternatives, in 1997 the council recommended that Congress extend interim authority beyond 1999 and expand the authority to include all management measures except limited entry provisions.

Abalone—Abalones are found mostly in California where utilization of the resource actually predates modern history. The meat is very valuable; a 14-ounce (397 grams) canned abalone may retail for $50 in Seattle's Chinatown. Of the five species harvested, the red, green, and black abalone are the most common. Red abalone is the only species to be harvested commercially in California since 1995. The central and southern California sport and commercial fishery was closed in May 1997, and the closure was extended indefinitely in early 1998. The black abalone fishery has been closed since 1993 to allow the population to recover from withering syndrome. The white abalone population is so low that it has been proposed as an endangered species. Commercial abalone harvesting is accomplished by "hooka" gear, where compressed air from the surface is supplied to the divers. Scuba gear is used in the California

sport fishery where allowed by law, but otherwise sport fishing is restricted to free diving and shore picking.

At present, most of the species of abalone in central and southern California are overutilized. This is due to commercial harvesting efficiency, increased market demand, popularity of the sport fishery, habitat degradation, increasing predation by sea otters, and disease. Despite stricter management, abalone stocks remain vulnerable to continued depletion, and a new state management plan is being developed. The history of catches shows a continually declining trend (Figure 21-4).

Clam—Clam digging is a popular recreation for many families throughout the Pacific Coast, and most are harvested this way. Many species are harvested: razor clam, littleneck clams, pismo clam, gaper clam, Washington clam, butter clam, geoduck, and others. The clam fisheries are regulated by season length and bag limits. The status of the stocks can be inferred from catch performance and would be expected to be known for localized areas only. Since the number of beaches and, thus, stocks are too numerous, it would be difficult to generalize on the status of the stocks. Thus status of the stocks and degree of utilization are largely unknown.

The Pacific geoduck is the largest burrowing bivalve on the Pacific coast. Individuals can live for more than 100 years and reach 9 kg. They are harvested both commercially and recreationally, and the majority of the harvest comes from Puget Sound and British Columbia. Commercial harvest is by divers using high pressure water jets to excavate the clams. In Puget Sound, the population between 10 and 30 m depth is estimated at 127,000 t, and the average annual commercial harvest is 1,300 t.

Squid—One species, the market squid, is harvested throughout the region, with California providing most of the catches. Squid landings in California reached a record high of 78,825 t in 1996, valued at about $30,000,000. It is harvested for bait as well as for food. In southern California, squid is popular in local ethnic food markets and the restaurant trade, but most of the catch is exported to Asia. Squid jigging is also a popular winter activity in the Pacific Northwest. In this sport fishery, anglers of all ages crowd under pier lights and jig for squid in the middle of cold winter nights.

Large-scale fluctuations are characteristic of the squid stock, due mainly to its short life span and from the influence of wide variations in the ocean environment, such as the 1997–98 El Niño event that caused landings to decrease by about 13% from 1996 landings. This short life history, however, makes it possible for squid to recover after natural population disasters as soon as ocean conditions improve again. Little is known about the biomass, structure, and status of the stock.

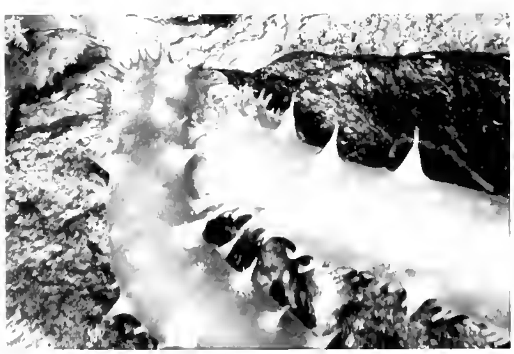
In recent years, the expansion of the southern California squid fishery and large harvests have prompted some fishermen and biologists to call for management measures to protect the squid resource, such as harvest restrictions and some form of limited entry. In 1977 the California state legislature enacted a bill that implemented a squid fishery permit program and directed the state Department of Fish and Game to provide recommendations for a squid management plan.

Left page, abalone; right page, California market squid.

Unloading sea urchins, Ventura, California.

Sea Urchin—Commercial utilization of sea urchins in the United States essentially started in the early 1970's with the harvest of red sea urchin roe or "uni" for export to the Japanese sushi market. In addition to red sea urchin, several other species are found in U.S. waters, but most are of little commercial importance due to the small size of their roe. Though limited fisheries for red sea urchin take place off Washington and Oregon, the major fishery occurs in California.

The commercial fishery for red sea urchin began in southern California in 1971 as part of an NMFS program to develop new fisheries for underutilized species. The fishery expanded to northern California in the late 1970's and 1980's, and in 1990 the value of the catch (20,534 t) amounted to $24,700,000, making it the most valuable fishery in the state, which it remained through 1995. Commercial divers harvest red sea urchins using hooka gear mainly within depths of 7–20 m. The catch is landed alive. The resource has been generally underutilized throughout the Pacific coast, except for selected commercial fishing areas. In southern California, landings have generally declined since 1990 but the sea urchin resource remains productive, suggesting that the status of the stock is still good. In other areas, however, like northern California and Baja California, the fisheries have been characterized by rapid growth and decline. These experiences suggest that local stocks can be rapidly overharvested.



Sea cucumbers.

Sea Cucumber—Like sea urchins, the sea cucumber emerged more recently as a commercial species in the late 1970's. The slimy, warty sea cucumber is harvested by trawl and by hand and processed into a dried product primarily sold to the Asian market where it is a delicacy. A variety of sea cucumber species are found from Washington to California; the giant red sea cucumber and the warty sea cucumber are the species harvested in California. Total California sea cucumber landings were a record high 381 t (worth $18,700,000) in 1996, with trawlers harvesting about 53% of the catch and divers harvesting the remainder. Little is known about the abundance and status of the stocks. Sea cucumbers have a relatively short life span, low maximum weight, low age of first maturity, high natural mortality, and highly fluctuating recruitment patterns. At the present level of harvest, the resource appears not threatened.

Elasmobranchs—Sharks, skates, and rays are an important commercial and recreational resource in the coastal waters of the eastern North Pacific. They are taken in large numbers as both target species and as bycatch in commercial groundfish and coastal pelagic fisheries. Sharks targeted for their flesh include the common thresher, shortfin mako, spiny dogfish, soupfin, and leopard sharks. Commercial shark fishing peaked off California during the mid 1980's with localized impact on the resource. Nearly 90% of pelagic sharks taken in this area are immature. Regulations imposed by fishery managers have since reduced total fishing effort and brought catches within manageable limits. Trends in localized catch rates and length at capture indicate that at least one species, the common thresher, may be recovering.

Skates, and some rays, are harvested as an inexpensive substitute for sea scallops. The longnose skate and big skate make up the most important catch in the skate trawl fishery off northern California, Oregon, and Washington. Increased demand from foreign markets has increased skate landings since 1995. Blue sharks are an important bycatch in most of these fisheries. Although the fins are valuable in the shark-fin trade, the carcasses are discarded. Shark finning is illegal in California.

Coastal pelagic sharks remain popular with recreational anglers as well. Angler effort directed at sharks has grown in recent years, and several shark fishing derbies are conducted annually.

Generally, the low reproductive potential of elasmobranchs makes them particularly susceptible

Allen Shimada, NMFS

Catch of spiny dogfish, ratfish, sea urchins, lingcod, and starfish, Washington coast.

to overfishing. Abundance and stock size remain unknown for most eastern Pacific elasmobranchs. However, much information has been learned in recent years, and fishery managers have taken steps to monitor and control harvest in most of these fisheries.

Smelt—Smelt resources in the region belong to two different families, Osmeridae (the true smelt) and Atherinidae (the silversides). There are a number of species of the two families. The resources provide for seasonal commercial and recreational fisheries for Washington, Oregon, and California. The resources are known for their migratory runs to coastal areas and rivers to spawn. They come en masse, which makes them attractive targets for recreational and commercial fisheries. Some smelt fishing is almost a ritual. Night smelt, for example, with its nocturnal habits is harvested during a brief spawning period by A-frame dip nets in the surf zone. Most are caught in the Eureka, California, area. The grunion (a species in the smelt group) fishery is quite unique since by state law sport anglers may use only their hands to grab the fish during their spawning runs on southern California beaches.

Despite their economic and social importance to humans and to ecologically related species as an important forage-base species, the abundance and status of many smelt stocks are still poorly known. Much is known of the species' biology and location and timing of the runs, but more is yet to be learned about the causes of population fluctuations and long-term trends.

WESTERN PACIFIC REGION

Fisheries in the nearshore waters of the tropical and subtropical islands of Hawaii and the U.S.-associated Pacific islands are highly diverse though lower in aggregate volume than commercial or recreational fisheries of the U.S. mainland. Landings are reported to be about 1,400 t annually (Table 21-5). Many fisheries are unique to certain localities such as that for the palolo worm in American Samoa, seasonal fisheries for rabbitfish in Guam, and limpet (opihi) fisheries in Hawaii. Other fisheries are common to all islands, such as the fisheries for bigeye scad, called akule in Hawaii, atule in American Samoa, and atulai in Guam and the Northern Mariana Islands.

The more highly populated Main Hawaiian Islands receive the heaviest inshore fishing pressure, with lighter pressure from the less densely populated islands to the mostly uninhabited islands of the Northwestern Hawaiian Islands and the northern islands of the Commonwealth of the

Table 21-5

Productivity in metric tons and status of western Pacific island nearshore fishery resources.

Species/group	Recent average yield (RAY)	Fishery utilization level	Stock level relative to LTPY[1]
Akule[2]	310	Full	Unknown
Opelu[2]	160	Full	Unknown
Other inshore fisheries[2]	700	Full	Unknown
Inshore reef fishes[3]	90	Full	Unknown
Inshore reef fishes[4]	160	Full	Unknown
Total	1,420		

[1]LTPY = long-term potential yield
[2]Hawaiian Islands (1993–95 averge)
[3]Guam (1993–95)
[4]American Samoa (1993–95 average)

Yellowfin goatfish, Oahu, Hawaii.

Northern Mariana Islands. In the Main Hawaiian Islands, between 1980 and 1990 an average of 1,179 t of fishes and invertebrates were reported taken annually within 100 fathoms by commercial fishermen. According to the Hawaii Division of Aquatic Resources, the two pelagic carrangids, akule and opelu, support the largest inshore fisheries in the state. During the 1993–95 period, annual commercial landings for akule and opelu averaged 310 and 160 t, respectively. Other important commercial fisheries include those for surgeonfishes, squirrelfishes, parrotfishes, goatfishes, snappers, octopus, and various jacks or trevallies. There are significant recreational fisheries, but participation, landings, expenditures, and economic values are not well documented. The recreational and subsistence component of Hawaii's marine fisheries was last assessed in 1986, when it was estimated that 200,000 trips were taken by 6,700 vessels involved in nonmarket fishing (which includes recreational, subsistence, and submarket sales). Estimated landings by these "recreational" fishermen were 9,525 t (21,000,000 pounds), of which 4,536 t (10,000,000 pounds) were sold ($22,000,000). Total direct expenditures by these fisheries was $24,000,000, and the nonmarket value of the fishing experience was valued at $239,000,000.

Ala kumu, also called "7–11 crab," Oahu, Hawaii.

The islands of American Samoa are partially surrounded by a narrow fringing coral reef which is inhabited by a diverse array of fishes and invertebrates. These are harvested by local residents on an almost daily basis. Total inshore subsistence catch for 1993–95 averaged 160 t worth $560,000. The catch is dominated in some years by the coastal migrant atule, but other more resident species such as other jacks, surgeonfish, mullet, octopus, groupers, and snappers are most consistently taken. Samoans also fish on the predicted nights of emergence of the palolo worm, which is considered a delicacy (actually its reproductive segments or epitokes). For Samoan inshore fisheries, downward trends in catch and catch per unit of effort have been observed in recent years, especially when the catches of the highly variable atule have been removed from the analysis.

Guam is the southernmost and largest island in the Mariana Island Archipelago, and like American Samoa, the principal inshore fisheries are based on a wide assortment of coral reef fishes. Fishes taken are jacks and scads (especially atulai, the bigeye scad), surgeonfishes, squirrelfishes, fusilier, rudderfish (guili), snappers, mullet (aguas), goatfishes (ti'ao), and rabbitfishes (mañahak). Invertebrate species include various marine crabs (including land crabs), spiny and slipper lobsters, sea urchins, octopus, squid, cuttlefish, tridacnid clams, topshell, chitons, conchs, strombids, and nerites. Guam inshore reefs appear to be fully exploited and have shown signs of overfishing. During 1993–95, the catch of nearshore reef fisheries averaged 90 t.

ALASKA REGION

Nearshore resources provide important subsistence and recreational fishing opportunities for Alaskans. Most nearshore fisheries take place in Southeast Alaska near population centers, although subsistence fishing is distributed all along the Alaska coastline into the Bering Sea and Arctic Ocean. The fisheries are a mix of historic fisheries that have intensified and grown to provide significant local economic benefits from a variety of species (Table 21-6). The nearshore resources and fisheries are managed by the Alaska Department of Fish and Game (ADFG).

Dungeness crabs are harvested near shore by small-boat commercial fleets and recreational fisheries primarily in the southeast Alaska, Yakutat, and Kodiak areas. About 30% of the U.S. production of Dungeness crabs traditionally comes from Alaska. Almost all Dungeness crabs (97%) are consumed domestically. The value and demand for the crabs are normally high. Commercial fishing effort in the traditional Dungeness crab fish-

Species/group	Recent average yield (RAY)[1]	Fishery utilization level	Stock level relative to LTPY
Dungeness crab	2,370	Full	Near
Tanner crab	900	Full	Unknown
Red King crab	160	Full	Below
Scallops	360	Full	Near
Shrimps	2,000	Unknown	Below
Geoduck clam	70	Unknown	Unknown
Other clams	200	Unknown	Unknown
Sea urchins	660	Unknown	Unknown
Sea cucumbers	655	Unknown	Unknown
Abalones	5	Full	Near
Sablefish	2,500	Full	Near
Lingcod	100	Full	Near
Rockfish	120	Full	Near
Other species	100	Unknown	Unknown
Total	10,200		

[1]1994–96

Table 21-6

Alaska nearshore resources productivity in metric tons and status.

ery has intensified to the point that virtually all habitat is now "potted down" with crab pots. This trend is likely to grow now that a limited entry system is in place and fishing permits can be sold: new buyers will need to intensively fish their full limit of pots to pay for their permits and equipment. The traditional Tanner crab fishery has also intensified to the point that the 900 t (2,000,000-pound) harvest cap is reached in 1 week, where in the early 1970's the fishery was year round. Management of these crab fisheries suffers in the absence of stock assessment research. The traditional fishery for red king crab in Southeast Alaska is a bright spot: the fishery reopened in 1993 following 8 years of closure and is now managed under a conservative harvest regime supported by an annual stock assessment survey.

Pot shrimp fisheries have grown dramatically in the past decade in nearshore Alaska waters, and along with the trawl shrimp fisheries are now limited to entry. These are the only two significant commercial shrimp fisheries remaining in Alaska, and concern is high to develop stock assessment and conservative management programs to provide for sustained harvests. The species taken is mainly Alaskan pink shrimp. Other species taken are spot, sidestripe, coonstripe, and humpy.

The primary scallop species harvested in Alaska is the weathervane scallop. The fishery was pioneered in 1967 and peaked in 1969 when 840 t of shucked scallop meat was landed. The principal harvest areas are Kodiak and Yakutat in the Gulf of Alaska, with Dutch Harbor (Bering Sea) as a new fishing ground. Harvesting is by similar dredging gear and fishing technique used in the New England scallop fisheries. While the status of the stocks is not well known, they are not believed to be abundant and are vulnerable to overfishing. The fishery is regulated by the State of Alaska which limits the number of vessels and sets catch quotas.

Sea cucumbers and sea urchins are recent fisheries. They are harvested by divers and exported to Asia. Sea urchins are shipped live to Japan for the fresh roe market. While the status of the stocks is largely unknown, the fisheries are managed conservatively according to their recent historical performance. The ADFG surveys the resource periodically at selected sites to monitor major changes in relative abundance of the stocks.

Alaska natives have a long history of harvesting abalone for food, trade, and shell ornaments. The only species of abalone harvested in Alaska is the pinto abalone, taken almost exclusively from Southeast Alaska. The commercial fishery, involving handpicking by divers, started in the early 1970's. Abalones are considered gourmet seafood and are normally exported to Japan. The status of the stocks is unknown, and the fishery is regu-


© Leo J Shaw The Seattle Aquarium

Tentacles of a giant Pacific octopus.

Pink scallop.

lated by the ADFG through monitoring of recent catch trends. The abalone fishery was closed in 1996 following 15 years of decline, due in part to overharvests and now to sea otter predation. The fishery will remain closed until a rebuilding program is developed. Commercial catch peaked at 82 t in 1977 and the 1994–96 recent average yield was only 5 t.

The dive fisheries in Southeast Alaska are developing actively. The red sea urchin fishery has grown from a 1994–96 recent average yield of 660 t to a 2,265 t (5,000,000-pound) harvest in just 2 years following the implementation of a fishery management plan and extensive stock assessment surveys funded largely by the industry and local governments. The sea cucumber fishery, now in its 8th year of sustained harvests under a conservative management regime, has become an established source of winter income for over 400 divers dividing an annual yield of 450 t (1,000,000 pounds). The geoduck clam fishery has the potential to double in size over the coming years due to industry sponsored exploration for new clam beds.

A key factor in the successful development of dive fisheries is a regional policy to require external funds for new fisheries. Also significant is a moratorium on entry to dive fisheries, creating a limited and known number of permit holders with a clear stake in the future of the resource. An expanding sea otter population, reintroduced in the mid 1960's following extirpation by the turn of the 20th century, may play the ultimate card in the future of nearshore dive fisheries for sea urchin, sea cucumber, and abalone, as well as for some Dungeness crab grounds. Significant losses to all of these fisheries have occurred in the past 5 years.

The amount of nearshore resources harvested by the subsistence and recreational fisheries off Alaska has been difficult to compile because of the state's wide geographical expanse and remoteness of such fishing activities. Excluding the recreational and subsistence catches of Pacific salmon and Pacific halibut, the total 1994–96 recent average yield was at least 10,200 t for the nearshore resource complex (Table 21-6). The recreational catch was probably 5% of the total. The component of the resources that are the most important are the invertebrates; although a wide variety of groundfish and other species are harvested incidentally to salmon and Pacific halibut fisheries.

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Marine Mammals of the Alaska Region

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Harbor seals, LeConte Glacier, Alaska.

INTRODUCTION

The Alaska region has 39 stocks of 24 species of marine mammals. Three of these species (sea otter, polar bear, and walrus) are managed by the U.S. Fish and Wildlife Service, and the remaining cetaceans and pinnipeds are managed by the National Marine Fisheries Service (NMFS). According to the criteria provided in the 1994 Amendments to the Marine Mammal Protection Act (MMPA), these include 10 strategic stocks: the northern fur seal (which is depleted under the MMPA); the sperm whale, the western North Pacific and central North Pacific humpback whales, the fin whale, the North Pacific right whale, and the bowhead whale (listed as endangered under the Endangered Species Act (ESA)); the Cook Inlet stock of beluga (annual takes exceeding the potential biological removal (PBR) level); and the western U.S. Pacific stock of Steller sea lions (listed as endangered under the ESA) as well as the eastern Pacific stock of this species (listed as threatened under the ESA). Of the 39 stocks, nine are believed to be increasing, five are stable, three are declining, and the population status of the remaining 22 are unknown.

Eight stocks, the western U.S. Pacific stock of the Steller sea lion, the northern fur seal, the Gulf of Alaska harbor seal and all stocks of beluga whales, are subject to subsistence harvests. While most marine mammal stocks are assessed under the authority of Section 117 of the MMPA, the NMFS determined that management of the stocks subject to subsistence harvests that do not have significant commercial takes should be developed through the comanagement process described in

Section 119 of the Act. The process should also include a sound research and management program to identify and address uncertainties concerning the stocks.

Table 22-1 presents a summary of the status of stocks for the marine mammals in the Alaska region. Important population parameters for the stocks and their status under the various protected species laws are included. These include: stock identification, N_{min} (a conservative estimate of abundance used to estimate the PBR, which is the maximum allowed level of human-related removal in a given year), estimates of current human-related mortality, population status, and current population trend. A narrative for some selected stocks follows:

STELLER SEA LION: EASTERN AND U.S. WESTERN NORTH PACIFIC STOCKS

Stock Definition and Geographic Range

Steller sea lions range along the North Pacific rim from northern Japan to California, with historic centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands, respectively. The species is not known to migrate, but individuals disperse widely outside of the breeding season (late May–early July), thus potentially intermixing with animals from other areas. Two separate stocks of Steller sea lions are recognized within U.S. waters: an eastern Pacific stock, which includes animals east of Cape Suckling, Alaska (144°W), and a western U.S. Pacific stock, which includes animals from Cape Suckling westward. Steller sea lions in Canada are part of the eastern Pacific stock.

Population Size

An estimate of Steller sea lion abundance in Alaska is made possible using survey data collected in June and July of 1996, from California to the western Aleutian Islands. The surveys included counts of animals, excluding pups, at 95 "trend sites," where sea lions in the western U.S. Pacific stock have been monitored since the 1970's. Using correction factors derived from previous surveys, the 1996 surveys resulted in an estimated 39,500 Steller sea lions (33,700 nonpups and 8,800 pups) for the entire Gulf of Alaska, Aleutian Islands, and Bering Sea region that comprises the western U.S. Pacific stock. A comparable estimate for the eastern Pacific stock is not possible. However, counts from the southeast Alaska, British Columbia, California, and Oregon region indicate a population of at least 30,400 Steller sea lions.


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Steller sea lion bull, cow, and pup, Southeast Alaska

Minimum Population Estimate

Using the population estimate (N) of 39,500 and an associated CV[1] of 0.0184, N_{min} for the western U.S. Pacific stock is calculated as 38,893 (Table 22-1). The population estimate for the east-

[1]Coefficient of variation (CV) is a statistical measure used to calculate confidence intervals (CI), which gauge the accuracy of population estimates. An accurate population estimate is characterized by a low CV and a narrow CI. CI is often given a percentage likelihood of being correct (e.g. 95% means that if the data were resampled and the CI were recalculated 100 times, then 95 times it would contain the true value.

Table 22-1

Status of marine mammal stocks in the Alaska Region.

Species	Stock area	Minimum population estimate (N_{min})[1]	Potential biological removal level (PBR)[2]	Annual human-caused mortality[3]	Strategic status[4]	MMPA /ESA status[5]	Trend[6]
Steller sea lion	Western U.S. Pacific	38,893	350	443	Y	E	D
Steller sea lion	Eastern Pacific	30,403	1,368	16	Y	T	I
Northern fur seal	North Pacific	848,539	18,244	1,722	Y	D	S
Harbor seal	Southeast Alaska	35,226	2,114	1,778			I
Harbor seal	Gulf of Alaska	27,917	868	824			D
Harbor seal	Bering Sea	12,648	379	26			D
Spotted seal	Alaska	N/A	N/A	N/A			S
Bearded seal	Alaska	N/A	N/A	N/A			U
Ringed seal	Alaska	N/A	N/A	N/A			U
Ribbon seal	Alaska	N/A	N/A	N/A			U
Beluga	Beaufort Sea	32,453	649	160			S
Beluga	Eastern Chukchi Sea	3,710	74	54			U
Beluga	Eastern Bering Sea	6,439	129	127			S
Beluga	Bristol Bay	1,316	26	20			S
Beluga	Cook Inlet	712	14	71	Y		U
Killer whale	Eastern North Pacific transient	197	2.0	0.8			U
Killer whale	Eastern North Pacific resident	642	6.4	0.8			U
Pacific white-sided dolphin	North Pacific	486,719	4,867	4			U
Harbor porpoise	Bering Sea	8,549	86	2			U
Harbor porpoise	Southeast Alaska	8,156	82	4			U
Harbor porpoise	Gulf of Alaska	7,085	71	25			U
Dall's porpoise	Alaska	76,874	1,537	42			U
Sperm whale	North Pacifc	N/A	N/A	N/A	Y	E	U
Baird's beaked whale	Alaska	N/A	N/A	0			U
Cuvier's beaked whale	Alaska	N/A	N/A	0			U
Stejneger's beaked whale	Alaska	N/A	N/A	0			U
Gray whale	Eastern North Pacific	21,597	432	47			I
Humpback whale	Western North Pacific	367	0.7	0	Y	E	U
Humpback whale	Central North Pacific	3,698	7.4	1.0	Y	E	I
Fin whale	Northeast Pacific	N/A	N/A	0	Y	E	U
Minke whale	Alaska	N/A	N/A	0			U
Northern right whale	North Pacific	N/A	0	0	Y	E	U
Bowhead whale	Western Arctic	7,738	77	49	Y	E	I
Sea otter[7]	South Central Alaska	20,948	2,095	313			I
Sea otter[7]	Southeast Alaska	8,709	871	376			I
Sea otter[7]	Southwest Alaska	65,761	5,659	101			U
Polar bear[7]	Alaska Chukchi & Bering Seas	N/A	N/A	55			I
Polar bear[7]	Alaska Southern Beaufort Sea	1,611	73	34			I
Walrus[7]	Alaska	188,316	7,533	4,890			U

[1]Nmin is a conservative estimate of abundance used to estimate PBR and provides reasonable assurance that the stock size is equal to or greater than the estimate.

[2]PBR (potential biological removal) is the maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or stay at its optimum sustainable population level (50–100% of its carrying capacity).

[3]Annual human-caused mortality is an estimate of the total number of annual mortalities and serious injuries (likely to result in death) caused by humans.

[4]Strategic status: Y = yes, N/A = information is not available, and N/D = estimated value has not been determined at this time.

[5]MMPA/ESA status: E = listed as endangered and T = listed as threatened under the Endangered Species Act. D = listed as depleted under the Marine Mammal Protection Act.

[6]Trend: increasing (I), stable(S), decreasing (D), or unknown (U).

[7]These species are under the jurisdiction of the U.S. Fish and Wildlife Service and are not included in the stock status tables of the National Overview.

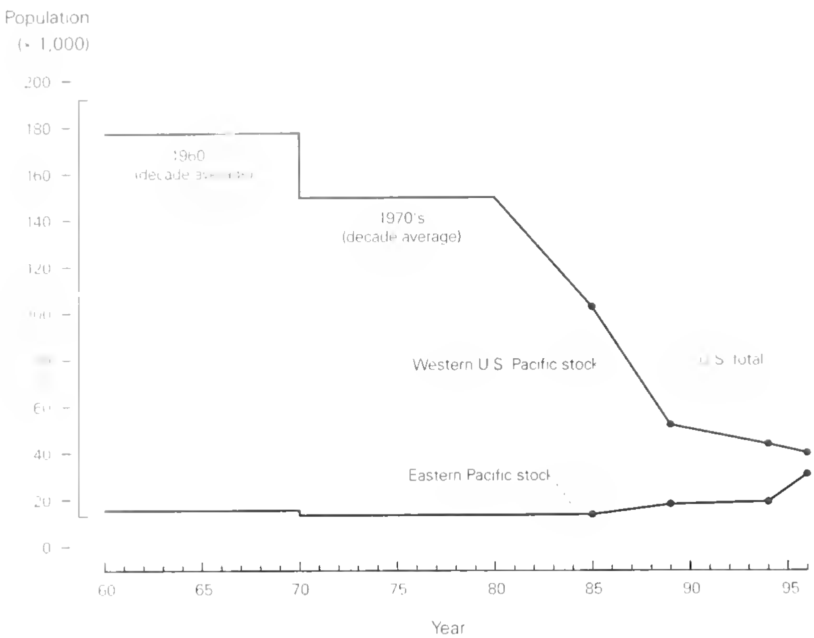

Figure 22-1
Estimated population size of Steller sea lions (adults, juveniles, and pups) of the two stocks off the United States and Canada

ern Pacific stock of 30,400 is used as a minimum because animals not seen in the surveys have not been taken into account.

Current Population Trend

Western U.S. Pacific Stock—The first reported trend counts (an index of population size) of Steller sea lions in Alaska were made during 1956–60 which indicated that there were at least 140,000 sea lions in the Gulf of Alaska and Aleutian Islands. Subsequent surveys indicated a major population decrease, first detected in the eastern Aleutian Islands in the mid 1970's. The decline appeared to have spread eastward to the Kodiak Island area during the late 1970's and early 1980's, and then westward to the central and western Aleutian Islands during the early and mid 1980's. The greatest declines occurred in the eastern Aleutian Islands and western Gulf of Alaska, but declines also occurred in the central Gulf of Alaska and central Aleutian Islands. Uncorrected counts from 1976–79 indicated about 104,000 sea lions. The western U.S. Pacific stock decreased 37.4% from 1989 to 1994. The 1994 estimate was 42,536 animals, and the 1996 estimate was 39,500.

Eastern Pacific Stock—Trend counts for the eastern Pacific stock have been relatively stable at about 2,000–3,000 animals (Figure 22-1). The counts in Oregon have shown a gradual increase since 1976, as the adult and juvenile count for that year was 1,486 compared to 3,522 for 1994. This increase is likely due to a recovery from reduced numbers caused by mortality prior to 1972, as immigration from other areas has not been documented. Counts in California declined by over 50% from 5,000–7,000 between 1927 and 1947 to 2,000–2,500 between 1980 and 1990; limited information suggests that counts in northern California have increased from the late 1970's to the early 1990's. At Año Nuevo, California, a steady decline in ground counts started around 1970, resulting in a 85% reduction in the breeding population by 1987. Based on data from vertical photography taken between 1990 and 1993, pup numbers declined at a rate of 9.9%, while older individuals declined at a rate of 31.5%. Most recently, population estimates for Steller sea lions in the eastern Pacific stock increased 5.8% from 1989 (22,600) to 1994 (23,533) an increase that apparently is continuing.

Stock Status

The PBR for the western U.S. Pacific stock of Steller sea lions has been estimated at 350 animals and for the eastern Pacific stock at 1,368. The estimated annual level of total human-caused mortality and serious injury was 443 animals for the western U.S. Pacific stock and 16 for the eastern Pacific stock. The mortalities for the western U.S. Pacific stock exceed this stock's estimated PBR. Both stocks of Steller sea lion are currently listed under the ESA; the western U.S. Pacific stock is listed as endangered, and the eastern Pacific stock is listed as threatened. Thus, both stocks of Steller sea lions are classified as strategic stocks. Management actions recently implemented to reduce interactions with human activities include no-entry buffer zones around rookeries, prohibition of groundfish trawling within 10–20 nautical miles of certain rookeries, and spatial and temporal allocation of Gulf of Alaska pollock catches.

Joe Scordino, NMFS

Northern fur seal bull, cow, and pup, Saint Paul Island, eastern Bering Sea.

NORTHERN FUR SEAL: EASTERN PACIFIC STOCK

Stock Definition and Geographic Range

Northern fur seals are found from southern California north to the Bering Sea and west to the Okhotsk Sea and Honshu Island, Japan. During the breeding season, approximately 74% of the worldwide population is found on the Pribilof Islands in the southern Bering Sea, with the remaining animals spread throughout the North Pacific. Of the seals in U.S. waters outside of the Pribilofs, approximately 1% of the population is found on Bogoslof Island in the southern Bering Sea and San Miguel Island off southern California. Fur seals may temporarily haul out onto land at other sites in Alaska, British Columbia, and on islets along the coast of the continental United States, but generally outside of the breeding season.

Adults usually are found on shore during the 6-month reproductive season (June–November), then migrate south and spend the next 6 months at sea. Adult females and pups from the Pribilof Islands migrate through the Aleutian Islands into the North Pacific, often to the Oregon and California offshore waters. Pups may remain at sea for 22 months before returning to their rookery of birth. Adult males generally migrate only as far south as the Gulf of Alaska and the Kamchatka coast. Two separate stocks of northern fur seals are recognized within U.S. waters: an eastern Pacific stock, and a San Miguel Island stock.

Population Size

The population estimate for the eastern Pacific stock of fur seals is calculated as the estimated number of pups at rookeries multiplied by a series of different expansion factors determined from a life table analysis to estimate the number of yearlings, 2-year-olds, 3-year-olds, and animals at least 4 years old. The expansion factors are based on a sex and age distribution estimated after the harvest of juvenile males was terminated. The resulting population estimate is equal to the pup count multiplied by approximately 4.475. As the great majority of pups are born on the Pribilof Islands, pup estimates are concentrated on these islands, though additional counts are made on Bogoslof Island. A total population estimate for the northern Pacific stock based on recent pup counts was 1,002,516 seals.

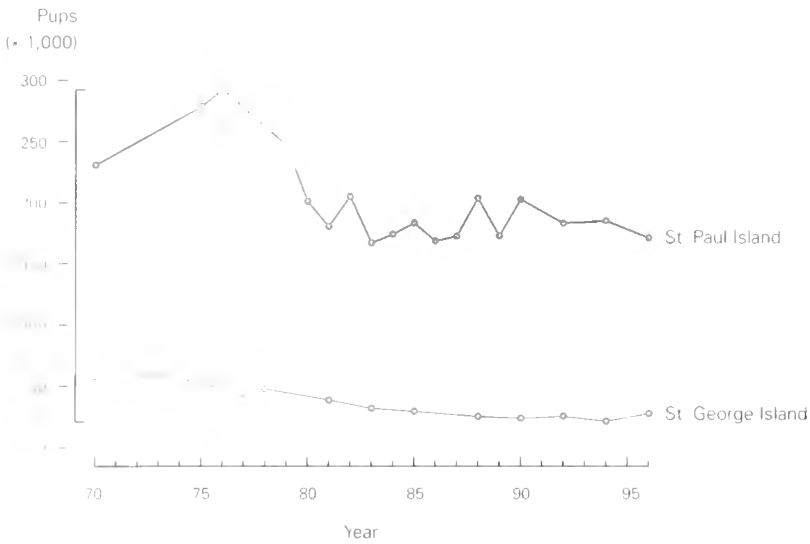

Figure 22-2
Northern fur seal pup counts from the Pribilof Islands, 1970–96.

Minimum Population Estimate

Using the population estimate (N) of 1,002,516 and a CV of 0.2 to account for the correction factor, N_{min} for the eastern Pacific stock of northern fur seals is 848,539 animals.

Current Population Trend

The Alaska population of northern fur seals recovered to approximately 1.25 million animals in 1974, after the killing of females was terminated in 1968. The population then began to decrease, with pup production declining at a rate of 6.5–7.8% per year into the 1980's; the total stock estimate in 1983 was 877,000. Annual pup production on St. Paul Island has remained relatively stable since 1981 (Figure 22-2), indicating that stock size has not changed much in recent years. The most recent stock estimates prior to 1996 were 984,000 in 1992, and 1.01 million in 1990. The northern fur seal was designated as depleted under the MMPA in 1988 because population levels had declined to less than 50% of levels observed in the late 1950's, and there was no compelling evidence that carrying capacity (K) had changed substantially since the late 1950's. Under the MMPA, this stock will remain listed as depleted until population levels reach at least the lower limit of its optimum sustainable population (60% of K).

Status of Stock

The PBR for the eastern Pacific stock of northern fur seals is 18,244 animals. The estimated annual level of total human-caused mortality and serious injury is less than 2,000 seals, and thus does not exceed its PBR. The eastern Pacific stock of the northern fur seal is classified as a strategic stock because it is designated as depleted under the MMPA.

BOWHEAD WHALE: WESTERN ARCTIC STOCK

Stock Definition and Geographic Range

Bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 54°N and south of 75°N in the Western Arctic Basin. Small stocks occur in the Sea of Okhotsk, Davis Strait, Hudson Bay, and Spitsbergen, but only a few tens to a few hundreds are found in each of these stocks. The largest remnant population is the western Arctic stock which migrates from wintering areas (November to March) in the northern Bering Sea, through the Chukchi Sea in the spring (March through June), to the Beaufort Sea where they spend much of the summer (mid May through September) before returning to the Bering Sea in the autumn (September through November). The bowhead spring migration follows fractures in the sea ice around the coast of Alaska, generally in the shear zone between the shorefast ice and the mobile polar pack ice. There is evidence of whales following each other, even when their route does not take advantage of large ice-free areas. As the whales travel east past Point Barrow, Alaska, their migration is somewhat funneled between the shoreline and the polar pack ice, making for an optimal location from which to study this stock. Most of the year, bowhead whales are closely associated with sea ice. Only during the summer is this population in relatively ice-free waters in the southern Beaufort Sea, an area often exposed to industrial activity related to petroleum exploration.

Population Size

All stocks of bowhead whales were severely depleted during intense commercial whaling prior to the 20th century, starting in the early 16th century near Labrador and spreading to the Bering Sea in the mid 19th century. Prior to commercial whaling, the minimum world wide population estimate was 50,000 animals, with 10,400–23,000 in the western Arctic stock. This population dropped to less than 3,000 when commercial whaling on this stock ceased at the end of the 19th century (Figure 22-3).

Since 1978, bowhead whales have been counted from sites on sea ice north of Point Barrow during the whales' spring migration. These counts have been corrected for whales missed due to distance offshore (through acoustical locators), whales missed when no watch was in effect (based on sighting rates), and whales missed during a watch (estimated as a function of visibility, number of observers, and distance offshore). However, in some years a small proportion of the population may not migrate past Point Barrow in the spring, therefore the estimate could be negatively biased. In 1993, unusually good counting conditions resulted in what is considered to be the most accurate population estimate to date for this stock: 8,200 bowhead whales (CV = 0.069), with a 95% confidence interval from 7,200 to 9,400.

Minimum Population Estimate

Using the population estimate (N) of 8,200 and its associated CV of 0.069, N_{min} for the western Arctic stock of bowhead whales is 7,738.

Current Population Trend

The western Arctic stock increased at a rate of 3.1% (95% CI = 1.4–4.7%) from 1978 to 1993, when abundance increased from approximately 5,000 to 8,000 whales. This rate of increase takes into account whales that passed beyond the viewing range of the observers.

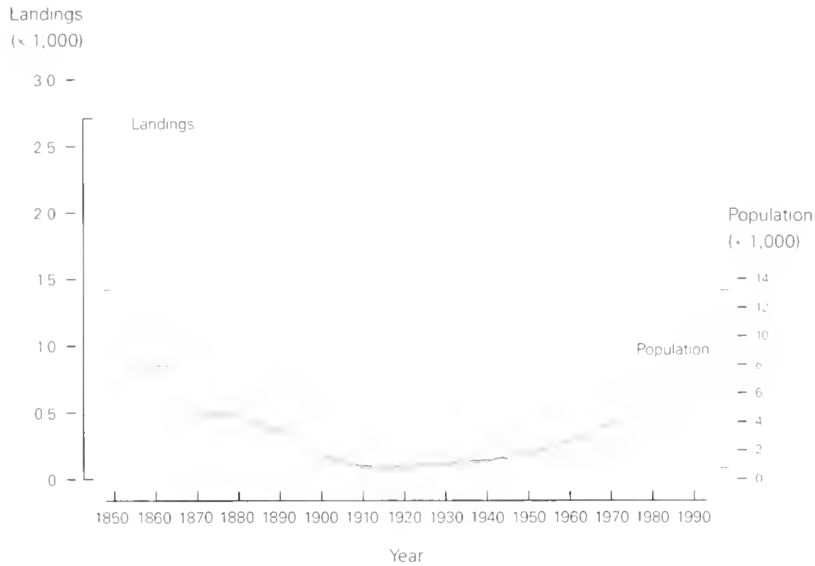

Figure 22-3
Bowhead whale population trend and catch history, 1848–1993.

Status of Stock

The PBR for this stock is 77 whales. The International Whaling Commission (IWC) independently established a quota for the number of bowhead whales to be taken by subsistence hunters, such that the number of whales struck could not exceed 68 in 1995, 67 in 1996, 66 in 1997, and 65 in 1998. The IWC determination takes precedence over the U.S. PBR estimate for the purpose of managing the Alaska native subsistence harvest. The level of human-caused mortality and serious injury averaged over the past five years (49) does not exceed the PBR (77) nor the IWC quota for 1998 (66). Bowhead whales of the western Arctic stock are listed as endangered under the ESA and further classified as a strategic stock.

BELUGA WHALE: BEAUFORT SEA, EASTERN CHUKCHI SEA, EASTERN BERING SEA, COOK INLET, AND BRISTOL BAY STOCKS

Stock Definition and Geographic Range

Beluga whales are distributed throughout seasonally ice-covered Arctic and subarctic waters of the Northern Hemisphere, and are closely associated with open leads and polynya in ice-covered regions. Depending on season and region, beluga whales in the western Arctic may occur in both offshore and coastal waters, with concentrations in Cook Inlet, Bristol Bay, Norton Sound, Kasegaluk Lagoon, and the Mackenzie Delta. It is assumed that most beluga whales from these summering areas overwinter in the Bering Sea. Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction. During winter, beluga whales occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers for molting and calving. Annual migrations may cover thousands of kilometers.

Five putative stocks of beluga whales are recognized within U.S. waters: Cook Inlet, Bristol Bay, Eastern Bering Sea, Eastern Chukchi Sea, and Beaufort Sea.

Population Size

The sources of information to estimate abundance of belugas have included both opportunistic and systematic observations. The most recent survey conducted in 1992 for the Beaufort Sea stock resulted in an estimate of approximately 20,805 whales. A correction factor of 2 has been recommended for the Beaufort Sea stock, resulting in a current population estimate of 39,258. The estimated minimum size of the Eastern Chukchi stock of belugas is 1,200 based on counts of animals from aerial surveys conducted during 1989–91. If this count is corrected for the proportion of animals that were diving and thus not visible at the surface, and for the proportion of newborns and yearlings not observed due to small size and dark coloration, the total corrected estimate for the Eastern Chukchi Sea is 3,710. The 1994 population estimate for Bristol Bay was 1,555. For Cook Inlet, the 1997 population estimate was 834 (N_{min} = 712, Table 22-1); however, the estimate for 1998 was less than 500. The current population estimate for the eastern Bering Sea stock is 7,986 based on surveys in 1992, 1993, and 1994.

Minimum Population Estimate

The minimum population estimates for Alaska beluga whale stocks are: 32,453 for the Beaufort Sea stock; 3,710 for the eastern Chukchi sea stock; 6,439 for the eastern Bering Sea stock; and 1,316 for the Bristol Bay stock. The minimum estimate of abundance for Cook Inlet beluga whales is currently being revised, but will likely be less than 400 animals.

Current Population Trend

The Beaufort Sea stock of beluga whales is believed to be stable or increasing; the eastern Chukchi Sea and Bristol Bay stocks are believed to be stable. The population trend for the Eastern Bering Sea stock is uncertain at this time. The Cook Inlet stock is likely declining.

Status of Stock

The PBR for Alaska beluga stocks are: 649 for the Beaufort Sea stock, 74 for the eastern Chukchi Sea stock, 26 for the Bristol Bay stock, 129 for the eastern Bering Sea stock, and 14 for the Cook Inlet stock. This latter PBR will likely be reduced as NMFS recently solicited information from the public regarding the need to classify this stock as endangered or threatened under the ESA or depleted under the MMPA. The levels of human-caused mortality and serious injury for these stocks averaged over the past 5 years are: 160 for the Beaufort Sea stock, 54 for the eastern Chukchi Sea stock, 127 for the eastern Bering Sea stock, 26 for the Bristol Bay stock, and 71 for the Cook Inlet stock. At this time, only the Cook Inlet stock of beluga whales has been classified as a strategic stock under the MMPA.

FOR FURTHER READING

Hill, P. S., and D. P. DeMaster. In press. Alaska marine mammal stock assessments: 1998. NOAA Technical Memorandum NMFS-AFSC-97, 150 p.

Hill, P. S., D. P. DeMaster, and R. J. Small. 1997. Alaska marine mammal stock assessments, 1996. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-78, 150 p.

Marine Mammals of the Pacific Region and Hawaii

Bruce Eilerts, USFWS

Unit 23

NMFS SOUTHWEST
FISHERIES SCIENCE CENTER

La Jolla
California

Hawaiian monk seal and red-footed boobies, Northwestern Hawaiian Islands National Wildlife Refuge

INTRODUCTION

The Pacific region has 65 stocks of at least 37 species of marine mammals. The U.S. Fish and Wildlife Service is responsible for managing two stocks of sea otters (central California and Washington), while the National Marine Fisheries Service (NMFS) has management authority for the cetacean and pinniped stocks. According to the criteria provided in the 1994 Amendments to the Marine Mammal Protection Act (MMPA), these include 11 strategic stocks. In the eastern Pacific (i.e. waters of Washington, Oregon, California, and northern Mexico), the strategic stocks include: endangered sperm, humpback, blue, fin, and sei whales; short-finned pilot whales, mesoplodont beaked whales, and threatened Guadalupe fur seals. Strategic stocks in Hawaiian waters include endangered blue, fin, and sperm whales, and Hawaiian monk seals.

Table 23-1 summarizes the status of marine mammal stocks in the Pacific region. Important population parameters of the stocks and their status under the various protected species laws are included. Some selected stocks are discussed below.

HAWAIIAN MONK SEAL

Stock Definition and Geographic Range

Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands (NWHI) in six main reproductive populations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure

Table 23-1

Status of marine mammal stocks of the Pacific region and Hawaii (Barlow et al., 1997).

Species	Stock area	Minimum population estimate (N_{min})[1]	Potential biological removal level (PBR)[2]	Annual human-caused mortality[3]	Strategic status[4]	ESA status[5]
California sea lion	United States	111,339	6,680	974	N	
Harbor seal	California	27,962	1,678	243	N	
Harbor seal	Oregon/Washington coast	25,665	1,540	15	N	
Harbor seal	Washington inland waters	15,349	921	36	N	
Northern elephant seal	California breeding	51,625	2,142	145	N	
Guadalupe fur seal	Mexico to California	3,028	104	0.0	Y	T
Northern fur seal	San Miguel Island, California	5,018	216	0.0	N	
Hawaiian monk seal	Hawaii	1,431	4.3	N/A	Y	E
Harbor porpoise	Central California	3,431	33	14	N	
Harbor porpoise	Northern California	7,640	76	0.0	N	
Harbor porpoise	Oregon/Washington coast	22,046	212	13	N	
Harbor porpoise	Inland Washington	2,681	21	15	N	
Dall's porpoise	California/Oregon/Washington	34,393	330	22	N	
Pacific white-sided dolphin	California/Oregon/Washington	82,939	796	22	N	
Risso's dolphin	California/Oregon/Washington	22,388	224	37	N	
Bottlenose dolphin	California coastal	134	1.3	0.0	N	
Bottlenose dolphin	Calif./Oreg./Wash. offshore	1,904	15	4.4	N	
Striped dolphin	California/Oregon/Washington	19,248	154	1.2	N	
Common dolphin, short-beaked	California/Oregon/Washington	309,717	3,097	272	N	
Common dolphin, long-beaked	California	5,504	53	14	N	
Northern right whale dolphin	California/Oregon/Washington	15,080	151	47	N	
Killer whale	California/Oregon/Washington	436	3.5	1.2	N	
Killer whale	Southern Resident Stock	96	1.9	0.0	N	
Pilot whale, short-finned	California/Oregon/Washington	741	5.9	13	Y	
Baird's beaked whale	California/Oregon/Washington	252	2.0	1.2	N	
Mesoplodont beaked whales	California/Oregon/Washington	1,169	11	9.2–13	N	
Cuvier's beaked whale	California/Oregon/Washington	6,070	61	28	N	
Pygmy sperm whale	California/Oregon/Washington	2,059	19	2.8	N	
Dwarf sperm whale	California/Oregon/Washington	N/A	N/A	0.0	N	
Sperm whale	California/Oregon/Washington	896	1.8	4.5	Y	E
Humpback whale	Calif./Oreg./Wash.–Mexico	563	0.5	1.8	Y	E
Blue whale	California/Mexico	1,463	1.5	0.2	Y	E
Fin whale	California/Oregon/Washington	747	1.5	<1	Y	E
Bryde's whale	Eastern Tropical Pacific	11,163	0.2	0.0	N	
Sei whale	Eastern North Pacific	N/A	N/A	0.0	Y	E
Minke whale	California/Oregon/Washington	122	1.0	1.2	N	
Rough-toothed dolphin	Hawaii	N/A	N/A	N/A	N	
Risso's dolphin	Hawaii	N/A	N/A	N/A	N	
Bottlenose dolphin	Hawaii	N/A	N/A	N/A	N	
Pantropical spotted dolphin	Hawaii	N/A	N/A	N/A	N	
Spinner dolphin	Hawaii	677	6.8	N/A	N	
Striped dolphin	Hawaii	N/A	N/A	N/A	N	
Melon-headed whale	Hawaii	N/A	N/A	N/A	N	
Pygmy killer whale	Hawaii	N/A	N/A	N/A	N	
False killer whale	Hawaii	N/A	N/A	N/A	N	
Killer whale	Hawaii	N/A	N/A	N/A	N	
Pilot whale, short-finned	Hawaii	N/A	N/A	N/A	N	
Blainville's beaked whale	Hawaii	N/A	N/A	N/A	N	
Cuvier's beaked whale	Hawaii	N/A	N/A	N/A	N	
Pygmy sperm whale	Hawaii	N/A	N/A	N/A	N	
Dwarf sperm whale	Hawaii	N/A	N/A	N/A	N	
Sperm whale	Hawaii	N/A	N/A	N/A	Y	E

Top: California sea lion near Everett, Washington; bottom: northern right whale dolphin.

Atoll. Additional populations, with limited reproduction and maintained by immigration, are found at Necker Island and Nihoa Island, and a small number of seals are distributed throughout the Main Hawaiian Islands.

Demographically, the different island populations have exhibited considerable independence. For example, abundance at French Frigate Shoals grew rapidly from the 1950's to the 1980's, while other populations declined rapidly. Current demographic variability among the island populations probably reflects a combination of different histories and varying environmental conditions. While management activities and research focus on single island and atoll populations, this species is managed as, and considered to be, a single stock.

In the last two centuries, this species has experienced two major declines which, presumably, have severely reduced its genetic variation. The tendency for genetic drift may have been (and may continue to be) relatively large, due to the small size of the different island and atoll populations. However, 10–15% of the seals migrate among the different populations and, at least to some degree, this movement should counter the development of separate genetic stocks.

Population Size

Abundance of the Hawaiian monk seal in 1997 was estimated by counts of individual seals, the relationship between beach counts and total population size for subpopulations at Necker and Nihoa Islands, and a "best guess" for the Main Hawaiian Islands. A total of 1,295 seals (including pups) were observed at the main reproductive populations in 1997. Estimates for Necker and Nihoa Islands (± standard deviation) are 65 (±15.1) and 56 (±21.1), respectively. Finally, sporadic reports indicate that abundance on the Main Hawaiian Islands may be as high as 40 seals.

By applying NMFS guidelines for assessing marine mammal stocks, which account for uncertainty in our abundance estimates, the minimum size for the entire Hawaiian monk seal population in 1997 was 1,423 seals.

Current Population Trend

Between 1958 and 1993, average beach counts at the main reproductive population sites declined by 60%. From 1985 to 1993, the total of the average site count declined by about 5% annually. From 1993 to 1997, the total remained relatively stable (Figure 23-1). In the near future the trend will likely be determined by the extent to which expected growth at Kure Atoll and Pearl and Hermes Reef will offset the expected further decline at French Frigate Shoals.

Human-induced mortality has caused two major declines of the Hawaiian monk seal, and it may continue to be an important factor impeding

Table 23-1
Continued from the previous page.

Species	Stock area	Minimum population estimate (N_{min})[1]	Potential biological removal level (PBR)[2]	Annual human-caused mortality[3]	Strategic status[4]	ESA status[5]
Blue whale	Hawaii	N/A	N/A	N/A	Y	E
Fin whale	Hawaii	N/A	N/A	N/A	Y	E
Bryde's whale	Hawaii	N/A	N/A	N/A	N	
Sea otter[6]	California	2,376	N/A	N/A	Y	T
Sea otter[6]	Washington	360	N/A	N/A	Y	T

[1]Nmin is a conservative estimate of abundance used to estimate PBR and provides reasonable assurance that the stock size is equal to or greater than the estimate. Calculations are from 1996. N/A = information is not available.
[2]PBR (potential biological removal) is the maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or stay at its optimum sustainable population level (50–100% of its carrying capacity). Calculations are from 1996.
[3]Annual human-caused mortality is an estimate of the total number of annual mortalities and serious injuries (likely to result in death) caused by humans. Annual records for each species are not available. Estimated totals are based upon available records, which vary by species (Barlow et al. 1997).
[4]Strategic status: Y = yes, N = no.
[5]ESA status: E = listed as endangered, and T = listed as threatened under the Endangered Species Act.
[6]This species is under the jurisdiction of the U.S. Fish and Wildlife Service, and is not included in the stock-status tables of the National Overview.

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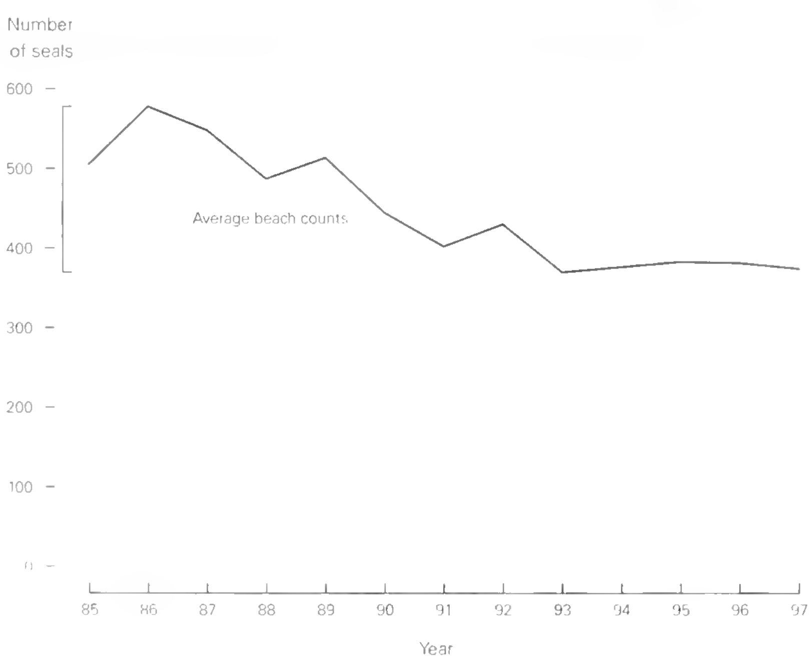

Figure 23-1
Average beach counts of Hawaiian monk seals (excluding Midway Island and pups).

its recovery. In the 1800's, this species was decimated by sealers, surviving sailors of wrecked ships, and guano and feather hunters. A 1958 survey indicated at least partial recovery of the species in the first half of this century; however, subsequent surveys documented a second major decline beginning in 1958 (or earlier), during which several populations (Kure Atoll, Midway Atoll, and Pearl and Hermes Reef) decreased by 80–100%. Population trends at Kure Atoll, Midway Atoll, and French Frigate Shoals appear to have been determined by the pattern of human disturbance. Such disturbances caused pregnant females to abandon prime pupping habitat and nursing females to abandon their pups, thereby increasing juvenile mortality.

Since 1979, disturbance from human activities on land has generally declined and is currently a matter of concern at only Midway Island, where opportunities for ecotourism must be carefully monitored and controlled to prevent such disturbances. Development and expansion of fisheries during the 1970's in the NWHI has led to interactions detrimental to monk seals. The interactions fall into four categories: operations and gear conflict, potential entanglement in fisheries debris, seal consumption of potentially toxic discard, and competition for prey. Direct Hawaiian monk seal interactions have involved four fisheries: the NWHI lobster fishery, the NWHI bottomfish fishery, the pelagic longline fishery, and recreational fisheries in the Main Hawaiian Islands. Recent construction efforts and the establishment of a Protected Species Zone around the Northwestern Hawaiian Islands appear to have substantially reduced the potential for direct fisheries interactions. Possible indirect interactions with fisheries, such as competition for lobster or the degradation of foraging habitat associated with precious coral harvesting, require further investigation.

Status of Stock

In 1976, the Hawaiian monk seal was designated as endangered under the Endangered Species Act (ESA) and depleted under the MMPA. Under the methodology specified in the 1994 amendments to the MMPA (NMFS, 1996), and employing the values of N_{min} (a conservative estimate of the minimum population of the stock) and R_{max} (one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size) or 1,423 monk seals and 0.07/yr, respectively, the calculated potential biological removal (PBR) is 5 seals. However, the ESA takes precedence in the management of this species and, under the ESA, the allowable take of monk seals is zero. The species is assumed to be well below its optimum sustainable population (OSP) and, therefore, is characterized as a strategic stock.

HARBOR PORPOISE: CENTRAL CALIFORNIA STOCK

Stock Definition and Geographic Range

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California, to Alaska and across to Kamchatka and Japan. Harbor porpoise appear to have more restricted movements along the west coast of the continental United States than along the U.S. east coast. Regional differences in pollutant residues from harbor porpoise tissue samples indicate that the species does not mix freely between California, Oregon, and Washington (Calambokidis and Barlow, 1991). The study also showed some regional differences within California (although the sample size was small). This pattern stands in sharp contrast to the east coast of the United States and Canada where harbor porpoises are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy. Early genetic analyses did not show any significant differences between samples from California and Washington, but more recent analyses with larger sample sizes do show significant differences. These studies show that porpoises on the west coast are not freely mixing or migratory, and movement is sufficiently restricted that genetic differences have evolved.

In its harbor porpoise assessment (Barlow and Hanan, 1995), the NMFS and the California Department of Fish and Game recommended that the animals inhabiting the central California coast (from Point Conception to the Russian River) be treated as a separate stock. The justifications for this were: 1) fishery mortality of harbor porpoise is limited to central California, 2) movement of individual animals appeared to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if the central California coast stock was not managed separately. Because the recent genetic studies have confirmed that movement on the west coast is limited, harbor porpoise in central California is considered to be a separate stock. Other Pacific coast stocks of harbor porpoise include: 1) a northern California stock, 2) an Oregon/Washington coastal stock, 3) a Washington inland-waters stock, and 4) an Alaska stock.

Population Size

A 1994 review (Barlow and Forney, 1994) of previous estimates of harbor porpoise abundance along central California resulted in a new estimate of 4,120 animals (CV = 0.22)[1] based on a series of aerial surveys from 1988 to 1993. This recent estimate is not significantly different from the previous estimate of 3,274 animals (CV = 0.31) but is more precise (owing to the greater number of kilometers surveyed). Both of these estimates only include the region between the coast and the 91 m (50 fathom) isobath. In California, the vast majority of harbor porpoises are sighted within this depth range; however, 24% of the harbor porpoises seen during aerial surveys of Oregon and Washington were between the 100 m and 200 m isobaths (55–109 fathoms). Thus, these abundance estimates are likely underestimates of the total abundance by a non-trivial amount. The current minimum population estimate of 3,431 animals in central California is based on aerial surveys conducted between 1988 and 1993 (Barlow and Forney, 1994).

Current Population Trend

An analysis of a 1986–95 time series of aerial surveys was conducted to examine trends in harbor porpoise abundance in central California (Forney, 1996). After controlling for the effects of sea state, cloud cover, and area on sighting rates, a negative trend in population size was evident. The trend was not statistically significant, but statisti-

[1]Coefficient of variation (CV) is a statistical measure used to calculate confidence intervals (CI), which gauge the accuracy of population estimates. An accurate population estimate is characterized by a low CV and a narrow CI. CI is often given a percentage likelihood of being correct (e.g. 95% means that if the data were resampled and the CI were recalculated 100 times, then 95 times it would contain the true value.

Left page: Hawaiian monk seal, Northwestern Hawaiian Islands National Wildlife Refuge.

cal power to detect trends remains low. Indications of a decline were most evident in the southern part of central California, between Point Conception and Monterey Bay. A real population decline would be somewhat surprising since fishery mortality has been declining during this same time period. Harbor porpoise abundance appears to be correlated with changes in sea surface temperature, and apparent trends could be caused by changing oceanographic conditions.

Status of Stock

The estimated PBR of 33 animals for this stock is calculated as the product of one half of the minimum population estimate (3,431), one-half the default maximum net growth rate for cetaceans (4%), and a recovery factor of 0.48 (for a species of unknown status with a mortality rate coefficient of variation equal to 0.44).

The harbor porpoise in California is not listed as threatened or endangered under the ESA nor as depleted under the MMPA. Calculation of harbor porpoise status relative to historic carrying capacity suggests that the central California population could have been reduced to between 30% and 97% of its carrying capacity by incidental fishing mortality. Present information is insufficient to narrow the range of this estimate, and the status of harbor porpoise relative to their OSP levels in central California is unknown. The average mortality rate of 14 animals over the past 3 years is less than the calculated PBR (33 animals) for central California harbor porpoise; thus, the central California harbor porpoise population is not considered a strategic stock under the MMPA. The Pacific Scientific Review Group (established by the MMPA) recommended, however, that this stock be considered strategic because it appears to be in decline and may be listed as threatened under the Endangered Species Act unless this trend is stopped. Because fishery mortality has been reduced over the past 10 years and because there is some indication that the decline in animals may be due to natural causes, the NMFS does not believe that a strategic status is justified at this time. Research will continue to monitor this population size and to investigate the possible causes of its decline.

Humpback whale, Southeast Alaska

HUMPBACK WHALE: CALIFORNIA/OREGON/WASHINGTON–MEXICO STOCK

Stock Definition and Geographic Range

Four relatively separate migratory populations of humpback whales have been identified in the North Pacific based on sightings of distinctively marked individuals. These are the coastal California/Oregon/Washington–Mexico stock, the Mexico offshore island stock (feeding destination unknown), the central North Pacific stock (Hawaii/Alaska), and the western North Pacific stock (Japan/feeding destination probably the Aleutian Islands). The California/Oregon/Washington–Mexico stock ranges from Costa Rica to southern British Columbia but is most common in coastal waters of California (in summer and fall) and Mexico (in winter and spring).

Significant levels of genetic differences exist between the California and Alaska feeding groups based on analyses of mitochondrial DNA and nuclear DNA. The genetic exchange rate between California and Alaska is estimated to be less than one female per generation. Genetic profiles from animal samples in the Hawaiian and coastal Mexican breeding areas showed fewer genetic differences than did the two feeding areas. These differences are substantiated by the observed movement of individually identified whales between Hawaii and Mexico. There have been no individual matches between 597 humpbacks photographed in California and 617 humpbacks photographed in Alaska. Few whales photographed in British Columbia have matched with a California photographic catalog, indicating that British Columbia is an approximate geographic boundary between feeding populations.

Population Size

Based on whaling statistics, the pre-1905 population of humpback whales in the North Pacific was estimated to be 15,000, but this population was reduced by commercial whaling to approximately 1,200 by 1966. The present North Pacific total almost certainly exceeds 3,000 humpback whales.

Population estimates for the California/Oregon/Washington–Mexico stock range from 338 (CV = 0.29) to 626 (CV = 0.41). The most precise and least biased estimate is likely to be a 1994 mark-recapture estimate of 597 (CV = 0.07) animals. The minimum population estimate for humpback whales in this stock from mark-recapture methods is approximately 563 humpback whales.

Current Population Trend

There is some indication that humpback whales have increased in abundance in California coastal waters between 1979–80 and 1991, but this trend is not significant. Mark-recapture population estimates have increased steadily from 1988–90 to 1992–93 at about 5% per year. Although the North Pacific population is expected to have grown since it was given protected status in 1966, the possible effects of continued unauthorized take, incidental ship strikes, and gillnet mortality make this uncertain.

Status of Stock

The PBR level is estimated as 1.1 whales; however, because this stock spends approximately half its time in Mexican waters, the PBR allocation for U.S. waters is one-half of the PBR estimate, or 0.5 whale/year.

Humpback whales in the North Pacific were estimated to have been reduced to 13% of carrying capacity by commercial whaling, and the population remains severely depleted. The population's initial abundance has never been estimated separately for the California/Oregon/Washington–Mexico stock, but this stock was also probably depleted by whaling. Humpback whales are formally listed as endangered under the ESA, and consequently the California/Oregon/Washington–Mexico stock is automatically considered as a depleted and strategic stock under the MMPA. Although the estimated annual mortality due to entanglement (1.2/yr) plus ship strikes (0.6/yr) in California is greater than the estimated PBR level allocation of 0.5 for this stock in U.S. waters, the California/Oregon/Washington–Mexico stock appears to be increasing in abundance.

EASTERN TROPICAL PACIFIC DOLPHINS

Approximately nine species of dolphins are incidentally taken in the international purse-seine fishery for yellowfin tuna in the eastern tropical Pacific (ETP) waters off Mexico and Central America. Only four species (representing 10 stocks) have experienced significant mortality associated with the tuna fishery. Since these four species also occur in U.S. waters and are impacted by U.S. fishing boats in the fleet, the NMFS Southwest Fisheries Science Center has routinely assessed these dolphin populations.

The greatest dolphin mortality occurred in the 1960's and 1970's and led to dramatic declines in abundance of the northeastern spotted dolphin and eastern spinner dolphin stocks to one-fourth of their pre-exploitation level in 1959. Additionally, trend data collected since 1975 indicate both stocks are still significantly below the levels of 1975. In 1993, the NMFS listed both the northeastern offshore spotted and the eastern spinner stocks as depleted under the MMPA because they

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Spinner dolphins.

were below their optimum sustainable populations.

Although the greatest mortality occurred in the 1960's and 1970's, incidental mortality of ETP dolphins was still fairly high as recently as 1986 when 133,174 dolphins were estimated killed, and, out of eight stocks for which a PBR level can now be calculated, seven had incidental mortalities that exceeded their PBR's. In 1991, mortality in the three stocks of greatest concern (northeastern spotted, eastern spinner, central common) still exceeded their PBR's. These comparisons are illustrative only, as the MMPA specifically manages ETP dolphins by quotas, not calculated PBRs. Incidental mortality of northeastern spotted dolphins increased in 1986 to 7% of their abundance estimate, a level that is not likely to be sustainable, and this apparently led to another significant decline in the stock between 1985 and 1994. The data also indicate that the central stock of common dolphins is still significantly below its 1975 level.

Mortality of ETP dolphins has been declining since 1986 and has decreased dramatically since 1991 (Table 23-2). A 1992 international agreement to manage the incidental mortality of ETP dolphins, which included individual vessel quotas, has led to a decrease in the total mortality (2,914 dolphins of all species) in 1997. Since 1992, the incidental mortality has been less than the estimated PBR for all stocks, and the annual incidental mortality of each stock is now less than 0.2% of their estimated abundance. Such low mortality rates should be sustainable and should, if continued, allow the northeastern spotted dolphin and the eastern spinner dolphin populations to increase and eventually recover.

Table 23-2

Mortality of dolphins in the eastern tropical Pacific due to the tuna fishery

Stock	Abundance 1986–90	Minimum population estimate (N_{min}) 1986–90	Potential biological removal level (PBR)[1] 1986–90	Incidental mortality in the eastern tropical Pacific tuna fishery 1994	1995[2]	1996[3]
Northeastern spotted[4]	730,000	648,900	6,489	934	952	818
West/South spotted	1,298,400	1,145,100	11,451	1,226	859	545
Coastal spotted	29,800	22,500	225	N/A	N/A	N/A
Eastern spinner[4]	631,800	518,500	5,185	743	654	450
Whitebelly spinner	101,9300	872,000	8,720	619	445	447
Central American spinner	N/A	N/A	N/A	11	17	11
Northern common	476,300	353,100	3,531	101	9	77
Central common	406,100	297,400	2,974	151	192	51
Southern common	2,210,900	1,845,600	18,456	0	0	30
Striped	1,918,000	1,745,900	17,459	11	34	5

[1] Comparisons of recent incidental mortality to potential biological removal levels (PBRs) calculated for stocks of eastern tropical Pacific dolphins. It should be noted that ETP dolphins are explicitly excluded from management under the PBR section of the Marine Mammal Protection Act. Nonetheless, the calculated PBRs still provide a useful guide for intepreting the significance of dolphin mortality. Abundance estimates are from Wade and Gerrodette (1992). PBRs were calculated using an assumed maximum net productivity rate of 0.04 and a recovery factor of 0.5 in each case.
[2] Hall and Lennert, 1997.
[3] Lennert and Hall, in press.
[4] Listed as depleted under the Marine Mammal Protection Act.

There are still some uncertainties and concerns about the status of two small populations of endemic subspecies that are found in the ETP, the coastal spotted dolphin and the Central American spinner dolphin. An abundance estimate, only available for the coastal spotted stock, indicates that mortality of more than 225 animals per year may not be sustainable. No coastal spotted dolphins were reported killed in 1993 and 1994 (with near 100% observer coverage), although they were reported killed in previous years. Additionally, 41 and 237 unidentified dolphins were reported killed in 1993 and 1994, respectively, which may have included some of these subspecies. Only 18 and 11 Central American spinner dolphins were reported killed in 1993 and 1994, respectively. Monitoring of both of these coastal distributed stocks remains important, particularly if much fishing effort occurs close to the coast.

In 1995, another international agreement set dolphin mortality limits by stock, provided for an end to U.S. embargoes of ETP tuna, and proposed a new definition of "dolphin-safe" tuna. U.S. legislation (the International Dolphin Conservation Program Act) signed into law in 1997 implemented provisions of this agreement and mandated new research to determine whether or not encirclement of dolphins during tuna purse-seine fishing has a significant adverse impact on dolphin stocks. If it is found that encirclement does have a significant adverse effect, the current definition of "dolphin-safe" (no dolphins were chased or encircled while catching the tuna) will be retained; otherwise, the definition will be changed to mean that no dolphins were killed or seriously injured in that particular set even if dolphins were chased and encircled. The Secretary of Commerce must make a preliminary determination on this matter by March 1999 and a final determination by December 2002.

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ERRATUM

In *Our Living Oceans 1995*, the section of Unit 23 on the harbor porpoise stock off central California contained a figure showing population counts (Figure 23-2). This figure was in error, and actually showed harbor seal counts.

Marine Mammals of the Atlantic Region and the Gulf of Mexico

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Unit 24

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Pantropical spotted dolphin.

INTRODUCTION

The Atlantic region has at least 91 stocks of 39 species of marine mammals. The U.S. Fish and Wildlife Service has management authority for two stocks of the endangered West Indian manatee (Florida and Antillean), and the National Marine Fisheries Service (NMFS) has responsibility for management of the remaining cetacean and pinniped stocks.

According to criteria provided by the 1994 Amendments to the Marine Mammal Protection Act (MMPA) there are 23 strategic stocks (Table 24-1). In the western North Atlantic, the strategic stocks include 6 stocks of endangered whales (right, humpback, fin, sei, blue, and sperm whales); the coastal bottlenose dolphin which is depleted under the MMPA; and stocks where estimated mortality exceeds their Potential for Biological Removal (PBR) (dwarf sperm whale, pygmy sperm whale, killer whale, Cuvier's beaked whale, mesoplodont beaked whale, short-finned pilot whale, common dolphin, Atlantic spotted dolphin, pantropical spotted dolphin, and the Gulf of Maine/Bay of Fundy harbor porpoise).

In the northern Gulf of Mexico, strategic stocks include the endangered sperm whale, bottlenose dolphin in coastal bays, sounds and estuaries, dwarf and pygmy sperm whales, and the Florida and Antillean stocks of endangered West

Table 24-1

Status of marine mammal stocks in the Atlantic region and Gulf of Mexico

Species	Stock area	Minimum population estimate (N_{min})[1]	Potential biological removal level (PBR)[2]	Annual human-caused mortality[3]	Strategic status[4]	ESA/ MMPA status[5]	Trend[6]
Harbor seal	Western North Atlantic	30,990	1,859	898	N		I
Gray seal	Northwest North Atlantic	2,010	121	41	N		I
Harp seal	Northwest North Atlantic	N/A	N/A	329	N		I
Hooded seal	Northwest North Atlantic	N/A	N/A	5.6	N		I
Harbor porpoise	Gulf of Maine/ Bay of Fundy	48,289	483	1,667	Y		U
Risso's dolphin	Western North Atlantic	11,140	111	18	N		U
Atlantic white-sided dolphin	Western North Atlantic	19,196	192	218	Y		U
White-beaked dolphin	Western North Atlantic	N/A	N/A	0	N		U
Common dolphin	Western North Atlantic	15,470	155	247	Y		U
Atlantic spotted dolphin	Western North Atlantic	1,617	16	16	Y		U
Pantropical spotted dolphin	Western North Atlantic	1,617	16	16	Y		U
Striped dolphin	Western North Atlantic	18,220	182	11	N		U
Spinner dolphin	Western North Atlantic	N/A	N/A	0.31	N		U
Bottlenose dolphin	Western North Atlantic, offshore	8,794	88	58	N		U
Bottlenose dolphin	Western North Atlantic, coastal	2,482	25	29	Y	D	S
Dwarf sperm whale	Western North Atlantic	N/A	N/A	0.2	Y		U
Pygmy sperm whale	Western North Atlantic	N/A	N/A	N/A	N		U
Killer whale	Western North Atlantic	N/A	N/A	0	N		U
Pygmy killer whale	Western North Atlantic	6	0.1	0	N		U
Northern bottlenose whale	Western North Atlantic	N/A	N/A	0	N		U
Cuvier's beaked whale	Western North Atlantic	895	8.9	9.7	Y		U
Mesoplodont beaked whale	Western North Atlantic	895	8.9	9.7	Y		U
Pilot whale, long-finned	Western North Atlantic	4,968	50	32	N		U
Pilot whale, short-finned	Western North Atlantic	457	4.6	32	Y		U
Sperm whale	Western North Atlantic	1,617	3.2	0	Y	E	U
North Atlantic right whale	Western North Atlantic	295	0.4	2.3	Y	E	U
Humpback whale	Western North Atlantic	10,019	32.6	5.7	Y	E	U
Fin whale	Western North Atlantic	1,704	3.4	0.5	Y	E	U
Sei whale	Western North Atlantic	N/A	N/A	N/A	Y	E	U
Minke whale	Canadian east coast	2,145	21	0.8	N		U
Blue whale	Western North Atlantic	N/A	N/A	N/A	Y	E	U
Bottlenose dolphin	Gulf of Mexico, outer continental shelf	43,233	432	2.8	Y		U
Bottlenose dolphin	Gulf of Mexico, continental shelf edge and slope	4,530	45	2.8	Y		U
Bottlenose dolphin	Western Gulf of Mexico coastal	2,938	29	13	Y		U
Bottlenose dolphin	Northern Gulf of Mexico coastal	3,518	35	10	Y		U
Bottlenose dolphin	Eastern Gulf of Mexico coastal	8,963	90	8	Y		U
Bottlenose dolphin	Gulf of Mexico bay, sound, and estuarine[7]	3,933	39.7	30	Y		U
Atlantic spotted dolphin	Northern Gulf of Mexico	2,255	23	1.5	N		U
Pantropical spotted dolphin	Northern Gulf of Mexico	26,510	265	1.5	N		U
Striped dolphin	Northern Gulf of Mexico	3,409	34	0	N		U
Spinner dolphin	Northern Gulf of Mexico	4,465	45	0	N		U
Rough-toothed dolphin	Northern Gulf of Mexico	660	6.6	0	N		U

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Sperm whale.

Table 24-1

Continued from previous page.

Species	Stock area	Minimum population estimate (N_{min})[1]	Potential biological removal level (PBR)[2]	Annual human-caused mortality[3]	Strategic status[4]	ESA/MMPA status[5]	Trend[6]
Clymene dolphin	Northern Gulf of Mexico	4,120	41	0	N		U
Fraser's dolphin	Northern Gulf of Mexico	66	0.7	0	N		U
Killer whale	Northern Gulf of Mexico	197	2	0	N		U
False killer whale	Northern Gulf of Mexico	236	2.4	0	N		U
Pygmy killer whale	Northern Gulf of Mexico	285	2.8	0	N		U
Dwarf sperm whale	Northern Gulf of Mexico	N/A	N/A	N/A	Y		U
Pygmy sperm whale	Northern Gulf of Mexico	N/A	N/A	N/A	Y		U
Melon-headed whale	Northern Gulf of Mexico	2,888	29	0	N		U
Risso's dolphin	Northern Gulf of Mexico	2,199	22	19	N		U
Cuvier's beaked whale	Northern Gulf of Mexico	20	0.2	0	N		U
Blainville's beaked whale	Northern Gulf of Mexico	N/A	N/A	0	N		U
Gervais' beaked whale	Northern Gulf of Mexico	N/A	N/A	0	N		U
Pilot whale, short-finned	Northern Gulf of Mexico	186	1.9	0.3	Y[8]		U
Sperm whale	Northern Gulf of Mexico	411	0.8	0	Y	E	U
Bryde's whale	Northern Gulf of Mexico	17	0.2	0	N		U
Manatee[9]	Florida				Y	E	D
Manatee[9]	Antillean				Y	E	D

[1] N_{min} is a conservative estimate of abundance used to estimate PBR and provides reasonable assurance that the stock size is equal to or greater than the estimate

[2] PBR (potential biological removal) is the maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or stay at its optimum sustainable population level (50–100% of its carrying capacity)

[3] Annual human-caused mortality is an estimate of the total number of annual mortalities and serious injuries (likely to result in death) caused by humans

[4] Strategic status Y = yes, N = no

[5] E = listed as endangered, and T = listed as threatened under the Endangered Species Act D = listed as depleted under the Marine Mammal Protection Act

[6] Trend is increasing (I), stable (S), decreasing (D), or unknown (U)

[7] Represents at least 33 individually recognized stocks of bottlenose dolphin in U S Gulf of Mexico bays, sounds, and other estuaries

[8] The total level of estimated fishery-related mortality and serious injury is unknown, but because there is a record of a fishery-related mortality or serious injury and because of the extremely low estimated stock size, this is a strategic stock

[9] This species is under the jurisdiction of the U S Fish and Wildlife Service, and is not included in the stock-status tables of the National Overview

Blue whale.

Indian manatees.

Recent assessments indicate that there is an increasing trend in the four seal stocks; the coastal bottlenose dolphin stock is believed to be stable; West Indian manatees are believed to be declining; and the trends for the remaining 84 stocks are unknown.

BOTTLENOSE DOLPHIN: GULF BAY, SOUND, AND ESTUARINE STOCKS

Stock Definition and Geographic Range

There are now 33 recognized provisional stocks that occupy the bays, sounds, and estuaries along the U.S. Gulf of Mexico. Seaward of these are recognized an additional three coastal-to-shelf edge and three offshore provisional stocks. Studies relying on identification of individual dolphins suggest that bottlenose dolphins inhabiting many of the bays, sounds, and other estuaries form discrete communities. Although breeding may occur between adjacent communities, the geographic nature of these areas suggests that each community exists as a functioning unit of its ecosystem and, under the MMPA, must be maintained as such. Therefore, each of the areas forming a contiguous enclosed or semi-enclosed body of water is provisionally considered to contain a distinct bottlenose dolphin stock or management unit, but the number of these will likely change as new information on the biological uniqueness and degree of mixing among these communities is obtained. Although this is believed to be a risk averse approach to management, the small size of many of these populations often results in estimates of sustainable removal levels (i.e. potential biological removal (PBR)) of less than one individual, and this becomes problematic. To this end, a major research objective is to develop biologically based criteria to better define and manage this species in the Gulf of Mexico.

The continuous distribution of bottlenose dolphins around the Gulf coast theoretically allows genetic exchange between adjacent communities. However, long-term mark-recapture studies using photo-identification of individual dolphins in the vicinity of Sarasota and Tampa Bays in Florida demonstrate that individual dolphins remain in a given area year-round. Three distinct dolphin communities have been described in and around Sarasota Bay. One community was formed by dolphins residing in the Gulf of Mexico coastal waters, another consisted of the dolphins in the deep-water areas of Passage Key Inlet and Tampa Bay (adjacent to Sarasota Bay), and a third community resided in the shallow waters of Sarasota Bay.

Females of the highly structured Sarasota dolphin community form a stable, discrete, long-term breeding unit with strong geographical fidelity. Electrophoretic isozyme analysis showed significant differences between dolphins of the shallow-water Sarasota community and the Tampa Bay community, and from dolphins from Charlotte Harbor, to the south; however, there was a high degree of genetic heterozygosity indicating that the Sarasota community, while socially and geographically distinct, is not genetically isolated. It has been suggested that the Sarasota community is likely one of a number of communities which comprise an extended population, the limits of which are unknown.

Photo-identification and radio-tracking studies confirmed that some individual dolphins remain in the same general areas within Matagorda Bay, Texas, throughout the year (Lynn, 1995); thus, the situation there may be similar to that of the Florida west coast. Movement of resident bottlenose dolphins in Texas through passes linking bays with the Gulf of Mexico appears to be relatively limited, but does occur and suggests that these communities, like those along the Florida west coast, may not be reproductively isolated from the coastal populations. For example, two bottlenose dolphins previously seen in the South Padre Island, Texas, coastal area were seen in Matagorda Bay, 285 kilometer north, in May 1992 and May 1993. Preliminary analyses of mitochondrial DNA using polymerase chain reaction procedures suggested that Matagorda Bay dolphins appear to be a localized population, despite the suggestion of mixing of some individuals over large distances (NMFS, unpublished data[1]). Over 1,000 individual bottlenose dolphins have been identified in bay and coastal waters near the northeast end of Galveston Island, Texas, but most of these were sighted only once with only 200 individuals reported to use the area over the long term, suggesting that a significant number of dolphins are not resident in this area.

Much less is known about the movements of resident bottlenose dolphins in estuaries of the northern Gulf of Mexico. Seasonal differences in bottlenose dolphin abundance in Mississippi Sound suggest seasonal migration; however, these migration patterns are yet to be fully described. It is probable that some exchange occurs between the Mississippi Sound communities and the coastal dolphins in this area as well.

Population Size

Population size for all of the provisional stocks except Sarasota Bay, Florida, was estimated from preliminary analyses of line-transect data collected during aerial surveys conducted in September-October 1992 in Texas and Louisiana, in September-October 1993 in Louisiana, Mississippi, Alabama, and the Florida panhandle, and aerial surveys of the west coast of Florida in September-November. Population estimates for the Sarasota Bay, Florida, community were obtained through direct count of known individuals. Minimum population estimates were calculated from the estimates of population size and their associated coefficients of variation (Table 24-1). Where the population size resulted from a direct count of known individuals, the minimum population size was identical to the estimated population size.

Current Population Trend

Population data are insufficient to determine trends for the provisional stocks of bottlenose dolphin that inhabit the bays, sounds, and estuaries in the Gulf of Mexico. However, three anomalous mortality events occurred among portions of these communities between 1990 and 1994. While these events may have resulted in declines in some locations, it is not possible to accurately partition the mortalities between the bay, sound, and estuary communities and adjacent coastal dolphin communities. Thus, the effect of these mortality events on the growth of these populations cannot be determined at this time. Ongoing monitoring will be required to establish more accurate populations estimates and, over time, trends in abundance for these dolphin communities.

Status of Stock

In the absence of information on population trends and unknown status for Gulf bay, sound, and estuary bottlenose dolphin communities, PBR's are calculated using a recovery factor of 0.50. The estimates for each provisional stock are given in Table 24-1.

Although these provisional stocks are not listed as threatened or endangered, the occurrence of the three anomalous mortality events within their communities is cause for concern. While the specific factors that presumably caused and or contributed to these mortality events has yet to been determined, evidence suggests that bottlenose dolphins in the northern and western coastal portion of the U.S. Gulf of Mexico may have experienced a morbillivirus epidemic in 1993 (Lipscomb,

[1]National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543

1994). Seven of 35 live-captured bottlenose dolphins (20%) from Matagorda Bay, Texas, in 1992, tested positive for previous exposure and it is possible that other estuarine resident dolphin communities have been exposed as well. The relatively high number of bottlenose dolphin deaths which occurred during these mortality events suggests that these populations may be physiologically stressed, possibly from nearshore pollution and chemical contamination or other causes. For these reasons, and because the PBR for most of these relatively small provisional stocks would be exceeded with the incidental capture of a single dolphin, each is recognized as a strategic stock.

HARBOR PORPOISE: GULF OF MAINE-BAY OF FUNDY STOCK

Stock Definition and Geographic Range

This harbor porpoise stock is found in U.S. and Canadian Atlantic waters. During the summer (July to September), harbor porpoises are concentrated in the northern Gulf of Maine-southern Bay of Fundy region, generally in waters less than 150 meters (m) deep (Palka et al., 1996). During fall (October to December) and spring (April to June), harbor porpoises are widely dispersed from North Carolina to Maine, though in much lower densities than that seen during the summer. No specific migratory routes to the northern Gulf of Maine-lower Bay of Fundy region have been documented. Animals are seen from the coastline to the middle of the Gulf of Maine (>200 m deep) in both spring and fall. During winter (December to March), some harbor porpoises have been reported in waters off the Mid-Atlantic (from New Jersey to North Carolina). Two stranding records from Florida occurred during the 1980's.

Gaskin (1984, 1992) proposed that there were four separate populations in the western North Atlantic: the Gulf of Maine-Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland populations. Recent analyses involving mitochondrial DNA (Wang et al., 1996), organochlorine contaminants (Westgate et al., 1997), heavy metals (Johnston, 1995), and life history parameters (Read and Horn, 1995) support Gaskin's proposal. In particular, there is a suggestion that the Gulf of Maine-Bay of Fundy females are different than Gulf of St. Lawrence females, but males were statistically indistinguishable (Palka et al., 1996). Research on microsatellites, a potentially powerful genetic tool, is currently being conducted to reanalyze existing genetic data and analyze new samples in order to resolve the larger scale stock structure question.

Population Size

Line-transect surveys were conducted during 1991, 1992, and 1995 to estimate the population size of harbor porpoises aggregated in the Gulf of Maine-Bay of Fundy region during the summer. The next scheduled survey is in the summer of 1999. The abundance estimated from the 1991 survey was 37,500 (CV^2 = 0.29, 95% CI = 26,700–86,400) (Palka, 1995a), 67,500 from the 1992 survey (CV = 0.23, 95% CI = 32,900–104,600) (Smith et al., 1993) and 74,000 harbor porpoises from the 1995 survey (CV = 0.20, 95% CI = 40,900–109,100) (Palka, 1996). The inverse variance weighted-average abundance estimate from all three surveys (Smith et al., 1993) was 54,300 harbor porpoises (CV = 0.14, 95% CI = 41,300–71,400). Possible reasons for inter-annual differences in abundance and distribution include experimental error and inter-annual changes in water temperature and availability of primary prey species (Palka, 1995b). The minimum population estimate calculated for this population is 48,289 (CV = 0.14).

Current Population Trend

Data are not sufficient to determine the population trends for this species. Previous abundance estimates for harbor porpoises in the Gulf of

[2]Coefficient of variation (CV) is a statistical measure used to calculate confidence intervals (CI), which gauge the accuracy of population estimates. An accurate population estimate is characterized by a low CV and a narrow CI. CI is often given a percentage likelihood of being correct (e.g. 95% means that if the data were resampled and the CI were recalculated 100 times, then 95 times it would contain the true value.

Maine-Bay of Fundy are available from earlier studies (e.g. 4,000 animals (Gaskin, 1977) and 15,800 animals (Kraus et al., 1983)). These estimates cannot be used in a trends analysis because they were from selected small regions within the entire known summer range and, in some cases, do not incorporate an estimate for the probability that an animal on the transect track line will be missed (NEFSC, 1992).

Status of the Stock

The National Marine Fisheries Service has proposed listing the Gulf of Maine-Bay of Fundy harbor porpoise as threatened under the Endangered Species Act (NMFS, 1993). The Gulf of Maine-Bay of Fundy harbor porpoise stock has also been classified as strategic because total U.S. annual fishery-related mortality and serious injury (1,667) exceeds PBR (483) (Waring et al., 1997). The estimated annual mortalities from the New England multispecies sink gillnet fishery from 1990 to 1996 are 2,900 (CV = 0.32), 2000 (CV = 0.35), 1,200 (CV = 0.21), 1,400 (CV = 0.18), 2,100 (CV = 0.18), 1,400 (CV = 0.27), and 1,200 (CV = 0.25) respectively (Bravington and Bisack, 1995; Bisack, 1997a). The annual estimated mortalities from the pelagic drift gillnet fishery from 1991 to 1996 are 0.7 (CV = 1.0), 0.4 (CV = 1.0), 1.5 (CV = 0.34), 0, 0, and 0, respectively (Bisack, 1997b). The annual estimated mortalities from the Mid-Atlantic coastal sink gillnet fisheries for 1995 and 1996 are 103 (CV = 0.57) and 311 (CV = 0.31) (Waring et al, 1999). In addition, harbor porpoise bycatch in Canadian gillnets in the Bay of Fundy from 1994 to 1997 were 101 (95% CI = 80–122), 87, 20, and 43 respectively (Trippel et al., 1996).

To address bycatch of harbor porpoises two take reduction teams have been formed to design a plan to reduce bycatch. The first team met in 1996 to address bycatch in the New England multispecies sink gillnet fishery. The second team met in 1997 to address bycatch in the Mid-Atlantic coastal gillnet fisheries.

Sue Matthews USFWS

Harbor seal.

HARBOR SEAL: WESTERN NORTH ATLANTIC STOCK

Stock Definition and Geographic Range

In the western North Atlantic, harbor seals are common from Labrador to southern New England and New York, and occasionally to the Carolinas (Boulva and McLaren, 1979; Katona et al., 1993; Gilbert and Guldager, 1998). Although the stock structure is unknown, the northwest Atlantic subspecies, *Phoca vitulina concolor*, is believed to represent one breeding population. Breeding and pupping normally occurs in waters north of the New Hampshire-Maine border, although breeding occurred as far south as Cape Cod in the early part of the twentieth century (Temte et al., 1991; Katona et al., 1993).

Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Katona et al., 1993), and seasonally along the southern New England and New York coasts from September through late May (Schneider and Payne, 1983). A general southward movement from the Bay of Fundy to southern New England waters occurs in autumn and early winter (Rosenfeld et al., 1988; Whitman and Payne, 1990). A northward movement from southern New England to Maine and eastern Canada occurs prior to the pupping season, which takes place from mid-May through June along the Maine

Fraser's dolphin.

Coast (Richardson, 1976; Kenney, 1994). The overall geographic range throughout U.S. Atlantic coast waters has not changed greatly during the last century.

Population Size

Since passage of the Marine Mammal Protection Act in 1972, the number of seals along the New England coast has increased nearly fivefold. Coast-wide aerial surveys along the Maine coast were conducted in May-June during pupping in 1981, 1982, 1986, 1993, and 1997 (Gilbert and Stein, 1981; Gilbert and Wynne, 1983; Gilbert and Wynne, 1984; Kenney, 1994; and Gilbert and Guldager, 1998). Aerial survey haul-out counts (adults and pups) were 10,540 (1981), 9,331 (1982), 12,940 (1986), 28,810 (1993), and 30,990 (1997). These numbers are considered to be minimum abundance estimates because they are uncorrected for animals in the water or outside the survey area. The annual increase since 1993 has been 1.8 percent (Gilbert and Guldager, 1998). Since 1981, the average annual increase has been 4.2 percent (Gilbert and Guldager, 1998), about 50% of the 8.9 percent annual increase estimated by Kenney (1994) from counts through 1993. Pup counts along the Maine coast during the May-June period were: 676 (1981), 1,198 (1982), 1,713 (1986), 4,250 (1993), and 5,359 (1997). The 1997 estimate is 26 percent above the 1993 value. Since 1981, the number of pups along the Maine coast has increased at an annual rate of 12.9 percent (Gilbert and Guldager, 1998).

Increased abundance of seals in wintering areas in southern New England and New York has also been documented in monitoring programs conducted by a variety nongovernment organizations. Canadian scientists counted 3,600 harbor seals during an August 1992 aerial survey in the Bay of Fundy (Stobo and Fowler, 1994), but noted that the survey was not designed to obtain a population estimate.

Harbor seals, like gray seals, were bounty hunted in New England waters until the late 1960's. This hunt may have caused the demise of this stock in U.S. waters (Katona et al., 1993). Researchers and fishery observers have documented incidental mortality in several fisheries in recent years, particularly within the Gulf of Maine (Waring et al., 1997). An unknown level of mortality also occurs in the mariculture industry (i.e. salmon farming), in power plant intake pipes, and by deliberate shooting (NMFS unpublished data[3]). An unknown number of harbor seals have been taken in Newfoundland and Labrador, Gulf of St. Lawrence, and Bay of Fundy groundfish gillnets, Atlantic Canada and Greenland salmon gillnets, Atlantic Canada cod traps, Bay of Fundy herring weirs, and from deliberate shooting (Read, 1994). Estimated average annual mortality and serious injury to this stock during 1990–93 are 602 (CV = 0.68), 231 (CV = 0.22), 373 (CV = 0.23), 698 (CV = 0.19), 1,330 (CV = 0.25), 1,179 (CV = 0.21), and 911 (CV = 0.27), respectively.

Small numbers of harbor seals regularly strand during the winter period in southern New England and Mid-Atlantic regions (NMFS, unpublished data[1]). Sources of mortality include human interactions (boat strikes, fishing gear, power plant intake, aquaculture operations), storms, abandonment by the mother, and disease (Katona et al., 1993; NMFS unpublished data[1]). In 1980, more than 350 seals were found dead in the Cape Cod area from an influenza outbreak (Geraci et al., 1981). The minimum population estimate is 30,990 harbor seals (Waring et al., 1997).

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[3]Northeast Fisheries Science Center, NMFS, 166 Water Street, Woods Hole, MA 02543.

Current Population Trend

Based on recent aerial survey counts during the May-June pupping season along the Maine coast, harbor seal abundance in U.S. waters is increasing, but the actual trend is unknown.

Status of Stock

PBR (Barlow et al., 1995) was specified as the product of minimum population size (30,990), one-half the maximum productivity rate (0.06), and a recovery factor of 1.0, to give a PBR for this stock of 1,859 harbor seals (Waring et al., 1997).

The status of the harbor seal population, relative to the optimum sustainable population, in the U.S. Atlantic Exclusive Economic Zone is unknown, but the population is increasing. The species is not listed as threatened or endangered under the Endangered Species Act. The estimated annual level of human-caused mortality and serious injury in U.S. waters does not exceed PBR; therefore, this is not a strategic stock.

NORTHERN RIGHT WHALE: NORTH ATLANTIC STOCK

Historical Background

The northern right whale was the first large whale to be hunted on a systematic, commercial basis. The species was taken by Basque whalers in the Bay of Biscay at least as early as the 11th century (Aguilar, 1986). By the late 1500's the Basques had established a substantial fishery off the Labrador coast (Cumbaa, 1986). This was succeeded by intensive shore whaling off New England in the 17th and 18th centuries, an activity which continued sporadically into the early part of this century. Similarly intensive exploitation occurred in the North Pacific population beginning in 1835. Although the right whale was officially protected throughout its range in 1935, it is now known that the former Soviet Union took substantial numbers of these animals in the North Pacific and Sea of Okhotsk into the 1960's (Yablokov, 1994). There is presently no evidence that these illegal catches extended to the North Atlantic.

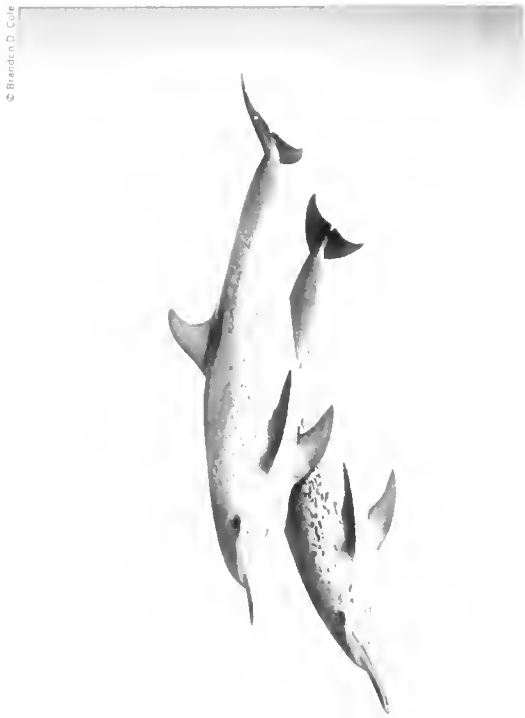
Stock Definition and Geographic Range

The right whale is a slow animal which frequents coastal and shelf habitats. It feeds in temperate or high latitudes in summer and calves in warmer water in winter. The North Atlantic population is generally thought to consist of two relatively discrete stocks in the eastern and western portions of this ocean basin.

Historically, right whales were found in coastal waters throughout the North Atlantic in a range which extended from Florida (and perhaps further south) to Greenland in the west, and from western Africa to Norway in the east. However, intensive exploitation has greatly reduced the range of this animal. In the western North Atlantic, the remaining population is today largely confined to U.S. and Canadian waters, feeding in the Gulf of Maine and on the Scotian Shelf, and calving in the coastal waters of Georgia and Florida (Kraus et al., 1986b; Winn et al., 1986). Right whales appear in the Cape Cod and Massachusetts Bays region in late winter, move to the Great South Channel (southeast of Cape Cod) in spring, and then migrate to Canadian waters for the summer. The Bay of Fundy constitutes a major summer nursery area for the population, although recent genetic studies suggest the existence of a second, unidentified nursery (Schaeff et al., 1993). In winter, pregnant females migrate to give birth off the southeastern United States; although other whales are also found there at this time, the whereabouts of a substantial portion of the population in winter remains unknown.

In the eastern North Atlantic, right whales are rarely observed today and the stock appears to be close to extinction. Historically, the species fed in northern European and Icelandic waters and was believed to have calved off the west coast of Africa (Reeves and Mitchell, 1986).

Female right whales are sexually mature between about 4 and perhaps 12 years of age, and produce a single calf on average every 3–4 years (Knowlton et al., 1994); this is a significantly slower rate of reproduction than that of the rorquals (Lockyer, 1984). The right whale is



Atlantic spotted dolphin.

stenophagous on zooplankton, notably copepods (Mayo and Marx, 1989). Individual animals can be identified from photographs of the pattern of callosities on the head, and from prominent scarring (Kraus et al., 1986a).

The western North Atlantic population has been the subject of a long-term study since the 1970's, and much of its biology and behavior is reasonably well understood (see Kraus et al., 1986b; Kenney et al., 1994; Knowlton et al., 1994). Most of the population has been biopsy sampled, and genetic analyses are ongoing (Schaeff et al., 1993, 1997; Brown et al., 1994). There is no ongoing field research on this species in the eastern North Atlantic.

Population Size

Based upon photographs of identified individuals, studies indicate that the present western North Atlantic population numbers fewer than 300 animals (Knowlton et al., 1994). The size of the eastern North Atlantic stock is unknown, but is clearly extremely small. It is assumed that the census of identified whales in the western North Atlantic in 1992 represents a minimum population size estimate (295 individuals). The minimum size of the eastern stock, based on rare sightings, is assumed to be a handful of individuals (perhaps fewer than 20).

Current Population Size

No sustained growth is apparent despite six decades of protection, although the initial post-whaling size of this stock in 1935 is unknown.

Status of Stock

The northern right whale is critically endangered throughout its range (Brownell et al., 1986; Clapham et al., In press). Given the various problems described below, this species is arguably the most threatened of all baleen whales, and further conservation action is urgently required to avoid its extinction.

In the North Atlantic, the eastern stock appears to be essentially extinct; it is likely that much of the then-extant population was wiped out by Norwegian whaling at the turn of the century (Collett, 1909). Rare sightings are made of single individuals in European waters (Brown, 1986), but it is not clear whether these represent a tiny remnant population or individuals who have wandered in from the west. Nineteenth-century whaling occurred at Cintra Bay on the coast of West Africa (Reeves and Mitchell, 1986), raising the hope that this area may still be a breeding ground for any remaining eastern North Atlantic animals. A survey in this region in early 1996 failed to find a single whale, although survey conditions were extremely poor.

Analyses based upon photographs of identified individuals indicate that the present western North Atlantic population numbers fewer than 300 animals (Knowlton et al., 1994); given that the majority of the population appears to have been identified, this is likely to represent one of the more accurate estimates of abundance for any large whale.

Unfortunately, the right whale appears to suffer from anthropogenic mortalities more than any other. In the western North Atlantic, entanglement in fishing gear and ship strikes are known to have caused several right whale deaths in recent years, undoubtedly contributing to the apparent failure to recover. Kraus (1990) estimated mortality in the first 4 years of life at between 2% and 17%, with at least a third attributable to ship collisions and entanglement. Photographs of 118 identified individuals showed that 57% possessed scarring indicative of entanglement (Kraus, 1990). Sources of ship strikes are generally unknown, but are primarily large commercial vessels; regrettably, many of the right whale's major habitats in the western North Atlantic are adjacent to, or even straddle, major shipping lanes. Given this population's dependence upon nearshore habitat for much of its life cycle, intensive coastal development in this and other portions of the range poses additional threats to recovery.

Studies showing relatively low genetic diversity in the western North Atlantic population (Schaeff et al., 1993, 1997) suggest that inbreeding may be inhibiting recovery, but this is difficult to interpret without a knowledge of historic genetic structure. The latter topic is currently being investigated using DNA extracted from historic baleen samples (Rosenbaum et al., 1997, 1998).

This is a strategic stock. PBR was specified as the product of minimum population size (295), one-half the maximum productivity rate (0.02), and a recovery factor of 0.1 because this species is listed as endangered under the ESA. PBR for the northern right whale is therefore 0.4 whales. Over the past several years, known human-caused mortality has consistently exceeded PBR. This is a cause for concern, given the critically endangered status of the stock and its apparent failure to recover.

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Sea Turtles


USFWS

Nesting green turtles.

Unit 25

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INTRODUCTION

Sea turtles are highly migratory and widely distributed throughout the world's oceans. The six species found in U.S. waters are the loggerhead, Kemp's ridley, olive ridley, green, leatherback, and hawksbill. In the Pacific Ocean, all these species except the Kemp's ridley inhabit either the U.S. Exclusive Economic Zone (EEZ) or the high seas. Nesting populations of the green turtle and the hawskbill occur in the Hawaiian Archipelago and American Samoa. With rare exception, the loggerhead, leatherback, and olive ridley do not nest in U.S. Pacific states or territories. The loggerhead, Kemp's ridley, green, hawksbill and leatherback are commonly found in U.S. Atlantic waters, while the olive ridley inhabits South Atlantic Ocean waters. Significant nesting assemblages of the loggerhead, leatherback, green, and hawksbill are found in the southeastern United States and in the U.S. Caribbean. The current status of U.S. sea turtles, based on research conducted at major nesting beaches, is summarized in Table 25-1.

All six species of sea turtles found in the United States (7 species worldwide) are currently listed either as endangered or threatened under the Endangered Species Act (ESA). The Kemp's ridley, hawksbill, and leatherback are listed as endangered throughout their ranges. The loggerhead and olive ridley are listed as threatened. The green turtle is also listed as threatened, except the Florida nesting population and the Pacific Mexico breeding population, which are listed as endangered. The authority to protect and conserve sea turtles in the marine environment is vested in the National Marine Fisheries Service (NMFS), while the U.S. Fish and Wildlife Service (USFWS) has principal responsibility at the Federal level for protection of sea turtles on land (nesting beaches).

SPECIES AND STATUS

Atlantic Region

Historical data on the size of sea turtle populations are limited or nonexistent. Complicating the question of population size is the need for a long time-series of data to understand the population dynamics of these species which have complex life histories. Standardized surveys of selected nesting beaches were implemented in the United States in the late 1980's. These surveys, which count the number of nests laid per year, provide an indirect estimate of the adult female population and an indication of whether this population is declining, stable, or increasing.

In recent years, our knowledge of sea turtle biology has been enhanced by the use of tools to understand the genetic identity of different nesting assemblages. Three subpopulations of loggerheads have been identified in the southeastern United States, and a fourth nests along the Yucatán coast of Mexico. Adult and immature turtles from these four subpopulations mix with each other on the foraging grounds. Most loggerhead nesting occurs along Florida's east coast where the annual number of nests deposited has remained relatively stable (about 65,000 nests/year), with evidence of some increases in recent years. In contrast, nesting of the subpopulation north of Cape Canaveral, Florida, has continued to decline (about 6,700 nests/year), and little is known about the small subpopulation that nests in the Florida Panhandle (about 500 nests/year).

The Kemp's ridley inhabits coastal waters throughout the Mid- and southeast Atlantic and the Gulf of Mexico. The Kemp's ridley is unusual in that it nests almost exclusively along one stretch

Table 25-1

Status and trends of principal sea turtle nesting populations in the U.S. Atlantic and Pacific regions.

Region and species	Location of principal nesting populations	Historic number of females nesting annually	Current number of nesting females	Trend in nesting population	Status in U.S.
Atlantic region					
Loggerhead, northern subpopulation	Northern Florida–North Carolina	~7,800	3,700	Decreasing	T
Loggerhead, southern Florida subpopulation	Central Florida–southwest Florida	Unknown	40,000	Increasing	T
Loggerhead, Florida Panhandle subpopulation	Florida Panhandle	Unknown	350	Unknown	T
Green	Florida	Unknown	675	Increasing	T, E
Kemp's ridley	Mexico	~40,000	954	Increasing	E
Leatherback	Florida, U.S. Virgin Islands, Puerto Rico	Unknown	160	Stable	E
Hawksbill	U.S. Virgin Islands, Puerto Rico	Unknown	367	Unknown	E
Pacific region					
Loggerhead	Japan	Unknown	1,000	Stable	T
Green	Hawaii, Mexico	Unknown	1,000	Increasing	T
Olive ridley	Mexico, Costa Rica	Unknown	350,000	Increasing	T
Leatherback	Mexico, Costa Rica, Maylasia, Irian Jaya	Unknown	985	Decreasing	E
Hawksbill	Hawaii	Unknown	30–40	Stable	E

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of beach in the State of Tamaulipas on the Caribbean coast of Mexico. This single population underwent a dramatic decline since 1947, when, on a single day, 40,000 Kemp's ridleys were filmed coming ashore to nest. The population plummeted to fewer than 1,000 females nesting annually through the early 1980's. Today, under strict protection, the population appears to be in the earliest stages of recovery (Figure 25-1). The increase can be attributed to two primary factors — full protection of nesting turtles and their nests in Mexico and the requirement to use turtle excluder devices (TED's) in shrimp trawls both in the United States and Mexico.

The green turtle nesting population in the southeastern United States appears to be stable. Based on genetic information, subpopulations throughout the North and South Atlantic commingle on the foraging grounds, but only one population nests in the continental United States—along Florida's east coast. The annual number of nests fluctuates greatly, usually alternating between high and low years. In recent years, the number of nests deposited annually has ranged from less than 450 to over 3,800.

The leatherback is widely distributed in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. In the United States, the largest nesting assemblages of leatherbacks are found in the U.S. Virgin Islands, Puerto Rico, and Florida. Nesting data for these locations have been collected since the early 1980's and indicate that the annual number of nests is likely stable; however, information regarding the status of the entire leatherback population in the Atlantic is lacking.

The hawksbill is most commonly found in the Caribbean, but also regularly occurs in southern Florida and southern Texas. Within the continental United States, a small amount of nesting occurs in southern Florida. The largest nesting assemblages of hawksbills in the United States are found at Mona Island, Puerto Rico; Buck Island, U.S. Virgin Islands; and at other sites in the U.S. Virgin Islands and Puerto Rico. There is clear and convincing evidence that hawksbill populations in the Atlantic have been greatly depleted during the 20th century as a result of overharvest for trade in products made from their shell.

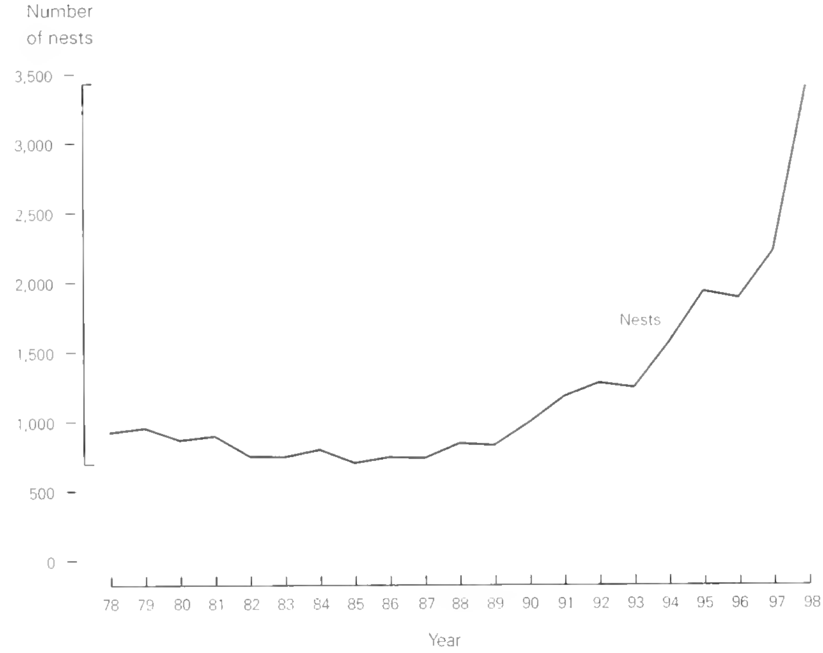

Figure 25-1
Number of Kemp's ridley nests observed annually at Rancho Nuevo, Tepehuajes, and Barra delTordo, Mexico, 1979–98 (Gladys Porter Zoo, 1997; R. Marquez M.[1], unpublished data).

Pacific Region

In the Pacific, most reproductive colonies of the olive ridley are in continental coastal areas and rarely on oceanic islands. Although large nesting assemblages of olive ridleys are found along the Pacific Coast of Mexico and Central America, there continues to be significant pressure on this population from harvest of eggs and incidental capture in trawl and longline fisheries.

Major North Pacific nesting populations of the loggerhead occurs in Japan and, in the South Pacific, in Australia. At different stages of their life cycle loggerheads occupy oceanic waters and coastal benthic habitats around continents. In the open ocean they are apt to be associated with convergence zones, oceanic fronts, and boundary currents. Loggerheads have been recorded in waters around the Northern Mariana Islands, American Samoa, and Hawaii but are uncommon there. The status of loggerhead populations in most areas of the Pacific is unknown due to a lack of historical data on their distribution and abundance. However, long-term data on nesting and foraging populations in Queensland, Australia, indicate that log-

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Olive ridley.

gerheads are declining in that area.

The leatherback is a pelagic species that probably occurs near all U.S. Pacific islands, is often sighted in U.S. west coast waters, and is widely distributed on the high seas. Principal leatherback nesting populations occur in the Solomon Islands, Irian Jaya, Papua New Guinea, Mexico, Costa Rica, and peninsular Malaysia. Leatherbacks are seriously declining at all major nesting beaches throughout the Pacific. The decline is dramatic along the Pacific Coasts of Mexico and Costa Rica and coastal Malaysia. Nesting along the Pacific Coast of Mexico declined at an annual rate of 22% over the last 12 years, and the Malaysian population represents 1% of the levels recorded in the 1950's. The collapse of these nesting populations was precipitated by a tremendous overharvest of eggs, direct harvest of adults, and incidental mortality from fishing.

The hawksbill is typically more insular than other sea turtles and is usually associated with coral reefs. Although not all U.S.-flag islands in the central-western Pacific have been surveyed, the hawksbill and the green turtle probably occur at most of them. The USFWS estimates that 30–40 hawksbills nest on the Main Hawaiian beaches each year, primarily along the east coast of the island of Hawaii. The number of hawksbills present in American Samoa and Guam is unknown, but nesting has been observed at Rose Atoll and the Manua Islands in American Samoa. The status of the hawksbill throughout the Pacific is unknown, but continued exploitation of hawksbills for their shells in areas outside the United States makes them a special conservation concern. The most important conservation achievement in recent years was Japan's decision to end the import of hawksbill shell. Further declines are possible if trade is renewed.

The green turtle is the most widely distributed sea turtle species in U.S. Pacific waters, particularly in Hawaii. A USFWS nesting survey found that in 1997 about 500 green turtles nested at East Island, a small, sandy islet at French Frigate Shoals in the Northwestern Hawaiian Islands, where about 50% of all Hawaii green turtle nesting is assumed to occur. The green turtle nesting population at East Island appears to have tripled since NMFS initiated the annual surveys in 1973 (Figure 25-2). The increase in Hawaiian green turtle nesting is attributed to a reduction of human-caused mortality after enactment of the ESA in 1974. The historic level of green turtle nesting in Hawaii is unknown. In American Samoa the primary nesting beach is at Rose Atoll where an estimated 25 to 35 females nest annually. The number of green turtles in Guam is unknown, and only sporadic nesting has been recorded there.

ISSUES

Bycatch and Fisheries Interactions

Sea turtles are threatened by multiple factors, most of which are human-related. A principal concern is incidental capture in commercial fisheries. Trawls, longline, and gillnet fisheries pose the greatest threats. Prior to the implementation of TED regulations, the National Academy of Sciences estimated that a maximum of 44,000 sea turtles, mostly loggerheads and Kemp's ridleys, were killed annually in the Gulf of Mexico and southeastern U.S. Atlantic shrimp fishery. While TED use is mandated for the shrimp fishery and some of the summer flounder trawl fishery, recent mortality events indicate that significant mortality is still occurring in some areas as a result of these or other trawl fisheries. Sea turtles are also taken and killed in pelagic longline, gillnet, and lobster trap lines. Of particular concern are the gillnet fisheries for coastal species, including sharks, and the longline and gillnet fisheries for swordfish, tuna, and sharks.

Propeller strikes and vessel collisions also pose significant threats to sea turtles, especially in areas of high human population, where recreational boat traffic is heavy and coastal ports are active.

Habitat Concerns

Coastal development can deter or interfere with nesting, affect nest success, and degrade foraging habitats for sea turtles. Nesting beaches of the southeastern United States and Hawaii are essential to the recovery and survival of sea turtles. Many nesting beaches have already been significantly degraded or destroyed. Nesting habitat is threatened by rigid shoreline protection or "coastal armoring" such as sea walls, rock revetments, and sandbag installations. Many miles of once productive nesting beach have been permanently lost to this type of shoreline protection. Additionally, nesting habitat can be negatively impacted by beach nourishment projects that result in altered beach and sand characteristics that affect nesting activity and nest success. Artificial beachfront lighting, increased human activity, and beach driving also seriously threaten species recovery. In light of these issues, conservation and long-term protection of sea turtle nesting habitats is an urgent and high priority need.

Marine Debris

Ingestion of marine debris can be a serious threat to sea turtles. When feeding, sea turtles can mistake debris for natural food items. An examination of the feeding habits of loggerhead hatchlings inhabiting offshore convergence zones revealed a high incidence of tar and plastic ingestion. Some types of marine debris may be directly or indirectly toxic, such as oil. Other types of marine debris, such as discarded or derelict fishing gear, may entangle and drown sea turtles.

Disease

A disease known as fibropapillomatosis (FP), originally identified in green turtles, but now affecting loggerheads and olive ridleys as well, has emerged as a serious threat to their recovery. The disease is most notably present in green turtles of Hawaii, Florida, and the Caribbean. FP is expressed as tumors which occur primarily on the skin and eyes, and the disease can be fatal. In Hawaii, green turtles afflicted with FP have a high incidence of tumors in the oral cavity, whereas oral tumors have not been found in Florida or other areas. The cause of the disease remains unknown. The disease has been systematically monitored in several locales in Hawaii. At a study site on southern Molokai, for example, where tumors were virtually unknown before 1988, the prevalence of tumored sea turtles ranged from 42 to 56% during the 1995–97 surveys. In Florida, up to 50% of the immature green turtles captured in the Indian River Lagoon are infected, and there are similar reports from other sites in Florida, including Florida Bay, as well as from Puerto Rico and the U.S. Virgin Islands. In Florida, the disease has been found to affect up to 13% of loggerheads inhabiting Florida Bay. FP appears to be the chief threat to full recovery of the Hawaii green turtle population, and the disease could hinder the recovery of green turtle populations elsewhere as well. Research to determine the cause of this disease is a high priority.

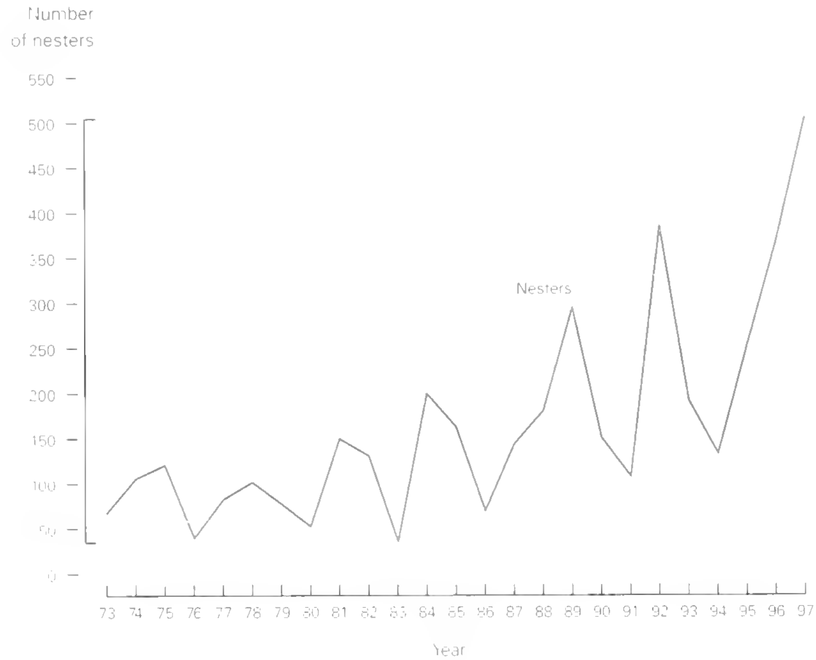

Figure 25-2
Population estimates for nesting green turtles on East Island.

Green turtle exhibiting fibropapillomatosis tumors.

Progress

In 1998, the NMFS and USFWS published recovery plans for five species of Pacific sea turtles and one distinct nesting population. Plans are underway to revise some of the U.S. Atlantic recovery plans which were completed in the early 1990's. These plans describe and prioritize the actions which are necessary to conserve and recover the species.

Significant progress is being made in the monitoring of Hawaiian green turtles by the NMFS and the USFWS. A 5-year series of saturation surveys, completed in 1992, led to the development of rigorous quantitative methods to estimate the nesting population. Progress is also being made in monitoring juvenile and subadult Hawaiian green turtles in their nearshore habitat. Significant progress has also been made in collaboration with Mexico and the USFWS to establish and maintain more comprehensive nesting beach surveys for Kemp's ridleys.

Progress has been made in the study of migratory movements of post-nesting sea turtles, to identify routes of travel and resident foraging grounds. NMFS scientists have conducted highly successful satellite telemetry studies with post-nesting Hawaiian and Florida green turtles and Florida loggerheads.

A multidisciplinary research program is underway to study the cause and effects of FP. Research has been initiated on the possible etiologies of the disease, including viruses, parasites, and environmental pollutants. Recent research has demonstrated the involvement of both a retrovirus and a herpesvirus. In addition to field and laboratory research, statistical analysis and modeling studies are underway to link FP incidence and severity to key aspects of green turtle population dynamics and assess impacts of the disease on population recovery.

In the Hawaii and Atlantic pelagic longline fisheries for tuna and swordfish, the incidental take of sea turtles is being monitored through a logbook and observer program. Workshops have been held to formulate research techniques to assess the population level effects of hooking and entanglement and to identify ways to reduce or mitigate incidental capture. In related research, satellite transmitters have been deployed on sea turtles hooked incidentally in the longline fishery to track post-release movements to better understand the long-term effects of hooking. Linkages between sea turtle movements and oceanographic processes are also being studied. Computer simulation models are under development to better assess the impacts of the Hawaii-based longline fishery.

In the last decade considerable efforts have been expended to elucidate sea turtle management units through the use of genetic tools. There is a high degree of genetic structuring within ocean basins for all species except the leatherback. These genetically distinct management units arose as a result of genetic isolation facilitated by the species' natal homing. While the animals do appear to segregate when nesting, they commingle on the foraging grounds, sometimes thousands of miles away from their natal beach (where they hatched). The analyses of genetic material from turtles incidentally taken in various fisheries can tell us which populations are being impacted. The Hawaii-based longline fishery interacts with loggerheads from Japan, green turtles from Hawaii and Mexico, and leatherbacks from both the eastern Pacific (Mexico or Costa Rica) and the southwestern Pacific (Irian Jaya, Malaysia, or Solomon Islands). Analyses for olive ridleys are currently in progress. In the Atlantic, the longline fisheries of the eastern Atlantic and the Mediterranean interact with loggerheads from the western Atlantic (primarily United States). Loggerheads inhabiting foraging habitats along the east coast of the U.S. originate from the United States, Mexico, and Brazil. Green turtles in the same area come from Florida, the Caribbean, and the South Atlantic Ocean (east and west).

Progress has been made in our understanding of the life history of Kemp's ridleys, loggerheads, and green turtles at various study sites in Florida, North Carolina, and the northwestern Gulf of Mexico. A number of current studies are investigating the use and importance of these inshore and nearshore habitats. Critical habitat for the green turtle has been designated for the nearshore foraging grounds off Culebra, Puerto Rico, and for the hawksbill in Mona and Monita Islands. NMFS has conducted considerable research on the use of various kinds of tags to mark and identify sea turtles in order to collect important biological information during their life history such as growth, survival rates, and age of maturity.

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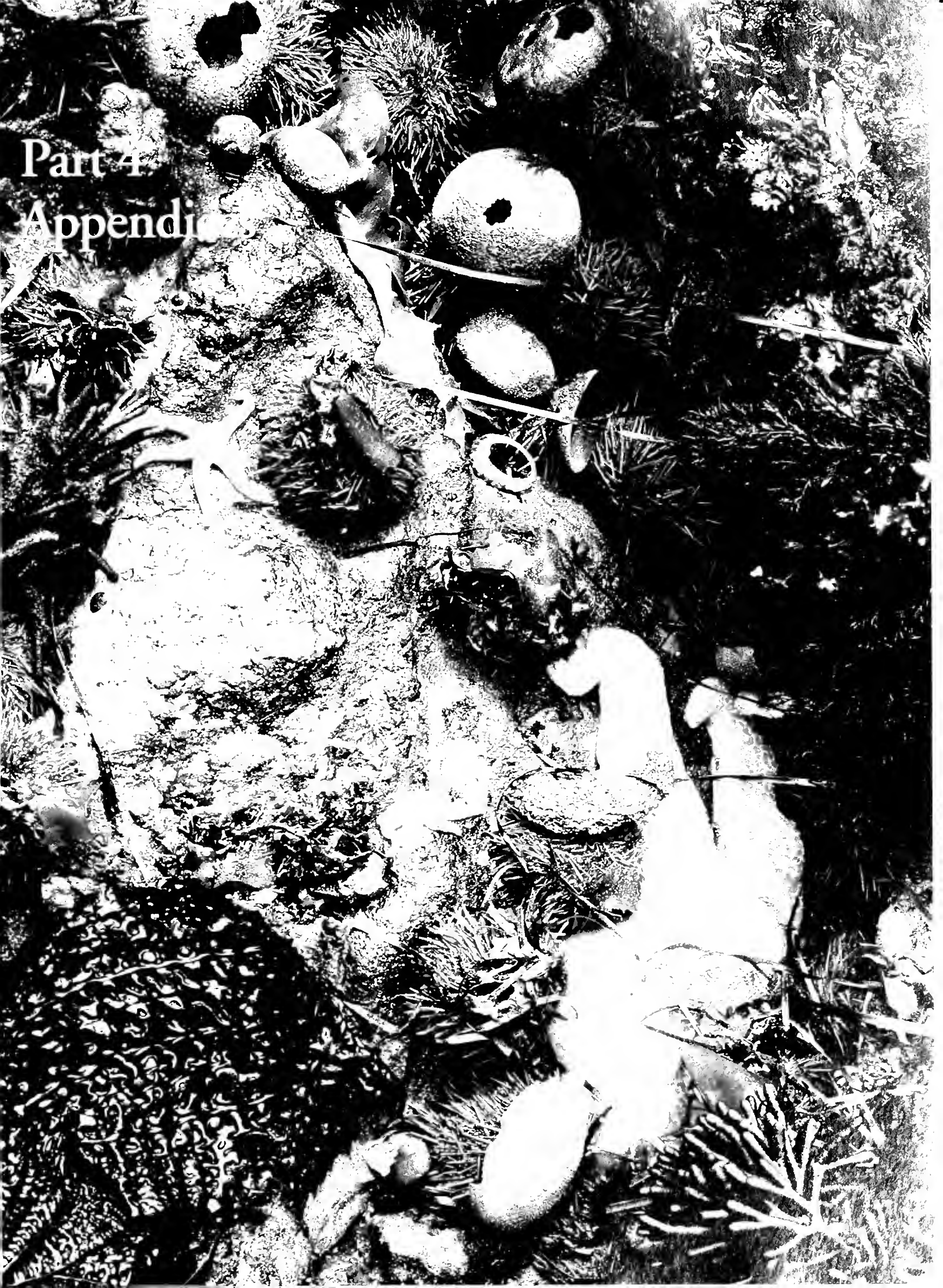
Part 4
Appendi



Previous page Intertidal zone at low tide, Puget Sound, Washington © Leo J Shaw, The Seattle Aquarium

Appendix 1: Acknowledgments

The National Marine Fisheries Service wishes to acknowledge the role of William W. Fox, Jr., Senior Scientist for Fisheries; the authors; and the following individuals for their contributions to this report:

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Unit 25—George H. Balazs and Jerry A. Wetherall, NMFS Southwest Fisheries Science Center, Honolulu, Hawaii; Therese Conant and Barbara Schroeder, NMFS Office of Protected Resources, Silver Spring, Maryland; and Sheryan E. Epperly, NMFS Southeast Fisheries Science Center, Miami, Florida.

Additional assistance provided by the following individuals and organizations:

Alaska Seafood Marketing Institute, Bellevue, Washington; Shelley E. Arenas, NMFS Scientific Publications Office, Seattle, Washington; Morris Barker, Washington Department of Fish and Wildlife, Olympia, Washington; John Blevins, NMFS Northeast Fisheries Science Center, Woods Hole, Massachusetts; James A. Bohnsack, NMFS Southeast Fisheries Science Center, Miami, Florida; William B. Brooks, Jr., U.S. Fish and Wildlife Service, Jacksonville, Florida; John L. Butler, NMFS Southwest Fisheries Science Center, La Jolla, California; Cara Campbell, NMFS Northwest Fisheries Science Center, Seattle, Washington; Alexander J. Chester, NMFS Southeast Fisheries Science Center, Miami, Florida; George Darcy, NMFS Office of Sustainable Fisheries, Silver Spring, Maryland; Sandra P. J. Davis, NMFS Scientific Publications Office, Seattle, Washington; William B. Folsom, NMFS Office of Science and Technology, Silver Spring, Maryland; Robert W. Hannah, Oregon Department of Fish and Wildlife, Newport, Oregon; Kevin Hill, California Department of Fish and Game, La Jolla, California; Ronald L. Hill, NMFS Office of Habitat Conservation, Silver Spring, Maryland; Rachel Husted, NMFS Office of Sustainable Fisheries, Silver Spring, Maryland; William G. Jacobson, NMFS Southwest Regional Office, Long Beach, California; Daniel K. Kimura, NMFS Alaska Fisheries Science Center, Seattle, Washington; Sari J. Kiraly, NMFS Office of Sustainable Fisheries, Silver Spring, Maryland; Cheri S. McCarty, NMFS Office of Sustainable Fisheries, Silver Spring, Maryland; Richard Methot, NMFS Northwest Fisheries Science Center, Seattle, Washington; John V. Merriner, NMFS Southeast Fisheries Science Center, Beaufort, North Carolina; Robert C. Morrill, NMFS Northeast Regional Office, Portland, Maine; Bruce C. Mundy, NMFS Southwest Fisheries Science Center, Honolulu, Hawaii; Sharon Newman, NMFS Office of Science and Technology, Silver Spring, Maryland; Joseph E. Powers, NMFS Southeast Fisheries Science Center, Miami, Florida; Phillip W. Rigby, Alaska Department of Fish and Game, Juneau, Alaska; Christopher Rogers, NMFS Office of Sustainable Fisheries, Silver Spring, Maryland; Greg Ruggerone, Natural Resources Consultants, Inc., Seattle, Washington; Gerald P. Scott, NMFS Southeast Fisheries Science Center, Miami, Florida; Tim D. Smith, NMFS Northeast Fisheries Science Center, Woods Hole, Massachusetts; Jacki A. Strader, NMFS Scientific Publications Office, Seattle, Washington; David L. Sutherland, NMFS Office of Science and Technology, Silver Spring, Maryland; The Seattle Aquarium, Seattle, Washington; Gary E. Walters, NMFS Alaska Fisheries Science Center, Seattle, Washington; and Ian K. Workman, NMFS Southeast Fisheries Science Center, Pascagoula, Mississippi.

Appendix 2: Fishery Management Councils, their Jurisdiction, and Fishery Management Plans

NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Suntaug Office Park
5 Broadway (Rt. 1)
Saugus, MA 01906
(781) 231-0422
http://www.nefmc.org

Jurisdiction

Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut

Fishery Management Plans

- American Lobster Fishery Management Plan
- Fishery Management Plan for the Northeast Multispecies Fishery
- Fishery Management Plan for Atlantic Sea Scallops
- Atlantic Salmon Fishery Management Plan
- Fishery Management Plan for Monkfish (Joint management with the Mid-Atlantic Fishery Management Council)

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Federal Building, Room 2115
300 S. New Street
Dover, DE 19904-6790
(302) 674-2331
http://www.mafmc.org

Jurisdiction

New York, New Jersey, Delaware, Virginia, Pennsylvania, Maryland, North Carolina

Fishery Management Plans

- Fishery Management Plan for the Atlantic Mackerel, Squid, and Butterfish Fisheries
- Fishery Management Plan for the Atlantic Surf Clam and Ocean Quahog Fisheries
- Fishery Management Plan for Atlantic Bluefish
- Fishery Management Plan for the Summer Flounder, Scup, and Black Sea Bass Fisheries
- Fishery Management Plan for Monkfish (Joint management with the New England Fishery Management Council)

SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL

One Southpark Circle, Suite 306
Charleston, SC 29407-4699
(843) 571-4366
http://www.safmc.nmfs.gov

Jurisdiction

North Carolina, South Carolina, Georgia, east coast of Florida

Fishery Management Plans

- Fishery Management Plan for the Spiny Lobster Fishery in the Gulf of Mexico and

South Atlantic (Joint management with the Gulf of Mexico Fishery Management Council)
- Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region
- Atlantic Coast Red Drum Fishery Management Plan
- Fishery Management Plan for Coastal Migratory Pelagic Resources in the Gulf of Mexico and South Atlantic (Joint management with the Gulf of Mexico Fishery Management Council)
- Fishery Management Plan for Coral, Coral Reefs, and Live/Hard Bottom Habitats of the South Atlantic Region
- Fishery Management Plan for the Shrimp Fishery of the South Atlantic Region
- Fishery Management Plan for the Golden Crab Fishery of the South Atlantic Region

GULF OF MEXICO FISHERY MANAGEMENT COUNCIL

The Commons at Rivergate
3018 U.S. Highway 301 North, Suite 1000
Tampa, FL 33619-2266
(813) 228-2815
(888) 833-1844 (toll free)
http://www.gulfcouncil.org

Jurisdiction

Texas, Louisiana, Mississippi, Alabama, west coast of Florida

Fishery Management Plans

- Fishery Management Plan for the Spiny Lobster Fishery in the Gulf of Mexico and South Atlantic (Joint management with the South Atlantic Fishery Management Council)
- Fishery Management Plan for Coastal Migratory Pelagic Resources in the Gulf of Mexico and South Atlantic (Joint management with the South Atlantic Fishery Management Council)
- Fishery Management Plan for Coral and Coral Reefs of the Gulf of Mexico
- Fishery Management Plan for the Stone Crab Fishery of the Gulf of Mexico
- Fishery Management Plan for the Shrimp Fishery of the Gulf of Mexico, U.S. waters
- Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico
- Fishery Management Plan for the Red Drum Fishery of the Gulf of Mexico

CARIBBEAN FISHERY MANAGEMENT COUNCIL

268 Munoz Rivera Avenue, Suite 1108
San Juan, PR 00918-2577
(809) 766-5926

Jurisdiction

Virgin Islands, Commonwealth of Puerto Rico

Fishery Management Plans

- Fishery Management Plan for the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands
- Fishery Management Plan for the Shallow-Water Reef Fish Fishery of Puerto Rico and the U.S. Virgin Islands
- Fishery Management Plan for Corals and Reef Associated Plants and Invertebrates of Puerto Rico and the U.S. Virgin Islands
- Fishery Management Plan for the Queen Conch Resources of Puerto Rico and the U.S. Virgin Islands

PACIFIC FISHERY MANAGEMENT COUNCIL

2130 SW 5th Avenue, Suite 224
Portland, OR 97201
(503) 326-6352
http://www.pcouncil.org

Jurisdiction

California, Washington, Oregon, Idaho

Fishery Management Plans

- Fishery Management Plan for the Groundfish Fishery off Washington, Oregon, and California
- Northern Anchovy Fishery Management Plan
- Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California

WESTERN PACIFIC FISHERY MANAGEMENT COUNCIL
1164 Bishop Street, Suite 1400
Honolulu, HI 96813
(808) 522-8220
http://www.wpcouncil.org

Jurisdiction
Hawaii, American Samoa, Guam, Northern Marianas Islands

Fishery Management Plans
- Fishery Management Plan for the Crustaceans Fisheries of the Western Pacific Region
- Fishery Management Plan for the Precious Corals Fishery of the Western Pacific Region
- Fishery Management Plan for the Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region
- Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region

NORTH PACIFIC FISHERY MANAGEMENT COUNCIL
605 W. 4th Avenue, Room 306
Anchorage, AK 99501-2252
(907) 271-2809
http://fakr.noaa.gov/npfmc

Jurisdiction
Alaska

Fishery Management Plans
- Fishery Management Plan for Groundfish of the Gulf of Alaska
- Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands Area
- Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska
- Fishery Management Plan for the Commercial King and Tanner Crab Fisheries in the Bering Sea/Aleutian Islands
- Fishery Management Plan for the Scallop Fishery off Alaska

OFFICE OF SUSTAINABLE FISHERIES HIGHLY MIGRATORY SPECIES DIVISION
1315 East-West Highway
Silver Spring, MD 20910
(301) 713-2347
http://www.nmfs.gov/sfweb/sfhome.html

Secretarial Plans
- Fishery Management Plan for Atlantic Tuna, Swordfish, and Sharks
- Fishery Management Plan for Atlantic Billfishes

Appendix 3: Principal Facilities of the National Marine Fisheries Service

OFFICE OF THE ASSISTANT ADMINISTRATOR FOR FISHERIES

National Marine Fisheries Service, NOAA
1315 East-West Highway
Silver Spring, MD 20910
(301) 713-2239
http://www.nmfs.gov/

REGIONAL OFFICES AND FISHERY SCIENCE CENTERS

Northeast Regional Office

One Blackburn Drive
Gloucester, MA 01930
(978) 281-9300
http://www.wh.whoi.edu/ro/doc/nero.html

Northeast Fisheries Science Center

166 Water Street
Woods Hole, MA 02543-1026
(508) 495-2000
http://www.wh.whoi.edu

Woods Hole Laboratory

166 Water Street
Woods Hole, MA 02543-1026
(508) 495-2000
http://www.wh.whoi.edu/noaa.html

Narragansett Laboratory

28 Tarzwell Drive
Narragansett, RI 02882-1199
(401) 782-3200
http://www.wh.whoi.edu/nefsc/nefsccenter.html

Milford Laboratory

212 Rogers Avenue
Milford, CT 06460-6499
(203) 579-7000
http://www.mi.nmfs.gov

James J. Howard Marine Sciences Laboratory

74 Magruder Road, Sandy Hook
Highlands, NJ 07732
(732) 872-3000
http://www.sh.nmfs.gov

National Systematics Laboratory

National Museum of Natural History
Room WC-57
10th & Constitution Avenue, N.W.
Washington, DC 20560-0001
(202) 357-2550
http://www.wh.whoi.edu/labs/systematic.html

Southeast Regional Office

9721 Executive Center Drive N., Suite 201
St. Petersburg, FL 33702-2432
(727) 570-5301
http://caldera.sero.nmfs.gov

Southeast Fisheries Science Center

75 Virginia Beach Drive
Miami, FL 33149-1003
(305) 361-4284
http://www.sefsc.noaa.gov/

Miami Laboratory

75 Virginia Beach Drive
Miami, FL 33149-1003
(305) 361-4200
http://www.sefsc.noaa.gov/public/mia.html

Mississippi Laboratories

3209 Frederic Street
Pascagoula, MS 39567
(228) 762-4591
http://www.sefsc.noaa.gov/public/mis.html

Panama City Laboratory

3500 Delwood Beach Road
Panama City, FL 32408-7499
(850) 234-6541
http://bio.fsu.edu/ ifre/

Galveston Laboratory

4700 Avenue U
Galveston, TX 77551-5997
(409) 766-3500
http:/galveston.ssp.nmfs.gov/galv/

Beaufort Laboratory

101 Pivers Island Road
Beaufort, NC 28516-9722
(252) 728-3595
http://www.sefsc.noaa.gov/public/bea.html

Southwest Regional Office

501 W. Ocean Boulevard, Suite 4200
Long Beach, CA 90802-4213
(562) 980-4000
http://swr.ucsd.edu/

Southwest Fisheries Science Center

P.O. Box 271 (mail)
La Jolla, CA 92038-0271
8604 La Jolla Shores Drive
La Jolla, CA 92037
(619) 546-7000
http://swfsc.ucsd.edu/

La Jolla Laboratory

8604 La Jolla Shores Drive
La Jolla, CA 92037
(619) 546-7000
http://swfsc.ucsd.edu/swfsclj.html

Honolulu Laboratory

2570 Dole Street
Honolulu, HI 96822-2396
(808) 983-5300
http://swfsc.ucsd.edu/swfschn.html

Santa Cruz/Tiburon Laboratory

3150 Paradise Drive
Tiburon, CA 94920-1211
(415) 435-3149
http://swfsc.ucsd.edu/swfsctb.html

Pacific Fisheries Environmental Laboratory

1352 Lighthouse Avenue
Pacific Grove, CA 93950-2097
(831) 648-8515
http://swfsc.ucsd.edu/swfscpg.html

Northwest Regional Office

7600 Sand Point Way N.E.
BIN C15700, Building 1
Seattle, WA 98115-0070
(206) 526-6150
http://www.nwr.noaa.gov/

Northwest Fisheries Science Center

2725 Montlake Boulevard E.
Seattle, WA 98112-2097
(206) 860-3200
http://research.nwfsc.noaa.gov/nwfsc-homepage.html

Hatfield Marine Sciences Laboratory

2030 Marine Sciences Drive
Newport, OR 97365
(541) 867-0143
http://www.nwfsc-hc.noaa.gov/hatindx.htm

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Fishery Industrial Technology Center
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Kodiak, AK 99615
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Seattle, WA 98115-0070
(206) 526-4000
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Seattle Laboratory

7600 Sand Point Way N.E.
BIN C15700, Building 4
Seattle, WA 98115-0070
(206) 526-4000

National Marine Mammal Laboratory

7600 Sand Point Way N.E.
BIN C15700, Building 4
Seattle, WA 98115-0070
(206) 526-4045
http://nmml.afsc.noaa.gov/

Auke Bay Laboratory

11305 Glacier Highway
Auke Bay, AK 99801-6094
(907) 789-6000
http://www.afsc.noaa.gov/abl/

Kodiak Laboratory

P.O. Box 1638
301 Research Court
Kodiak, AK 99615
(907) 481-1700
http://www.afsc.noaa.gov/kodiak/

Appendix 4: Stock Assessment Principles and Terms

Much of the information in this report comes from the scientific analysis of fisheries data to develop stock assessments. **Stock assessment** includes an estimation of the amount or abundance of the resource, an estimation of the rate at which it is being removed due to harvesting and other causes, and one or more **reference levels** of harvesting rate and/or abundance at which the stock can maintain itself in the long term. Such assessments often contain short-term (1–5 years, typically) projections or prognoses for the stock under a number of different scenarios. This information on resource status is used by managers to determine what actions are needed to promote the best use of our living marine resources.

Stock assessment analyses rely on various sources of information to estimate resource abundance and population trends. The principal information comes from the commercial and recreational fisheries. For example, the quantity of fish caught, the individual sizes of the fish and their biological characteristics (e.g. age, maturity, and sex), and the ratio of fish caught to the time spent fishing (catch per unit of effort) are basic data for stock assessments. In addition, the National Marine Fisheries Service (NMFS) conducts resource surveys with specialized fishery research vessels or chartered fishing vessels. These surveys, often conducted in cooperation with state marine resource agencies, universities, the fishing industry, international scientific organizations, and fisheries agencies of other nations, produce estimates of resource abundance.

Resource surveys are conducted differently from commercial fishing. Commercial operations seek out the greatest aggregations of fish and target on them to obtain the largest or most valuable catch. Fishery research vessels operate in a standardized manner, over a wide range of locations and within waters inhabited by the stocks, to provide unbiased population abundance and distribution indices year after year. The survey results are then used with commercial and recreational catch data to assess the resource base. The final critical data comes from studies on the basic biology of the animals themselves. Understanding the natural history of the harvested species and the other species with which they interact is crucial to understanding the population dynamics of living marine resources.

Fish abundance or population size can be expressed as either the number of fish or the total fish weight (or biomass). Increases in the amount of fish are determined by body growth of individual fish in the population, and the addition or **recruitment** of new generations of young fish (i.e. **recruits**. recruits from the same year are said to comprise a **year class** (or **cohort**). Those gains must then be balanced against the proportion of the population removed by harvesting (called **fishing mortality, F**) and other losses due, for example, to predation, starvation, or disease (called **natural mortality, M**). In stock assessment work, removals of fish from the population are commonly expressed in terms of rates within a time period. The **fishing mortality rate** is a function of **fishing ef-**

fort, which includes the amount, type, and effectiveness of fishing gear and the time spent fishing. **Catch per unit of effort (CPUE)** is an index showing the ratio of a catch of fish, in numbers or in weight, and a standard measure of the fishing effort expended to catch them. Intermittent high fishing effort is termed **pulse fishing**.

Surplus production (or **production**) is the total weight of fish that can be removed by fishing without changing the size of the population. It is calculated as the sum of the growth in weight of individuals in a population, plus the addition of biomass from new recruits, minus the biomass of animals lost to natural mortality.

The **production rate** is expressed as a proportion of the population size or biomass. The production rate can be highly variable owing to environmental fluctuations, predation and other biological interactions with other populations. On average, production decreases at low and high population sizes, and biomass decreases as the amount of fishing effort increases. This means there is a relationship between average production and fishing effort. This relationship is known as the production function.

Production functions are the basis for certain important concepts used in this report: **long-term potential yield**, **current potential yield**, and **recent average yield**. In addition, the term **stock-level** is employed as a biological reference for determining resource status relative to the level which would on average support the long-term potential yield. Recent average yield also is reported in order to allow comparison of the current situation to long-term potential.

Many other **reference levels** are used as benchmarks for guiding management decisions. A number of these are expressed as **fishing mortality rate** levels that would achieve specific results from the average recruit to the fishery if the stock were subjected to fishing at those rates indefinitely. Some of these benchmarks are used to index potential fishery production, and others are used to index potential reproductive output. $\mathbf{F_{max}}$ is the fishing mortality rate that maximizes the yield obtained from the average recruit. **Growth overfishing** occurs over the range of fishing mortality, at which the losses in weight from total mortality exceed the gain in weight due to growth. This range is defined as beyond F_{max}. $\mathbf{F_{0.1}}$ is a rate that results in almost as much yield per recruit as F_{max} does, but can be much lower—and thus more conservative—than F_{max} (at $F_{0.1}$, only a 10% increase in yield per recruit occurs following an additional unit of fishing effort compared to the yield per recruit produced by the first unit of effort on the unexploited stock). Benchmarks used to measure reproductive potential usually express an amount of spawning output relative to the amount expected under no fishing. For example, $\mathbf{F_{20\%}}$ and $\mathbf{F_{30\%}}$ are the rates that would reduce spawning biomass per recruit to 20 or 30% of the unfished level, respectively. This percentage of the unfished level is also known as the **spawning potential ratio (SPR)**.

Long-term potential yield (LTPY)

LTPY is the maximum long-term average yield that can be achieved through conscientious stewardship, by controlling **F** through regulating fishing effort or total catch levels. LTPY is a reference point for judging the potential of the resource. However, it is not necessarily the goal of fishery managers to always set the maximum yield. Other factors influence the choice of a management objective, such as socioeconomic considerations or conservation and ecosystem concerns for other marine life indirectly affected by fishery harvests. The methods of estimating LTPY, and LTPY itself, may be controversial. Nevertheless, NMFS scientists have used their best professional judgment to provide these figures as a gauge of long-term production potential whenever possible.

Current potential yield (CPY)

CPY, the current potential catch that can be safely taken, depends on the current abundance of fish and population dynamics of the stock. It is usually estimated by applying the **F** associated with LTPY (e.g. target fishing effort) to the current population size. This yield may be either greater than or less than LTPY. CPY is the amount of catch that will maintain the present population level (biomass) or, for overutilized stocks, stimulate a trend toward recovery to a population size that will produce the LTPY. For stocks at high biomass levels, the CPY may be larger than the LTPY.

In this circumstance a large fishery harvest would not be sustainable in the long run, but it would bring the stock down to the level supporting LTPY.

Recent average yield (RAY)

RAY is equivalent to recent average catch. Unless designated otherwise, RAY is the reported fishery landings averaged for the most recent three-year period, 1995–97.

Stock-level relative to LTPY

To further clarify resource status, stock level (i.e. abundance) in the most recent year is compared with the level of abundance that on average would support the LTPY harvest. This is expressed as being **below**, **near**, **above** or **unknown** relative to the LTPY stock level. In some cases, heavy fishing in the past reduced a stock to a low abundance, and even if the stock currently is harvested only lightly, it may take many years for it to rebuild.

Status of resource utilization

In this report, a resource is classified as **underutilized**, **fully utilized**, **overutilized**, or **unknown** as a qualitative measure of the level of fishery use. This is derived by comparing the present levels of fishing effort and stock abundance to those levels necessary to achieve LTPY.

A fishery resource is defined as **fully utilized** when the amount of fishing effort used is about equal to the amount needed to achieve LTPY and where the resource is near its LTPY stock level. For fully utilized fisheries, the RAY and CPY are usually about equal. In most cases, LTPY and CPY are also about equal, but they may differ as a result of production variability.

A fishery resource is considered **overutilized** when more fishing effort is employed than is necessary to achieve LTPY. When RAY is greater than CPY, and CPY is less than LTPY, overutilization is indicated. If stock abundance is near the level that on average produces LTPY, RAY may be greater than LTPY for an overutilized stock, implying that recent landing levels cannot be sustained. If stock abundance is below the level associated with LTPY, RAY will likely be less than LTPY.

Additionally, it is possible for RAY, CPY, and LTPY to be about equal while the fishery resource is overutilized. This occurs when reducing fishing effort would have little effect on the amount of catch realized. In such cases, overutilization may not have an apparent adverse effect on production, but it further reduces the size of the population, it wastes effort and economic resources, and imposes other deleterious consequences (e.g. excessive bycatch and gear interactions).

A fishery resource is classified as **underutilized** when more fishing effort is required to achieve LTPY. This situation is generally indicated when RAY is less than CPY and CPY is greater than LTPY while stock level is above the reference level that on average produces LTPY. But there may be exceptions. For example, RAY may be held below CPY and LTPY by management to compensate for uncertainty in population estimates and ecosystem considerations.

Classification of stock and fishery status

The utilization level and stock-level relative to LTPY are the major factors NMFS considers for determining the status of a stock for *Our Living Oceans*, but they may not always give a complete picture or one that is consistent with legal classifications.

It is important to note the differences between this classification system and the classification systems based on requirements for overfishing definitions or status determination criteria in fishery management plans (FMP's). In 1989, NMFS published revised guidelines addressing National Standards 1 and 2 of the 1976 Magnuson Fishery Conservation and Management Act, as amended (Magnuson Act). Among other things, the intent of the guidelines was to prevent recruitment overfishing and to have a conservation standard for each fishery such that stocks were not driven to, or maintained at, the threshold of overfishing. The guidelines defined overfishing as a level or rate of fishing mortality that jeopardizes the long-term capacity of a stock or stock-complex to produce **maximum sustainable yield (MSY)** on a continuing basis. Each FMP was required to specify, to the maximum extent possible, an objective and measurable definition of overfishing for each stock or stock complex covered by that FMP, and to provide an explanation of how the definition was determined and how it relates to reproductive potential. Overfishing could be expressed in terms of a minimum level of spawning biomass, maximum level or rate of fishing mortality, or other acceptable measurable standard. If data indicated that an overfished condition existed, a program must be established for rebuilding the stock over a period of time specified by the fishery management councils (FMC's) and acceptable to the Secretary of Commerce.

Over the period 1989–96, NMFS and the FMC's used the 1989 guidelines as a basis for developing, refining, and evaluating definitions of overfishing based on **recruitment overfishing** thresholds. There was considerable variation in the overfishing definitions developed and accepted, due to the flexibility afforded by the guidelines. Subsequently, in late 1996, the Magnuson Act was reauthorized as the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) with several changes that required a rethinking of the basis for defining overfishing. In particular, the MSFCMA required MSY itself to be the upper limit on the allowable amount or rate of fishing. NMFS responded by producing new guidelines that were finalized in mid 1998. The new guidelines require the specification of **status determination criteria**, which include both a maximum fishing mortality rate (beyond which **overfishing** is deemed to be occurring) and a minimum stock size threshold (below which the stock is deemed to be **overfished**). Both criteria must be associated with MSY-based reference points. The MSFCMA and the new guidelines have considerably reduced the amount of flexibility allowed in defining overfishing, and require a much greater degree of conservatism in the biological reference points used to delimit overfishing.

At the present time, most FMP's still contain definitions of overfishing that are based on the previous (more flexible) guidelines, although new definitions based on the new (less flexible and more conservative) guidelines are in the process of being developed and evaluated. Thus an analysis of stock status based on the overfishing definitions or status determination criteria contained in FMP's would not be consistent between stocks due to the widely differing degrees of conservatism embodied in the various definitions.

In summary, **overfished** (as defined in FMP's) is not equivalent to **overutilized** (as defined in OLO), and therefore, there will not be a one-to-one correspondence between the classifications. It should also be noted that NMFS's annual Report to Congress on the status of fisheries of the United States relies primarily on FMP definitions of overfishing and should therefore not be expected to give the same results for every stock as the OLO analysis. In the future, when all FMP's have incorporated status determination criteria based on the new guidelines, there may be greater correspondence between the FMP and OLO evaluations.

Economic value

In many of the fishery units, a dollar figure is given for the **ex-vessel revenue** generated by the commercial fishery on a given stock or group of stocks. Ex-vessel revenue is defined as the quantity of fish landed by commercial fishermen multiplied by the average price received by them at the first point of sale. As such, ex-vessel revenue captures the immediate value of the commercial harvest, but does not reflect multiplier effects of subsequent revenues generated by seafood processors, distributors, and retailers.

The estimate of economic value often takes both recreational and commercial catches and multiplies them by an average price to arrive at a baseline measure of economic worth among various user groups. It may underestimate those fisheries where there is a large recreational component. Nevertheless, the value serves as a useful gauge of relative potential revenues generated over many disparate stocks, fisheries, and regions.

Marine Mammal and Sea Turtle Assessments

The same scientific principles apply to the population dynamics of these protected species, but the terminology of underutilized, fully utilized, and overutilized does not apply. Instead, marine mammals are referred to as **depleted** when their population size is below the level of maximum net production. This is often referred to as their **optimum sustainable population (OSP)** level.

The Marine Mammal Protection Act (MMPA) defines OSP to mean "with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." For operational purposes, NMFS and the U.S. Fish and Wildlife Service (USFWS) have interpreted this definition to mean "a population size falling within a range from the population level of a given species or stock which is the largest supportable within the ecosystem to the population level that results in **maximum net productivity (MNP)**." Maximum net productivity is defined as "the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction or growth less loses due to natural mortality."

Potential biological removal (PBR) is the maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or stay at its optimum sustainable population level (50–100% of its carrying capacity. $\mathbf{N_{min}}$ is a conservative estimate of abundance used to estimate PBR and provides reasonable assurance that the stock size is equal to or greater than the estimate.

Protected species of marine mammals and sea turtles may also be classified as **threatened** or **endangered** under the Endangered Species Act. A species is considered threatened if it is likely to become an endangered species in the foreseeable future throughout a significant portion of its range. A species is considered endangered if it is in danger of extinction throughout a significant portion of its range. In addition to some marine mammals and all sea turtles, several Pacific Coast salmon stocks are now listed as threatened or endangered.

Appendix 5: Common and Scientific Names of Species

The following is a listing of common and scientific names of fish, shellfish, marine mammals, and sea turtles. This listing is included for reference purposes only and is not all-inclusive.

Unit 1: Northeast Demersal Fisheries

Principal groundfish
- Atlantic cod, *Gadus morhua*
- Silver hake, *Merluccius bilinearis*
- Pollock, *Pollachius virens*
- Summer flounder, *Paralichthys dentatus*
- Winter flounder, *Pleuronectes americanus*
- American plaice, *Hippoglossoides platessoides*
- Haddock, *Melanogrammus aeglefinus*
- Yellowtail flounder, *Pleuronectes ferrugineus*
- Witch flounder, *Glyptocephalus cynoglossus*
- Red hake, *Urophycis chuss*
- Windowpane, *Scophthalmus aquosus*
- Redfish, *Sebastes* spp.

Skates and spiny dogfish
- Spiny dogfish, *Squalus acanthias*
- Little skate, *Raja erinacea*
- Winter skate, *Raja ocellata*
- Barndoor skate, *Raja laevis*
- Thorny skate, *Raja radiata*
- Clearnose (Briar) skate, *Raja eglanteria*
- Rosette skate, *Raja garmani*
- Smooth skate, *Raja senta*

Other finfish
- Goosefish, *Lophius americanus*
- Weakfish, *Cynoscion regalis*
- White hake, *Urophycis tenuis*
- Black sea bass, *Centropristis striata*
- Scup, *Stenotomus chrysops*
- Spot, *Leiostomus xanthurus*
- Tilefish, *Lopholatilus chamaeleonticeps*
- Cusk, *Brosme brosme*
- Wolffishes, *Anarhichas* spp.
- Ocean pout, *Macrozoarces americanus*
- Atlantic halibut, *Hippoglossus hippoglossus*

Unit 2: Northeast Pelagic Fisheries

Atlantic herring, *Clupea harengus*
Atlantic mackerel, *Scomber scombrus*
Bluefish, *Pomatomus saltatrix*
Butterfish, *Peprilus triacanthus*

Unit 3: Atlantic Anadromous Fisheries

Striped bass, *Morone saxatilis*
American shad, *Alosa sapidissima*
Alewife, *Alosa pseudoharengus*
Blueback herring, *Alosa aestivalis*
Atlantic sturgeon, *Acipenser oxyrhynchus*
Shortnose sturgeon, *Acipenser brevirostrum*
Atlantic salmon, *Salmo salar*

Unit 4: Northeast Invertebrate Fisheries

American lobster, *Homarus americanus*
Atlantic surfclam, *Spisula solidissima*
Ocean quahog, *Arctica islandica*
Longfin inshore squid, *Loligo pealeii*
Northern shortfin squid, *Illex illecebrosus*
Sea scallop, *Placopecten magellanicus*
Northern shrimp, *Pandalus borealis*
Red crab, *Chaceon quinquedens*

Unit 5: Atlantic Highly Migratory Pelagic Fisheries

Yellowfin tuna, *Thunnus albacares*
Bigeye tuna, *Thunnus obesus*
Albacore, *Thunnus alalunga*
Skipjack tuna, *Katsuwonus pelamis*
Bluefin tuna, *Thunnus thynnus*
Other tunas
  Blackfin tuna, *Thunnus atlanticus*
  Little tunny, *Euthynnus alletteratus*
  Atlantic bonito, *sarda sarda*
  Wahoo, *Acanthocybium solandri*
  Bullet mackerel, *Auxis rochei*
  Frigate mackerel, *Auxis thazard*
Swordfish, *Xiphias gladius*
Billfishes
  Blue marlin, *Makaira nigricans*
  White marlin, *Tetrapturus albidus*
  Sailfish, *Istiophorus platypterus*

Unit 6: Atlantic Sharks

Large coastal sharks
  Sandbar shark, *Carcharhinus plumbeus*
  Reef shark, *Carcharhinus perezi*
  Blacktip shark, *Carcharhinus limbatus*
  Dusky shark, *Carcharhinus obscurus*
  Spinner shark, *Carcharhinus brevipinna*
  Silky shark, *Carcharhinus falciformis*
  Bull shark, *Carcharhinus leucas*
  Bignose shark, *Carcharhinus altimus*
  Galapagos shark, *Carcharhinus galapagensis*
  Night shark, *Carcharhinus signatus*
  Tiger shark, *Galeocerdo cuvier*
  Lemon shark, *Negaprion brevirostris*
  Nurse shark, *Ginglymostoma cirratum*
  Narrowtooth shark, *Carcharhinus brachyurus*
  Scalloped hammerhead, *Sphyrna lewini*
  Smooth hammerhead, *Sphyrna zygaena*
  Great hammerhead, *Sphyrna mokarran*
Small coastal sharks
  Atlantic sharpnose shark, *Rhizoprionodon terraenovae*
  Caribbean sharpnose shark, *Rhizoprionodon porosus*
  Finetooth shark, *Carcharhinus isodon*
  Blacknose shark, *Carcharhinus acronotus*
  Bonnethead, *Sphyrna tiburo*
  Atlantic angel shark, *Squatina dumeril*
  Smalltail shark, *Carcharhinus porosus*
Pelagic sharks
  Longfin mako, *Isurus paucus*
  Shortfin mako, *Isurus oxyrinchus*
  Blue shark, *Prionace glauca*
  Porbeagle, *Lamna nasus*
  Thresher shark, *Alopias vulpinus*
  Bigeye thresher, *Alopias superciliosus*
  Oceanic whitetip shark, *Carcharhinus longimanus*
  Sevengill shark, *Heptranchias perlo*
  Sixgill shark, *Hexanchus griseus*
  Bigeye sixgill shark, *Hexanchus vitulus*

Unit 7: Atlantic and Gulf of Mexico Coastal Migratory Pelagic Fisheries

Dolphinfish, *Coryphaena hippurus*
King mackerel (Atlantic and Gulf), *Scomberomorus cavalla*
Spanish mackerel (Atlantic and Gulf), *Scomberomorus maculatus*
Cobia, *Rachycentron canadum*
Cero (mackerel), *Scomberomorus regalis*

Unit 8: Atlantic, Gulf of Mexico, and Caribbean Reef Fish Fisheries

Gulf of Mexico

Red snapper, *Lutjanus campechanus*
Red grouper, *Epinephelus morio*
Nassau grouper, *Epinephelus striatus*
Jewfish, *Epinephelus itajara*
Shallow groupers
  Gag, *Mycteroperca microlepis*
  Rock hind, *Epinephelus adscensionis*
  Speckled hind, *Epinephelus drummondhayi*
  Red hind, *Epinephelus guttatus*
  Black grouper, *Mycteroperca bonaci*
  Scamp, *Mycteroperca phenax*
  Yellowfin grouper, *Mycteroperca venenosa*
Other groupers
  Snowy grouper, *Epinephelus niveatus*
  Yellowedge grouper, *Epinephelus flavolimbatus*
  Yellowmouth grouper, *Mycteroperca interstitialis*
  Misty grouper, *Epinephelus mystacinus*
  Warsaw grouper, *Epinephelus nigritus*

Other snappers
- Vermilion snapper, *Rhomboplites aurorubens*
- Queen snapper, *Etelis oculatus*
- Mutton snapper, *Lutjanus analis*
- Schoolmaster, *Lutjanus apodus*
- Blackfin snapper, *Lutjanus buccanella*
- Cubera snapper, *Lutjanus cyanopterus*
- Mahogany snapper, *Lutjanus mahogoni*
- Lane snapper, *Lutjanus synagris*
- Dog snapper, *Lutjanus jocu*
- Silk snapper, *Lutjanus vivanus*
- Yellowtail snapper, *Ocyurus chrysurus*
- Grey (Mangrove) snapper, *Lutjanus griseus*
- Black snapper, *Apsilus dentatus*

Porgies
- Jolthead porgy, *Calamus bajonado*
- Longspine porgy, *Stenotomus caprinus*
- Red porgy, *Pagrus pagrus*
- Whitebone porgy, *Calamus leucosteus*
- Knobbed porgy, *Calamus nodosus*
- Littlehead porgy, *Calamus proridens*

Amberjacks
- Greater amberjack, *Seriola dumerili*
- Lesser amberjack, *Seriola fasciata*

Grunts
- White grunt, *Haemulon plumieri*
- Bluestriped grunt, *Haemulon sciurus*
- French grunt, *Haemulon flavolineatum*

Sea basses
- Black sea bass, *Centropristis striata*
- Rock sea bass, *Centropristis philadelphica*
- Bank sea bass, *Centropristis ocyurus*

Others
- Sheepshead, *Archosargus probatocephalus*
- Queen triggerfish, *Balistes vetula*
- Gray triggerfish, *Balistes capriscus*
- Ocean triggerfish, *Canthidermis sufflamen*
- Blueline (grey) tilefish, *Caulolatilus microps*
- Blackline tilefish, *Caulotilus cyanops*
- Tilefish (golden), *Lopholatilus chamaeleonticeps*
- Yellow goatfish, *Mulloidichthys martinicus*
- Blue runner, *Caranx crysos*
- Pigfish, *Orthopristis chrysoptera*
- Hogfish, *Lachnolaimus maximus*
- Queen angelfish, *Holacanthus ciliaris*
- Atlantic Spadefish, *Chaetodipterus faber*
- Great barracuda, *Sphyrena barracuda*

Atlantic

- Wreckfish, *Polyprion americanus*
- Vermilion snapper, *Rhomboplites aurorubens*
- Red snapper, *Lutjanus campechanus*
- Red porgy, *Pagrus pagrus*
- Nassau grouper, *Epinephelus striatus*
- Jewfish, *Epinephelus itajara*

Other groupers
- Red grouper, *Epinephelus morio*
- Gag, *Mycteroperca microlepis*
- Rock hind, *Epinephelus adscensionis*
- Speckled hind, *Epinephelus drummondhayi*
- Red hind, *Epinephelus guttatus*
- Black grouper, *Mycteroperca bonaci*
- Scamp, *Mycteroperca phenax*
- Yellowfin grouper, *Mycteroperca venenosa*
- Snowy grouper, *Epinephelus niveatus*
- Yellowedge grouper, *Epinephelus flavolimbatus*
- Yellowmouth grouper, *Mycteroperca interstitialis*
- Misty grouper, *Epinephelus mystacinus*
- Warsaw grouper, *Epinephelus nigritus*
- Coney, *Epinephelus fulvus*
- Graysby, *Epinephelus cruentatus*
- Creole-fish, *Paranthias furcifer*

Sea basses
- Black sea bass, *Centropristis striata*
- Rock sea bass, *Centropristis philadelphica*
- Bank sea bass, *Centropristis ocyurus*

Other snappers
- Queen snapper, *Etelis oculatus*
- Mutton snapper, *Lutjanus analis*
- Schoolmaster, *Lutjanus apodus*
- Blackfin snapper, *Lutjanus buccanella*
- Cubera snapper, *Lutjanus cyanopterus*
- Mahogany snapper, *Lutjanus mahogoni*
- Lane snapper, *Lutjanus synagris*
- Silk snapper, *Lutjanus vivanus*
- Yellowtail snapper, *Ocyurus chrysurus*
- Grey (Mangrove) snapper, *Lutjanus griseus*
- Black snapper, *Apsilus dentatus*

Amberjacks
- Greater amberjack, *Seriola dumerili*
- Lesser amberjack, *Seriola fasciata*

Other porgies
- Jolthead porgy, *Calamus bajonado*
- Longspine porgy, *Stenotomus caprinus*
- Whitebone porgy, *Calamus leucosteus*

Knobbed porgy, *Calamus nodosus*
Littlehead porgy, *Calamus proridens*
Saucereye porgy, *Calamus calamus*
Spottail pinfish, *Diplodus holbrooki*
Scup, *Stenotomus chrysops*
Grunts
White grunt, *Haemulon plumieri*
Bluestriped grunt, *Haemulon sciurus*
French grunt, *Haemulon flavolineatum*
Margate, *Haemulon album*
Sailors choice, *Haemulon parra*
Tomtate, *Haemulon aurolineatum*
Porkfish, *Anisotremus virginicus*
Black margate, *Anisotremus surinamensis*
Spanish grunt, *Haemulon macrostomum*
Pigfish, *Orthopristus chrysoptera*
Smallmouth grunt, *Haemulon chrysargyreum*
Others
Sheepshead, *Archosargus probatocephalus*
Queen triggerfish, *Balistes vetula*
Gray triggerfish, *Balistes capriscus*
Ocean triggerfish, *Canthidermus sufflamen*
Blueline (grey) tilefish, *Caulolatilus microps*
Blackline tilefish, *Caulotilus cyanops*
Tilefish (golden), *Lopholatilus chamaeleonticeps*
Hogfish, *Lachnolaimus maximus*
Queen angelfish, *Holacanthus ciliaris*
Atlantic Spadefish, *Chaetodipterus faber*
Great barracuda, *Sphyrena barracuda*

Caribbean

Nassau grouper, *Epinephelus striatus*
Other groupers
Rock hind, *Epinephelus adscensionis*
Red hind, *Epinephelus guttatus*
Yellowfin grouper, *Mycteroperca venenosa*
Yellowmouth grouper, *Mycteroperca interstitialis*
Coney, *Epinephelus fulvus*
Graysby, *Epinephelus cruentatus*
Snappers
Vermilion snapper, *Rhomboplites aurorubens*
Queen snapper, *Etelis oculatus*
Mutton snapper, *Lutjanus analis*
Schoolmaster, *Lutjanus apodus*
Blackfin snapper, *Lutjanus buccanella*
Mahogany snapper, *Lutjanus mahogoni*
Lane snapper, *Lutjanus synagris*
Silk snapper, *Lutjanus vivanus*
Yellowtail snapper, *Ocyurus chrysurus*
Black snapper, *Apsilus dentatus*
Grunts
White grunt, *Haemulon plumieri*
Bluestriped grunt, *Haemulon sciurus*
French grunt, *Haemulon flavolineatum*
Margate, *Haemulon album*
Tomtate, *Haemulon aurolineatum*
Others
Greater amberjack, *Seriola dumerili*
Blue runner, *Caranx crysos*
Crevalle jack, *Caranx hippos*
Horse-eye jack, *Caranx latus*
Black jack, *Caranx lugubris*
Bar jack, *Caranx ruber*
Lookdown, *Selene vomer*
Bigeye scad, *Selar crumenophthalmus*
Yellow jack, *Caranx bartholomaei*
Sea bream, *Archosargus rhomboidalis*
Jolthead porgy, *Calamus bajonado*
Sheepshead porgy, *Calamus penna*
Yellow goatfish, *Mulloidichthys martinicus*
Spotted goatfish, *Pseudupeneus maculatus*
Spotfin butterflyfish, *Chaetodon ocellatus*
Foureye butterflyfish, *Chaetodon capistratus*
Atlantic Spadefish, *Chaetodipterus faber*
Queen angelfish, *Holacanthus ciliaris*
Rock beauty, *Holacanthus tricolor*
Gray angelfish, *Pomacanthus arcuatus*
French angelfish, *Pomacanthus paru*
Spanish hogfish, *Bodianus rufus*
Hogfish, *Lachnolaimus maximus*
Puddingwife, *Halichoeres radiatus*
Midnight parrotfish, *Scarus coelestinus*
Blue parrotfish, *Scarus coeruleus*
Striped parrotfish, *Scarus croicensis*
Rainbow parrotfish, *Scarus guacamaia*
Princess parrotfish, *Scarus taeniopterus*
Queen parrotfish, *Scarus vetula*
Redband parrotfish, *Sparisoma aurofrenatum*
Redtail parrotfish, *Sparisoma chrysopterum*
Redfin parrotfish, *Sparisoma rubripinne*
Stoplight parrotfish, *Sparisoma viride*
Ocean surgeonfish, *Acanthurus bahianus*
Doctorfish, *Acanthurus chirurgus*
Blue tang, *Acanthurus coeruleus*
Queen triggerfish, *Balistes vetula*
Ocean triggerfish, *Canthidermis sufflamen*
Black durgon, *Melichthys niger*

- Spotted trunkfish, *Lactophrys bicaudalis*
- Honeycomb cowfish, *Lactophrys polygonia*
- Scrawled cowfish, *Lactophrys quadricornis*
- Smooth trunkfish, *Lactophrys triqueter*
- Trunkfish, *Lactophrys trigonus*
- Squirrelfish, *Holocentrus adscensionis*
- Longspine squirrelfish, *Holocentrus rufus*
- Bigeye, *Priacanthus arenatus*
- Porkfish, *Anisotremus virginicus*
- Mutton Hamlet, *Epinephelus afer*

Unit 9: Southeast Drum and Croaker Fisheries

Black drum, *Pogonias cromis*
Atlantic croaker, *Micropogonias undulatus*
Spot, *Leiostomus xanthurus*
Red drum, *Sciaenops ocellatus*
Seatrouts
- Grey seatrout (weakfish), *Cynoscion regalis*
- Spotted seatrout, *Cynoscion nebulosus*
- Silver seatrout, *Cynoscion nothus*
- Sand seatrout, *Cynoscion arenarius*

Kingfishes
- Southern kingfish, *Menticirrhus americanus*
- Gulf kingfish, *Menticirrhus littoralis*
- Northern kingfish, *Menticirrhus saxatilis*

Unit 10: Southeast Menhaden Fisheries

Atlantic menhaden, *Brevoortia tyrannus*
Gulf menhaden, *Brevoortia patronus*

Unit 11: Southeast and Caribbean Invertebrate Fisheries

Shrimps
- Brown shrimp, *Penaeus aztecus*
- White shrimp, *Penaeus setiferus*
- Pink shrimp, *Penaeus duorarum*
- Royal red shrimp, *Pleoticus robustus*
- Seabob, *Xiphopenaeus kroyeri*
- Rock shrimp, *Sicyonia brevirostris*

Spiny lobster (Southeast and Caribbean), *Panulirus argus*
Spotted spiny lobster, *Panuliris guttatus*
Stone crab, *Menippe mercenaria*
Queen conch, *Strombus gigas*
Coral, Phylum Cnidaria

Units 12 and 13: Pacific Coast and Alaska Salmon

Chinook salmon, *Oncorhynchus tshawytscha*
Coho salmon, *Oncorhynchus kisutch*
Pink salmon, *Oncorhynchus gorbuscha*
Sockeye salmon, *Oncorhynchus nerka*
Chum salmon, *Oncorhynchus keta*

Unit 14: Pacific Coast and Alaska Pelagic Fisheries

Northern anchovy, *Engraulis mordax*
Pacific sardine, *Sardinops sagax*
Jack mackerel, *Trachurus symmetricus*
Chub (Pacific) mackerel, *Scomber japonicus*
Pacific herring, *Clupea pallasi*

Unit 15: Pacific Coast Groundfish Fisheries

Pacific hake (whiting), *Merluccius productus*
Sablefish (black cod), *Anoplopoma fimbria*
Lingcod, *Ophiodon elongatus*
Pacific cod, *Gadus macrocephalus*
Flatfishes
- Arrowtooth flounder, *Atheresthes stomias*
- Dover sole, *Microstomus pacificus*
- English sole, *Pleuronectes vetulus*
- Petrale sole, *Eopsetta jordani*

Other flatfishes
- Butter sole, *Pleuronectes isolepis*
- Curlfin sole, *Pleuronichthys decurrens*
- Flathead sole, *Hippoglossoides elassodon*
- Pacific sanddab, *Citharichthys sordidus*
- Rex sole, *Errex zachirus*
- Rock sole, *Pleuronectes bilineatus*
- Sand sole, *Psettichthys melanostictus*
- Starry flounder, *Platichthys stellatus*

Rockfishes
- Bocaccio, Sebastes *paucispinis*
- Canary rockfish, *Sebastes pinniger*
- Chilipepper, *Sebastes goodei*
- Pacific ocean perch, *Sebastes alutus*
- Shortbelly rockfish, *Sebastes jordani*
- Shortspine thornyhead, *Sebastolobus alascanus*
- Longspine thornyhead, *Sebastolobus altivelis*
- Yellowtail rockfish, *Sebastes flavidus*
- Widow rockfish, *Sebastes entomelas*

Other rockfishes
- Aurora rockfish, *Sebastes aurora*

Bank rockfish, *Sebastes rufus*
Black rockfish, *Sebastes melanops*
Black-and-yellow rockfish,
Sebastes chrysomelas
Blackgill rockfish, *Sebastes melanostomus*
Blue rockfish, *Sebastes mystinus*
Bronzespotted rockfish, *Sebastes gilli*
Brown rockfish, *Sebastes auriculatus*
Calico rockfish, *Sebastes dalli*
China rockfish, *Sebastes nebulosus*
Copper rockfish, *Sebastes caurinus*
Cowcod, *Sebastes levis*
Darkblotched rockfish, *Sebastes crameri*
Dusky rockfish, *Sebastes ciliatus*
Flag rockfish, *Sebastes rubrivinctus*
Gopher rockfish, *Sebastes carnatus*
Grass rockfish, *Sebastes rastrelliger*
Greenblotched rockfish, *Sebastes rosenblatti*
Greenspotted rockfish, *Sebastes chlorostictus*
Greenstriped rockfish, *Sebastes elongatus*
Harlequin rockfish, *Sebastes variegatus*
Honeycomb rockfish, *Sebastes umbrosus*
Kelp rockfish, *Sebastes atrovirens*
Mexican rockfish, *Sebastes macdonaldi*
Olive rockfish, *Sebastes serranoides*
Pink rockfish, *Sebastes eos*
Quillback rockfish, *Sebastes maliger*
Redbanded rockfish, *Sebastes babcocki*
Redstripe rockfish, *Sebastes proriger*
Rosethorn rockfish, *Sebastes helvomaculatus*
Rosy rockfish, *Sebastes rosaceus*
Rougheye rockfish, *Sebastes aleutianus*
Sharpchin rockfish, *Sebastes zacentrus*
Shortraker rockfish, *Sebastes borealis*
Silvergray rockfish, *Sebastes brevispinis*
Speckled rockfish, *Sebastes ovalis*
Splitnose rockfish, *Sebastes diploproa*
Squarespot rockfish, *Sebastes hopkinsi*
Starry rockfish, *Sebastes constellatus*
Stripetail rockfish, *Sebastes saxicola*
Tiger rockfish, *Sebastes nigrocinctus*
Treefish, *Sebastes serriceps*
Vermilion rockfish, *Sebastes miniatus*
Yelloweye rockfish, *Sebastes ruberrimus*
Yellowmouth rockfish, *Sebastes reedi*
Other groundfishes
Leopard shark, *Triakis semifasciata*
Soupfin shark, *Galeorhinus zyopterus*
Spiny dogfish, *Squalus acanthias*
Big skate, *Raja binoculata*
California skate, *Raja inornata*
Longnose skate, *Raja rhina*
Spotted ratfish, *Hydrolagus colliei*
Pacific flatnose, *Antimora microlepis*
Pacific (rattail) Grenadier,
Coryphaenoides acrolepis
Cabezon, *Scorpaenichthys marmoratus*
Kelp greenling, *Hexagrammos decagrammus*
California scorpionfish, *Scorpaena guttata*

Unit 16: Western Pacific Invertebrate Fisheries

Spiny lobster (Ula), *Panulirus marginatus*
Slipper lobster (Ulapapa),
Scyllarides squammosus

Unit 17: Western Pacific Bottomfish and Armorhead Fisheries

Bottomfishes
Silverjaw jobfish (lehi), *Aphareus rutilans*
Gray jobfish (uku), *Aprion virescens*
Squirrelfish snapper (ehu), *Etelis carbunculus*
Ruby (Long-tail) snapper (onaga),
Etelis coruscans
Bluestripe snapper (taape), *Lutjanus kasmira*
Yellowtail snapper (yellowtail kalekale),
Pristipomoides auricilla
Crimson snapper (opakapaka),
Pristipomoides filamentosus
Yelloweye snapper (yelloweye opakapaka),
Pristipomoides flavipinnis
Pink snapper, (kalekale),
Pristipomoides sieboldii
Small-scaled snapper (Opakapaka),
Pristipomoides microlepis
Giant trevally (white ulua), *Caranx ignobilis*
Black jack, (black ulua), *Caranx lugubris*
Thick lipped trevally, (butaguchi),
Pseudocaranx dentex
Greater amberjack, (kahala), *Seriola dumerili*
Blacktip grouper, *Epinephelus fasciatus*
Grouper (hapu upu u), *Epinephelus quernus*
Lunartail grouper, *Variola louti*
Ambon emperor, *Lethrinus amboinensis*
Redgill emperor, *Lethrinus rubrioperculatus*
Seamount fishes
Pelagic armorhead, *Pseudopentaceros wheeleri*

Unit 18: Pacific Highly Migratory Pelagic Fisheries

Yellowfin tuna, *Thunnus albacares*
Skipjack tuna, *Katsuwonus pelamis*
Albacore (North and South), *Thunnus alalunga*
Bigeye tuna, *Thunnus obesus*
Blue marlin, *Makaira nigricans*
Black marlin, *Makaira indica*
Striped marlin, *Tetrapturus audax*
Sailfish, *Istiophorus platypterus*
Shortbill spearfish, *Tetrapturus angustirostris*
Swordfish, *Xiphias gladius*
Wahoo, *Acanthocybium solandri*
Dolphinfish (mahimahi), *Coryphaena hippurus*
Pelagic sharks
Families: Carcharhinidae, Alopiidae, Sphyrnidae, and Lamnidae

Unit 19: Alaska Groundfish Fisheries

Pacific halibut, *Hippoglossus stenolepis*
Bering Sea and Aleutian Islands groundfish resources
Walleye pollock, *Theragra chalcogramma*
Pacific cod, *Gadus macrocephalus*
Yellowfin sole, *Pleuronectes asper*
Greenland (turbot) halibut, *Reinhardtius hippoglossoides*
Arrowtooth flounder, *Atheresthes stomias*
Rock sole, *Pleuronectes bilineatus*
Other flatfishes
Flathead sole, *Hippoglossoides classodon*
Alaska plaice, *Pleuronectes quadrituberculatus*
Kamchatka flounder, *Atheresthes evermanni*
Bering flounder, *Hippoglossoides robustus*
Arctic flounder, *Pleuronectes glacialis*
Butter sole, *Pleuronectes isolepis*
C-O Sole, *Pleuronichthys coenosus*
California tonguefish, *Symphurus atricauda*
Curlfin sole, *Pleuronectes decurrens*
Deepsea sole, *Embassichthys bathybius*
Dover sole, *Microstomus pacificus*
English sole, *Pleuronectes vetulus*
Hybrid sole, *Inopsetta ischyra*
Longhead dab, *Pleuronectes proboscideus*
Pacific sanddab, *Citharichthys sordidus*
Petrale sole, *Eopsetta jordani*
Rex sole, *Errex zachirus*
Roughscale sole, *Clinoderma asperrimum*
Sand sole, *Psettichthys melanostictus*
Slender sole, *Eopsetta exilis*
Starry flounder, *Platichthys stellatus*
Sablefish (black cod), *Anoplopoma fimbria*
Pacific ocean perch, *Sebastes alutus*
Other rockfishes
Aurora rockfish, *Sebastes aurora*
Black rockfish, *Sebastes melanops*
Blackgill rockfish, *Sebastes melanostomus*
Blue rockfish, *Sebastes mystinus*
Bocaccio, *Sebastes paucispinis*
Brown rockfish, *Sebastes auriculatus*
Canary rockfish, *Sebastes pinniger*
Chameleon rockfish, *Sebastes phillipsi*
Chilipepper, *Sebastes goodei*
Copper rockfish, *Sebastes caurinus*
Darkblotched rockfish, *Sebastes cramei*
Dusky rockfish, *Sebastes ciliatus*
Gray rockfish, *Sebastes glaucus*
Greenstriped rockfish, *Sebastes elongatus*
Harlequin rockfish, *Sebastes variegatus*
Northern rockfish, *Sebastes polyspinis*
Pinkrose rockfish, *Sebastes simulator*
Pygmy rockfish, *Sebastes wilsoni*
Redbanded rockfish, *Sebastes babcocki*
Redstripe rockfish, *Sebastes proriger*
Rosethorn rockfish, *Sebastes helvomaculatus*
Rosy rockfish, *Sebastes rosaceus*
Rougheye rockfish, *Sebastes aleutianus*
Sharpchin rockfish, *Sebastes zacentrus*
Shortraker rockfish, *Sebastes borealis*
Silvergray rockfish, *Sebastes brevispinis*
Splitnose rockfish, *Sebastes diploproa*
Stripetail rockfish, *Sebastes saxicola*
Tiger rockfish, *Sebastes nigrocinctus*
Widow rockfish, *Sebastes entomelas*
Yelloweye rockfish, *Sebastes ruberrimus*
Yellowmouth rockfish, *Sebastes reedi*
Yellowtail rockfish, *Sebastes flavidus*
Broadbanded thornyhead, *Sebastolobus macrochir*
Longspine thornyhead, *Sebastolobus altivelis*
Shortspine thornyhead, *Sebastolobus alascanus*
Atka mackerel, *Pleurogrammus monopterygius*
Other fishes
Antlered sculpin, *Enophrys diceraus*
Armorhead sculpin, *Eurymen gyrinus*
Bigmouth sculpin, *Hemitripterus bolini*

Blackfin sculpin, *Malacocottus kincaidi*
Blob sculpin, *Psychrolutes phrictus*
Brown Irish lord, *Hemilepidotus spinosus*
Butterfly sculpin, *Hemilepidotus papilio*
Calico sculpin, *Clinocottus embryum*
Crested sculpin, *Blepsias bilobus*
Dusky sculpin, *Icelinus burchami*
Great sculpin,
Myoxocephalus polyacanthocephalus
Pacific staghorn sculpin, *Leptocottus armatus*
Plain sculpin, *Myoxocephalus jaok*
Red Irish lord, *Hemilepidotus hemilepidotus*
Ribbed sculpin, *Triglops pingeli*
Scissortail sculpin, *Triglops forficatus*
Shorthorn sculpin, *Myoxocephalus scorpius*
Spinyhead sculpin, *Dasycottus setiger*
Tadpole sculpin, *Psychrolutes paradoxus*
Thorny sculpin, *Icelus spiniger*
Warty sculpin, *Myoxocephalus verrucosus*
Yellow Irish lord, *Hemilepidotus jordani*
Alaska skate, *Bathyraja parmifera*
Aleutian skate, *Bathyraja aleutica*
Big skate, *Raja binoculata*
Deepsea skate, *Bathyraja abyssicola*
Golden skate, *Bathyraja smirnovi*
Longnose skate, *Raja rhina*
Starry skate, *Raja stellulata*
Blue shark, *Prionace glauca*
Pacific sleeper shark, *Somniosus pacificus*
Salmon shark, *Lamna ditropis*
Sixgill shark, *Hexanchus griseus*
Soupfin shark, *Galeorhinus zyopterus*
Spiny dogfish, *Squalus acanthias*
Thresher shark, *Alopias vulpinus*
Capelin, *Mallotus villosus*
Eulachon, *Thaleichthys pacificus*
Rainbow smelt, *Osmerus mordax*
Giant octopus, *Octopus dofleini*
Orange bigeye octopus, *Octopus californicus*
Magistrate armhook squid,
Berryteuthis magister
Boreal clubhook squid,
Onychoteuthis borealijaponica

Gulf of Alaska groundfish resources

Walleye pollock, *Theragra chalcogramma*
Pacific cod, *Gadus macrocephalus*
Flatfishes
Arrowtooth flounder, *Atheresthes stomias*
Alaska plaice, *Pleuronectes quadrituberculatus*
Butter sole, *Pleuronectes isolepis*
Deepsea sole, *Embassichthys bathybius*
Dover sole, *Microstomus pacificus*
English sole, *Pleuronectes vetulus*
Flathead sole, *Hippoglossoides elassodon*
Greenland (turbot) halibut,
Reinhardtius hippoglossoides
Rex sole, *Errex zachirus*
Rock sole, *Pleuronectes bilineatus*
Sand sole, *Psettichthys melanostictus*
Starry flounder, *Platichthys stellatus*
Yellowfin sole, *Pleuronectes asper*
Sablefish (black cod), *Anoplopoma fimbria*
Atka mackerel, *Pleurogrammus monopterygius*
Slope rockfishes
Northern rockfish, *Sebastes polyspinis*
Pacific ocean perch, *Sebastes alutus*
Rougheye rockfish, *Sebastes aleutianus*
Shortraker rockfish, *Sebastes borealis*
Thornyhead rockfishes
Broadbanded thornyhead,
Sebastolobus macrochir
Longspine thornyhead, *Sebastolobus altivelis*
Shortspine thornyhead,
Sebastolobus alascanus
Pelagic shelf rockfishes
Dusky rockfish, *Sebastes ciliatus*
Widow rockfish, *Sebastes entomelas*
Yellowtail rockfish, *Sebastes flavidus*
Demersal shelf rockfishes
Yelloweye rockfish, *Sebastes ruberrimus*

Unit 20: Alaska Shellfish Fisheries

Tanner crab, *Chionoecetes bairdi*
Snow crab, *Chionoecetes opilio*
King crabs
Blue king crab, *Paralithodes platypus*
Golden (brown) king crab,
Lithodes aequispina
Red king crab, *Paralithodes camtschatica*
Shrimps
Alaskan pink shrimp, *Pandalus eous*
Side-stripped shrimp, *Pandalopsis dispar*
Humpy shrimp, *Pandalus goniurus*
Coonstripped shrimp, *Pandalus hypsinotus*
Spot shrimp, *Pandalus platyceros*
Sea snails
Angular whelk,
Buccinum angulosum angulosum

Fat whelk, *Neptunea ventricosa*
Fragile whelk, *Volutopsius fragilis*
Ladder whelk, *Buccinum scalariforme*
Lyre whelk, *Neptunea lyrata lyrata*
Oregon triton, *Fusitriton oregonensis*
Polar whelk, *Buccinum polare*
Pribilof whelk, *Neptunea pribiloffensis*
Sinuous whelk, *Buccinum plectrum*
Tulip whelk, *Volutopsius middendorffii*
Hero whelk, *Neptunea heros*
Whelk, *Plicifusus kroyeri*

Unit 21: Nearshore Fisheries

Northeast Nearshore Fishery Resources

Blue crab, *Callinectes sapidus*
Sea urchin, *Strongylocentrotus* spp.
Atlantic hardshell clam, *Mercenaria mercenaria*
Eastern oyster (Atlantic), *Crassostrea virginica*
Blue mussel, *Mytilus edulis*
Horseshoe crab (Atlantic), *Limulus polyhemus*
Tautog, *Tautoga onitis*
Other shads and herring
Gizzard shad, *Dorosoma cepedianum*
Hickory shad, *Alosa mediocris*
Round herring, *Etrumeus teres*
White perch, *Morone americana*
Jonah crab, *Cancer borealis*
Softshell clam, *Mya arenaria*
Atlantic rock crab, *Cancer irroratus*
Conchs
Channeled whelk, *Busycotypus canaliculatus*
Knobbed whelk, *Busycon carica*
Lightning whelk, *Busycon sinistrum*
Sea cucumber, *Cucumaria frondosa*
American eel, *Anguilla rostrata*
Sea worms
Sandworm, *Nereis virens*
Bloodworm, *Glycera dibranchiata*
Tapeworm (milk worm), *Cerebratulus lacteus*
Periwinkle, *Littorina littorea*
Bay scallop, *Argopecten irradians*

Southeast Nearshore Fishery Resources

Blue crab, *Callinectes sapidus*
Mullets, Family Mugilidae
Eastern oyster (Atlantic), *Crassostrea virginica*
Other herrings and Spanish sardine
Gizzard shad, *Dorosoma cepedianum*
Round herring, *Etrumeus teres*
Atlantic thread herring, *Opisthonema oglinum*
Hickory shad, *Alosa mediocris*
Threadfin shad, *Dorosoma petenense*
Spanish sardine, *Sardinella aurita*
Gulf flounder, *Paralichthys albigutta*
Southern flounder, *Paralichthys lethostigma*
Bait shrimp, Decapoda, Dendrobranchiata
Calico scallops (Atlantic), *Argopecten gibbus*
Ballyhoo, *Hemiramphus brasiliensis*
Bigeye scad, *Selar crumenophthalmus*
Flyingfish (Atlantic), *Cypselurus melanurus*

Pacific Nearshore Fishery Resources (California)

California market squid, *Loligo opalescens*
Sea urchins, *Strongylocentrotus* spp.
Shrimps
Bay shrimp, *Crangon franciscorum*
Dock shrimp, *Pandalus danae*
Ocean shrimp, *Pandalus jordani*
Pacific ridgeback rock shrimp, *Sicyonia ingentis*
Pacific (pink) shrimp, *Pandalus borealis*
Sidestripe shrimp, *Pandalopsis dispar*
Spot shrimp, *Pandalus platyceros*
Dungeness crab, *Cancer magister*
Other crabs
Rock crab, *Cancer* spp.
Sheep crab, *Loxorhynchus grandis*
Pacific bonito, *Sarda chiliensis*
Smelts
Night smelt, *Spirinchus starksi*
Surf smelt, *Hypomesus pretiosus*
Whitebait smelt, *Allosmerus elongatus*
Elasmobranchs, Class Elasmobranchiomorphi
California halibut, *Paralichthys californicus*
Sea cucumbers, *Parastichopus* spp.
California spiny lobster, *Panulirus interruptus*
Abalones, *Haliotis* spp.
Croakers
Spotfin croaker, *Roncador stearnsi*
Yellow croaker, *Umbrina roncador*
White croaker, *Genyonemus lineatus*
Pacific barracuda, *Sphyraena argentea*
Bivalves
Pacific razor clam, *Siliqua patula*
Butter clam, *Saxidomus nuttalli*

Banded chione, *Chione californiensis*
Smooth chione, *Chione fluctifraga*
Wavy chione, *Chione undatella*
Thin-shelled littleneck clam, *Protothaca tenerrima*
Manila clam, *Venerupis japonica*

Pacific Nearshore Fishery Resources (Oregon)

Clams
- Butter clam, *Saxidomus nuttalli*
- Horseneck gaper clam, *Tresus capax*
- Pacific littleneck clam, *Protothaca staminea*

Oysters
- Pacific oyster, *Crassostrea gigas*

Dungeness crab, *Cancer magister*

Shrimps
- Blue mud shrimp, *Upogebia pugettensis*
- Ocean shrimp, *Pandalus jordani*
- Pacific (pink) shrimp, *Pandalus borealis*

Sea Urchins
- Purple sea urchin, *Strongylocentrotus purpuratus*
- Red sea urchin, *Strongylocentrotus franciscanus*

Elasmobranchs
- Blue shark, *Prionace glauca*
- Spiny dogfish, *squalus acanthias*
- Big skate, *Raja binoculata*
- Longnose skate, *Raja rhina*

Sturgeon
- Green sturgeon, *Acipenser medirostris*
- White sturgeon, *Acipenser transmontanus*

Other fish and invertebrates
- Chub (Pacific) mackerel, *Scomber japonicus*
- Pacific herring, *Clupea pallasi*
- Pacific sardine, *Sardinops sagax*
- Market squid, *Loligo opalescens*
- Humboldt squid, *Dosidicus gigas*

Pacific Nearshore Fishery Resources (Washington)

Pacific geoduck clam, *Panopea abrupta*

Other clams
- Horseneck gaper clam, *Tresus capax*
- Manila clam, *Venerupis japonica*
- Pacific littleneck clam, *Protothaca staminea*

Oysters
- Pacific oyster, *Crassostrea gigas*

Other bivalves
- Venus clams, *Psephidia* sp.
- Mussels, Family Mytilidae
- Dungeness crab, *Cancer magister*

Shrimps
- Ocean shrimp, *Pandalus jordani*
- Pacific (pink) shrimp, *Pandalus borealis*

Sea cucumber
- California sea cucumber, *Parastichopus californicus*

Elasmobranchs
- Spiny dogfish, *squalus acanthias*

Sturgeons
- Green sturgeon, *Acipenser medirostris*
- White sturgeon, *Acipenser transmontanus*

Western Pacific Island Nearshore Fishery Resources

Bigeye scad (Akule), *Selar crumenophthalmus*
Mackerel scad (Opelu), *Decapturus macarellus*

Alaska Nearshore Fishery Resources

Dungeness crab, *Cancer magister*
Tanner crab, *Chionoecetes bairdi*
Red king crab, *Paralithodes camtschatica*

Scallops
- Weathervane scallop, *Patinopectin caurinus*
- Pink scallop, *Chlamys rubida*
- Spiny scallop, *Chlamys hastata*
- Rock scallop, *Crassadoma gigantea*
- Pacific geoduck clam, *Panopea abrupta*

Shrimps
- Alaskan pink shrimp, *Pandalus eous*
- Coonstriped shrimp, *Pandalus hypsinotus*
- Humpy shrimp, *Pandalus goniurus*
- Ocean shrimp, *Pandalus jordani*
- Sidestripe shrimp, *Pandalopsis dispar*
- Spot shrimp, *Pandalus platyceros*

Other clams
- Arctic surfclam, *Mactromeris polynyma*
- Butter clam, *Saxidomus giganteaus*
- Cockles, *Clinocardium* spp.
- Pacific littleneck clam, *Protothaca staminea*
- Pacific razor clam, *Siliqua patula*
- Softshell clam, *Mya arenaria*
- Sea urchins, *Strongylocentrotus* spp.
- Sea cucumbers, *Parastichopus* spp.
- Abalones, *Haliotis* spp.

Units 22, 23 and 24: Marine Mammals of Alaska, Pacific, and Atlantic Regions

Dolphins
- Atlantic spotted dolphin, *Stenella frontis*
- Atlantic white-sided dolphin, *Lagenorhynchus acutus*
- Bottlenose dolphin, *Tursiops truncatus*
- Clymene Dolphin, *Stenella clymene*
- Common dolphin, *Delphinus delphis*
- Fraser's dolphin, *Lagenodelphis hosei*
- Northern right-whale dolphin, *Lissodelphis borealis*
- Pacific white-sided dolphin, *Lagenorhynchus obliquidens*
- Pantropical spotted dolphin, *Stenella attenuata*
- Risso's dolphin, *Grampus griseus*
- Rough-toothed dolphin, *Steno bredanensis*
- Spinner dolphin (Eastern), *Stenella longirostris orientalis*
- Striped dolphin, *Stenella coeruleoalba*
- Whitebelly spinner dolphin, *Stenella longirostris*
- White-beaked dolphin, *Lagenorhynchus albirostris*

Fur seals
- Guadalupe fur seal, Ar*ctocephalus townsendi*
- Northern fur seal, *Callorhinus ursinus*

Manatees
- Florida manatee, *Trichecus manatus latirostris*
- Antillean manatee, *Trichecus manatus manatus*

Porpoises
- Dall's porpoise, *Phocoena dalli*
- Harbor porpoise, *Phocoena phocoena*

Seal lions
- California sea lion, *Zalophus californianus*
- Stellar sea lion, *Eumetopias jubatus*

Seals
- Bearded seal, *Erignathus barbatus*
- Grey seal, *Halichoerus grypus*
- Harbor seal, *Phoca vitulina*
- Harp seal, *Phoca groenlandica*
- Hawaiian monk seal, *Monachus shauinslandi*
- Hooded seal, *Cystophora cristata*
- Northern elephant seal, *Mirounga angustirostris*
- Ribbon seal, *Phoca fasciata*
- Ringed seal, *Phoca hispida*
- Spotted seal, *Phoca largha*

Whales
- Baird's beaked whale, *Berardius bairdii*
- Beluga, *Delphinapterus leucas*
- Blainville's beaked whale, *Mesoplodon densirostris*
- Blue whale, *Balaenoptera musculus*
- Bowhead whale, *Balaena mysticetus*
- Bryde's whale, *Balaenoptera edeni*
- Cuvier's beaked whale, *Ziphius cavirostris*
- Dwarf sperm whale, *Kogia simus*
- False killer whale, *Pseudorca crassidens*
- Fin whale, *Balaenoptera physalus*
- Gervais' beaked whale, *Mesoplodon europaeus*
- Gray whale, *Eschrichtius robustus*
- Humpback whale, *Megaptera novaeangliae*
- Killer whale, *Orcinus orca*
- Longfin pilot whale, *Globicephala melaena* (melas)
- Melon-headed whale, *Peponocephala electra*
- Mesoplodont beaked whales, *Mesoplodon* spp.
- Minke whale, *Balaenoptera acutorostrata*
- Northern bottlenose whale, *Hyperoodon ampullatus*
- Northern Right whale, *Eubalaena glacialis*
- Pygmy Killer whale, *Feresa attenuata*
- Pygmy sperm whale, *Kogia breviceps*
- Sei whale, *Balaenoptera borealis*
- Shortfin pilot whale, *Globicephala macrorhynchus*
- Sperm whale, *Physeter macrocephalus* (catodon)
- Stejneger's beaked whale, *Mesoplodon stejnegeri*

Other marine mammals
- Polar bear, *Ursus maritimus*
- Sea otter, *Enhydra lutris*
- Walrus, *Odobenus rosmarus*

Unit 25: Sea Turtles

Kemp's ridley, *Lepidochelys kempi*
Olive ridley, *Lepidochelys olivacea*
Leatherback, *Dermochelys coriacea*
Green turtle, *Chelonia mydas*
Foggerhead, *Caretta caretta*
Hawksbill, *Fretmochelys imbricata*

Appendix 6: Acronyms and Abbreviations

ABC	acceptable biological catch
ADFG	Alaska Department of Fish and Game
AFSC	Alaska Fisheries Science Center
ASMFC	Atlantic States Marine Fisheries Commission
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CFR	Code of Federal Regulations
CI	confidence interval
cm	centimeter
CNMI	Commonwealth of the Northern Mariana Islands
COFI	Committee on Fisheries
CPUE	catch per unit of effort
CPY	current potential yield
CV	coefficient of variation
CWP	central-western Pacific Ocean
DDT	DichloroDiphenylTrichloroethane
DNA	deoxyribonucleic acid
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
ESA	Endangered Species Act of 1973
ESU	evolutionarily significant unit
ETP	eastern tropical Pacific Ocean
F	instantaneous fishing mortality rate
FAO	Food and Agriculture Organization of the United Nations
FFA	South Pacific Forum Fisheries Agency
fm	fathom
F_{max}	rate of fishing mortality that results in the maximum level of yield per recruit
FMC	fishery management council
FMP	fishery management plan
FP	fibropapillomatosis
FWCA	Fish and Wildlife Coordination Act
GPS	global positioning system
GSMFC	Gulf States Marine Fisheries Commission
HMS	highly migratory species
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea

ICNAF	International Convention for the Northwest Atlantic Fisheries
IFQ	individual fishing quota
INPFC	International North Pacific Fisheries Commission
IPHC	International Pacific Halibut Commission
IWC	International Whaling Commission
K	carrying capacity
kg	kilogram
LIDAR	light detection and ranging
LMR	living marine resource(s)
LTPY	long-term potential yield
m	meter
M	instantaneous rate of natural mortality
MAFMC	Mid-Atlantic Fishery Management Council
MFCMA	Magnuson Fishery Conservation and Management Act of 1976
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act (as amended through October 11, 1996)
MHI	Main Hawaiian Islands
mm	millimeter
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service, Department of Interior
MRFSS	Marine Recreational Fisheries Statistics Survey
MSAP	Mackerel Stock Assessment Panel
MSY	maximum sustainable yield
NAFO	Northwest Atlantic Fisheries Organization
NASCO	North Atlantic Salmon Conservation Organization
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
n.mi.	nautical mile
N_{min}	minimum population estimate of the stock
NOAA	National Oceanic and Atmospheric Administration
NPAFC	North Pacific Anadromous Fish Commission
NPFMC	North Pacific Fishery Management Council
NWFSC	Northwest Fisheries Science Center
NWHI	Northwestern Hawaiian Islands
ODFW	Oregon Department of Fish and Wildlife
OLO	Our Living Oceans
OY	optimum yield
OSP	optimum sustainable population
PA	Precautionary Approach
PacFIN	Pacific Fisheries Information Network
PCB	polychlorinated biphenyl
PBR	potential biological removal
PFMC	Pacific Fishery Management Council
PICES	North Pacific Marine Science Organization
PSC	U.S.-Canada Pacific Salmon Commission
PSP	paralytic shellfish poisoning
RAY	recent average yield

R_{max}	one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size
SAR	Stock Assessment Report
SARC	Stock Assessment Review Committee
SAW	Stock Assessment Workshop
SEFSC	Southeast Fisheries Science Center
SEP	Socio-economic Panel
SNE	southern New England
SPR	spawning potential ratio or spawner per recruit
SSB	spawning stock biomass
SWFSC	Southwest Fisheries Science Center
t	metric ton
TAC	total allowable catch
TED	turtle excluder device
U	exploitation rate
UNCED	United Nations Conference on Environment and Development
UNIA	United Nations Implementing Agreement
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife