An Annotated Bibliography on the Biological Effects of Constructing Channels, Jetties, and Other Coastal Structures

by
Julie C. Ford,
Arthur K. Hurme, and Edward J. Pullen

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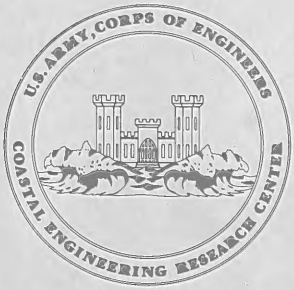

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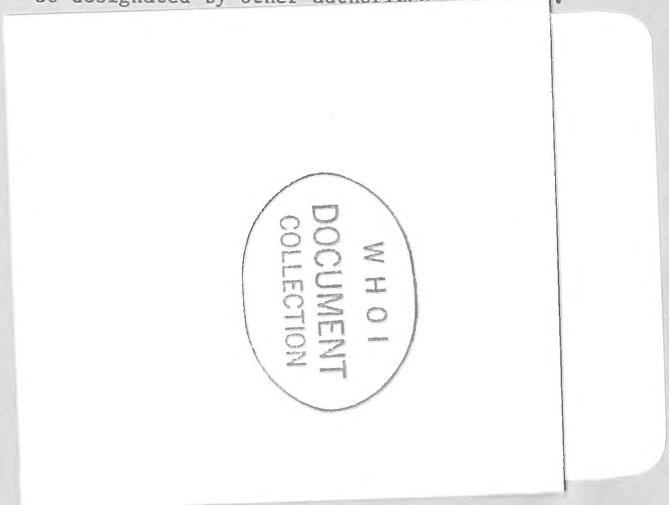

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This bibliography includes 199 historic and recently published research reports for use in evaluating the biological effects of constructing channels, jetties, and other coastal structures on fish and shellfish migration.

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PREFACE

This report is published to provide coastal engineers and scientists a comprehensive annotated bibliography for evaluating the biological effects of constructing channels, jetties, and other coastal structures. The bibliography is useful for planning and designing coastal engineering projects and preparing environmental assessments and statements. The compilation of the bibliography was carried out under the U.S. Army Coastal Engineering Research Center's (CERC) Effects of Channel Deepening and Jetties on Fish and Shellfish Migration work unit, Environmental Impact Program, Environmental Quality Area of Civil Works Research and Development.

The report was compiled by Julie C. Ford, Arthur K. Hurme, and Edward J. Pullen of the Coastal Ecology Branch, under the general supervision of Mr. R.P. Savage, Chief, Research Division.

Technical Director of CERC was Dr. Robert W. Whalin, P.E.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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AN ANNOTATED BIBLIOGRAPHY ON THE BIOLOGICAL EFFECTS OF CONSTRUCTING CHANNELS, JETTIES, AND OTHER COASTAL STRUCTURES

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I. INTRODUCTION

This bibliography presents a collection of references to early 1980 to aid the coastal planner in an evaluation of the biological effects of constructing channels, jetties and other coastal structures. Emphasis is placed on their effects on fish and shellfish migration. Most of the citations were obtained through an intra-agency bibliographic retrieval system, a computerized searching process that provided citations of the most recent publications available by keyword. Abstracts not included in the original citations were found at the Coastal Engineering Research Center (CERC) library or at the Library of Congress. This bibliography is published primarily to assist engineers, planners, and administrators in planning and assessing the effect of projects on fish and shellfish. It should be used in conjunction with Mulvihill, et al. (1980)[1] which was prepared simultaneously.

II. USE OF THE BIBLIOGRAPHY

The bibliography is arranged alphabetically by author and the entries are numbered. Most references include a citation and a short abstract. Each reference is listed by number in the subject index (keywords) located in the back of the publication.

To search a given topic, refer to the subject index and locate the term that best describes the subject. For example, if the subject is *migration* then review all references and abstracts listed under *migration*. If references on more specific topics are required, a combination of keywords may be used. For example, if information on *shellfish migration* is desired, check those references that appear under both keywords (*shellfish* and *migration*).

Some references may be listed under only one of several closely related keywords and the literature dealing specifically with channel deepening and jetty effects on fish and shellfish migration is sparse; therefore, potential keywords should be checked to insure complete coverage of a particular subject.

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[1]MULVIHILL, E.L., et al., "Biological Impacts of Minor Shoreline Structures on the Coastal Environment: State of the Art Review," FWS/OBS-77/51, 2 Vols., Biological Services Program, U.S. Fish and Wildlife Service, Washington, D.C., Mar. 1980.

III. ANNOTATED BIBLIOGRAPHY

1. ADKINS, G., and BOWMAN, P., "A Study of the Fauna in Dredged Canals of Coastal Louisiana," *Technological Bulletin of the Louisiana Wildlife and Fisheries Commission*, No. 18, Feb. 1976.

Samples were made on four environmental types: (a) open, unaltered areas, (b) open canals, (c) semiopen canals, and (d) closed canals. Sampling was accomplished by using various gear over a 2-year period. During the study, 67,560 individuals composed of 88 different species were collected. The open, undisturbed areas offered the largest numbers of individuals and the closed canals contained the fewest, although the animals collected in the closed canals were larger. A decrease in catch and in species diversity of planktonic organisms was noted in closed canals. Hydrological conditions were most stable in closed canals. Dissolved oxygen remained within tolerance limits of marine organisims during most of the study; however, fish kills were observed in semiopen and closed canals. Water chemistry reflected a fluctuation trend dependent on freshwater and saltwater intrusion. Peak levels of most nutrients were recorded following flooding conditions of storm surges caused by the passage of hurricanes.

2. APPLIED BIOLOGY, INC., "Literature Review for the Assessment of Larval Fish and Shellfish Movement Through Oregon Inlet and the Potential Effects of Inlet Stabilization by Jetties," U.S. Army Engineer District, Wilmington, Wilmington, N.C., unpublished, Apr. 1980.

This literature evaluates the potential effects of jetty emplacement on ocean-to-estuary larval transport at Oregon Inlet, North Carolina. Commercially important fish and shellfish in Pamlico Sound can be categorized in terms of their vulnerability to potential jetty construction effects by assessing their migratory patterns and life-cycle relationships to estuarine nurseries. Seasonal observation of larval density distributions, in association with current direction and speed data, would allow a prediction of jetty emplacement effects and provide a data base for comparison with postconstruction monitoring study results.

3. ARNER, D.H., et al., "Effects of Channelization of the Luxapalia River on Fish, Aquatic Invertebrates, Water Quality, and Furbearers," FWS/OBS-76-08, U.S. Fish and Wildlife Service, Washington D.C., June 1976.

Biological data collected July 1973 to January 1976 from an old channelized segment, an unchannelized segment, and a newly channelized segment of the Luxapalia River in Mississippi and Alabama revealed that productivity of the old channelized segment has not recovered to the levels exhibited in the unchannelized segment. There was an increase in the turbidity trends and in the number of plankton organisms in the newly channelized segment. In the unchannelized segment there was an increase in the average number per sample of fish and macroinvertebrates and in the diversity of plankton, macroinvertebrates, and fish. Utilization of an expanding habitat created by annual flooding was indicated by the preponderance of terrestrial invertebrates found in the stomachs of fish collected behind the levee. Indexes of the abundance of furbearers associated with the river were obtained by night lighting, sign count, and trapping. Muskrat and beaver, the species most commonly associated with an aquatic habitat, were far more numerous in the unchannelized segment than in either the old or newly channelized segments.

4. ARNOLD, E.L., Jr., "Man's Alterations of Estuaries by Dredging and Filling a Grave Threat to Marine Resources," *Proceedings of the 18th Annual Conference of the Southeast Association of Game Fish Commissioners*, Vol. 18, 1964, pp. 269-273.

Estuaries are being unwisely exploited to develop waterfront real estate by dredging and filling. Accumulative effects of landfill activities threaten the balance of nature in which estuaries play a major role. The typical dredge-and-fill operation along the Florida coast is in the shallow bay bottom and tidal flat areas. The operations destroy the marine productivity in the shallows where extensive grass beds are prime fish nursery and forage areas. These development activities also change long established currents. The Tampa-Boca Ciega Bay dredge-and-fill project is noted to involve 9.25 million cubic yards of fill materials. The Boca Ciega Bay is an excellent nursery and forage area that would be destroyed by an extensive dredge-and-fill project.

5. ARON, W.I., and SMITH, S.H., "Ship Canals and Aquatic Ecosystems," *Science*, Vol. 174, No. 4004, Oct. 1971, pp. 13-20.

Through a combination of ecosystem homeostasis and the perversity of man and nature, often times the significant biological changes effected by environmental modifications are not detected until long after the initial change has taken place. The immediate impact, which may range from spectacular to undetectable, is a deceptive measure of the long-term and often more important changes in the ecosystem.

6. AULD, A.H., and SCHUBEL, J.R., "Effects of Suspended Sediment on Fish Eggs and Larvae: A Laboratory Assessment," *Estuarine and Coastal Marine Science*, Vol. 6, No. 2, Feb. 1978, pp. 153-164.

Eggs and larvae of six species of anadromous and estuarine fish indigenous to the Chesapeake Bay were exposed to different concentrations of suspended sediment to determine the effects on hatching success and short-term survival. The egg experiments indicated that concentrations did not significantly affect the hatching success of yellow perch, blueback herring, alewife, or American shad eggs. Higher concentrations significantly reduced the hatching success of white perch and striped bass; lower concentrations did not. Experiments with larvae indicated that high concentrations significantly reduced the survival of striped bass and yellow perch larvae exposed for 48 to 96 hours. American shad larvae appeared to be less tolerant than the other two species tested. Low concentrations significantly reduced the survival of shad larvae continuously exposed for 96 hours. The significance of these results is discussed relative to natural and man-induced changes in sediment loading of estuaries.

7. BARADA, W., and PARTINGTON, W.M., Jr., "Report of Investigation of Environmental Effects of Private Water Front Canals," Environmental Information Center, Winter Park, Fla., 1972.

The impact of canal-type waterfront developments on Florida's aquatic environment and its possible conflict of public interest is discussed. Topics include effects on fish and fishing, changes in water quality, benthos, sources of pollutants, the effect on ground water, the effect on public health, and the economic impact of these developments. The study was based on a literature review and assessment by knowledgeable persons. Developing private waterfront property causes serious environmental degradation beyond the private boundaries and therefore affects public interest.

8. BASSI, D.E., and BASCO, D.R., "Field Study on an Unconfined Spoil Disposal Area of the Gulf Intracoastal Waterway in Galveston Bay, Texas," Sea Grant Publication TAMU-SG-74-208, Texas A & M University, College Station, Tex., Jan. 1974.

Dredge material obtained from maintenance dredging of the gulf Intracoastal Waterway is presently disposed in unconfined, submerged areas alongside the channel. Of interest, for economic and environmental reasons, is the dispersion of the dredged material with time. Grain-size analysis of bottom sediment samples, depth soundings, and wooden stakes were employed in field investigations to determine the approximate location of material from one such disposal area over a 5-month period after disposal.

9. BAXTER, K.W., and RENFRO, W.C., "Seasonal Occurrence and Size Distribution of Postlarval Brown and White Shrimp Near Galveston, Texas, With Notes on Species Identification," *Fishery Bulletin*, Vol. 66, No. 1, 1967, pp. 149-158.

Postlarvae of the genus *Penaeus* were collected at the entrance to Galveston Bay, Texas, over a 4-year period and along Galveston Island's beach during a 1-year period. Postlarval brown shrimp, *P. aztecus*, and white shrimp, *P. setiferus*, were the predominant penaeids caught. Morphological characters, seasonal size differences, and the occurrence of juveniles in adjacent nursery areas were used to identify these species. Seasonal occurrence, size distribution, and measures of relative abundance are given for the two species. The uniform size of the postlarvae in collections taken along the beach and the bay entrance indicated that small shrimp grow very little when they are along the beach.

10. BEARDSLEY, G.L., Jr., "Distribution in the Water Column of the Migrating Juvenile Pink Shrimp, *Penaeus duorarum* (Burkenroad), in Buttonwood Canal, Everglades National Park, Florida," *American Doctoral Dissertations*, University of Miami, Miami, Fla., 1967.

A 1-year study was made of the vertical and horizontal distribution of migrating juvenile pink shrimp in Buttonwood Canal, Everglades National Park, Florida. The sampling gear consisted of 13 conical nets mounted in iron frames evenly spaced across the canal. Samples were 1 hour long and were taken during hours of darkness on the ebbtide. Sampling was scheduled each month to coincide with the full, new, and one of the quarter moons. Results indicated that juvenile shrimp are most abundant on the surface of the canal during nights of the full moon and the last-quarter moon. Juvenile shrimp also respond to changes in current velocity moving off the bottom at the end of the floodtide and moving back to the bottom at the end of the ebbtide. Changes in lateral distribution also occur. These changes can be related to current patterns in the canal or to the amount and distribution of floating vegetation in the canal. Studies were also made on abundance, size, and sex ratio.

11. BEERS, G.D., "The Role of Dredging in the Ecosystem Management Program Proposal for the Los Angeles Harbor," *Summaries of the Second Annual Environmental Engineers and Science Conference*, University of Louisville, Louisville, Ky., 1972, pp. 14-16.

In an ecological study of the dredging of Los Angeles Harbor, surface and substrate sediment samples were analyzed for particle-size distribution, total

Nitrogen, oil and grease, chemical oxygen demand, total sulfides and phosphates, and benthic animal diversity and biomass. The degree of dredging was associated with the degree of potential improvement in the quality of the sediments. Dredging to a depth of 3 meters would restore conditions for desirable benthic communities.

12. BENEFIELD, R.L., "Shell Dredging Sedimentations in Galveston and San Antonio Bays," Technical Series No. 19, Texas Parks and Wildlife Department, Austin, Tex., 1976.

Sedimentation on oyster reefs caused by hydraulic mudshell dredging was studied at seven sites in Galveston and San Antonio Bays. Silt baskets and core tubes were used to monitor rates of sedimentation. Important factors in reef sedimentation were oyster reef contours, sediment composition, direction of current flow, and number of shell dredges discharging sediments. Sedimentation was not found on a reef 0.91 to 1.22 meters above the surrounding bottom during the operation of a shell dredge 91.4 meters from the reef edge. A reef with a flat profile received deposits of dredged sediments when the nearest of five dredges was 1798 meters away. Sediment deposits of 10.2 to 15.2 centimeters caused oyster mortalities. It was found that each dredge site contained particular characteristics and that regulations requiring inflexible minimum distances between dredges and reefs were not appropriate.

13. BOEHMER, R., et al., "Effects of Suspended Marine Sediments on Selected Commercially Valuable Fish and Shellfish of Massachusetts," *Proceedings of the Seventh Annual Offshore Technology Conference*, Vol. I, 1975, pp. 133-141.

With various levels of suspended, fine-grained marine sediment, acute bioassays were performed on several marine fish and shellfish to determine possible lethal effects of short-term exposure to levels of suspended sediments encountered in the dredge plume of an offshore sand and gravel mining operation. Toxicity increasing with longer term exposure was evident with coho salmon and silverside and, to a lesser extent, with winter flounder, hake, and bay scallops. Coho salmon was the most tolerant of the fish, followed by winter flounder and silverside. Although initially tolerant of higher concentrations of suspended sediment, menhaden, yellowtail flounder, hake, and silverside were less tolerant at longer durations. This indicates that with some species the toxicity of suspended fine sediment is more dependent on the length of exposure, whereas with other species the toxicity is more dependent on the concentration. The highest tolerance was exhibited by the adult stage of quahog, soft-shell clam, and oyster. Although these three shellfish were the most tolerant, the bay scallop was the most susceptible of those species tested. Bay scallop larvae were more tolerant than adults. Lobsters were relatively tolerant to suspended sediments, although apparently vulnerable while molting.

14. BOUMA, A.H., "Environmental Studies Related to Shell Dredging in Gulf Coast Estuaries," *Proceedings of the Seventh Annual Offshore Technology Conference*, Vol. I, 1975, pp. 83-91.

Although the many estuaries along the gulf coast vary significantly in physical and biological aspects, the various studies on shell dredging all point to the same general conclusions. The additional suspended load resulting from dredge discharge, the oxygen budget, and the rapid salinity changes is considered to be the most important environmental aspect. The impact of dredging on the estuarine environmental parameters is less than would be suspected.

15. BOUMA, A.H., and HOLLIDAY, B.W., "Shell Dredging and Environmental Impact Statements," *Symposium on Ocean Mining, OSM* 11, World Dredging Conference Association, 1973, pp. 66-84.

An environmental impact study was required for San Antonio Bay, Texas, to determine the influence of shell dredging on the bay environment and on the adjacent Aransas National Wildlife Refuge. Industry and nonbiologically oriented agencies recognize a degree of harmful effects inherent to shell dredging, including silting of exposed oyster reefs. Other groups and agencies heavily oppose dredging because it may destroy certain benthic species and the food chain of other animals. Comparisons with other states reveal that a proper management program should be initiated to evaluate the problems in these two viewpoints.

16. BOUMA, A.H., HOLLIDAY, B.W., and HALL, G.L., "Environmental Statement on Shell Dredging: San Antonio Bay, Texas," Sea Grant Publication TAMU-SG-74-104, *Proceedings of the Sixth Dredging Seminar,* Mar. 1974, pp. 38-58.

A study of the environmental effects of shell dredging in San Antonio Bay, Texas, on the Aransas National Wildlife Refuge and the adjacent bays was undertaken by a team of approximately 50 investigators. Certain changes to the bay environment, which were a direct result of dredging, were studied and evaluated. These changes included circulation, aquatic life, population density of dredge holes, feeding habits of fishes, oyster reef distribution, dispersal of pollutants and navigation routes. Other studies dealt with the effect of spoil distribution from dredging operations on live reefs, dredging fossil reefs, and implantation of artificial reefs. In addition, the effect on the economy and revenue to the State, due to the termination of shell dredging as a detrimental measure or due to the depletion of resources, was discussed.

17. BROWN, C.L., and CLARK, R., "Observations on Dredging and Dissolved Oxygen in a Tidal Waterway," *Water Resources Research,* Vol. 4, No. 6, 1968, pp. 1381-1384.

Evidence indicates that resuspension of oxidizable bottom sediments in a tidal waterway caused significant reductions in the dissolved oxygen concentration of the water. During dredging, dissolved oxygen was reduced 16 to 83 percent below normal.

18. BRUER, J.P., "An Ecological Survey of the Lower Laguna Madre of Texas, 1953-1959," *Publications of the Institute of Marine Science,* Vol. 8, University of Texas, Austin, Tex., 1962, pp. 153-185.

Hydrographic data and comments on the distribution and habits of marine species are presented for the lower Laguna Madre of Texas, a shallow, hypersaline marine bay extending 122 kilometers north of the Rio Grande delta. In summer, waters of the gulf move northward through the lagoon with increasing salinity due to evaporation. The various species in the plankton and bottom communities diminish with distance from the pass. In winter, the flow is southward. A population of commercial oysters, *Crassostrea virginica,* near the pass apparently is adapted to high salinity conditions. Some ecological effects of manmade changes are described, including the effects of opening Port Mansfield Pass, the isolation and silting of South Bay due to dredged material disposal, and the management of the Rio Grande River during floods.

19. CADDY, J.F., "Underwater Observations on Tracks of Dredges and Trawls and Some Effects of Dredging on a Scallop Ground," *Journal of the Fisheries Research Board of Canada*, Vol. 30, No. 2, Feb. 1973, pp. 173-180.

Three types of fishing gear tracks in bottom sediments were observed from a submersible in Chaleur Bay (Gulf of St. Lawrence). Tracks from past otter-trawling activities covered at least 3 percent of the bottom area; these were probably made by trawl doors. Shallow tracks made by inshore and offshore dredges during the course of the study could be distinguished from each other and from trawl tracks.

Scallop dredging lifts fine sediments into suspension, buries gravel below the sand surface, and overturns large rocks embedded in the sediment, thereby roughening the bottom. Dredging causes appreciable lethal and sublethal damage to scallops left in the track; this damage is greatest on rough bottom. Incidental mortalities to scallops with an offshore dredge of at least 13 to 17 percent per tow are of the same magnitude as estimates of the harvesting efficiency made in earlier studies. Predatory fish and crabs were attracted to the dredge tracks within 1 hour of scallop dredging and were observed in the tracks at densities 3 to 30 times those observed outside the tracks.

20. CALDER, D.R., BEARDON, C.M., and BOOTHE, B.B., Jr., "Environmental Inventory of a Small Neutral Embayment: Murrells Inlet, South Carolina," Technical Report No. 10, South Carolina Marine Research Center, Charleston, S.C., 1976.

Studies were conducted to inventory macrobenthic communities, marshlands, oyster reefs, and other wetlands areas of Murrells Inlet prior to initiation of a project to construct two jetties to stabilize the channel. Dredge and grab samples were collected and aerial photos were used. Species diversity was highest inside the inlet and lowest at the mouth of the inlet. This pattern is typical of a neutral embayment and reflects the absence of a salinity gradient.

21. CALDER, D.R., and KNOTT, D.M., "Ecological Effects of Rubble Weir-Jetty Construction at Murrells Inlet, South Carolina," Interim Report, Marine Resources Research Institute, South Carolina Wildlife and Marine Resources Department, Charleston, S.C., Aug. 1979.

This study at Murrells Inlet, South Carolina, describes the macrobenthic communities during 1977, prior to jetty construction, and during early post-construction. The effects of the north jetty construction on macroinvertebrate communities were somewhat masked by seasonal population dynamics. However, certain effects on the populations were apparent. The jetty construction caused an increase in the number of species and altered the community structure at locations sheltered by the jetty. Changes south of the jetty, which changed from a high to a low wave energy environment, resulted in population changes. The only other major impact during the early postconstruction study was the elimination of communities directly in the path of the jetty. However, this is expected to be offset by the buildup of plants and animals on and around the jetty.

22. CALDER, D.R., et al., "A Reconnaissance of the Macrobenthic Communities, Wetlands, and Shellfish Resources of Little River Inlet, North Carolina and South Carolina," Technical Report No. 17, South Carolina Marine Research Center, Charleston, S.C., 1977.

Prior to initiation of the Little River navigation project involving channel stabilization and a jetty system, a study was conducted to inventory benthic communities, wetlands, and shellfish resources of the area. Qualitative and quantitative samples were collected and aerial photos were used. The number of benthic invertebrate species is relatively low; however, the estuary serves as an important nursery for shrimp, crabs and fishes.

23. CAMMEN, L.M., "Macroinvertebrate Colonization of Spartina Marshes Artificially Established on Dredge Spoil," *Estuarine and Coastal Marine Science*, Vol. 4, No. 4, July 1976, pp. 357-372.

Core samples were taken from dredge spoil planted with *Spartina alterniflora*, spoil left bare, and the nearby natural marsh in two locations to determine the factors influencing the development of the spoil fauna and also to compare the spoil with the natural marsh fauna. Based on the calculation of total numbers, total biomass, sample diversity, species richness, and faunal similarity between plots, the difference in the elevation between the bare and planted spoil appeared to be the major factor in determining the degree of similarity in their fauna. Five factors are suggested to control the development of the planted spoil fauna: the similarity of the spoil to the natural marsh in elevation and sediment particle size, the natural sedimentation rate in the area, the proximity of the spoil to the natural marsh, and the relative maturity of the natural marsh faunal community.

24. CAMMEN, L.M., SENECA, E.D., and COPELAND, B.J., "Animal Colonization of Man-Initiated Salt Marshes on Dredged Spoil," TP 76-7, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., June 1976.

This study determined the differences in fauna in spoil areas and natural marsh at Drum Inlet and Snow's Cut, North Carolina. A marked difference in faunal development was found at the sites. Research also showed that planting *Spartina* on dredge spoil leads to the creation of a salt marsh, which resembles a natural marsh.

25. CARSTEA, D., et al., "Guidelines for the Environmental Impact Assessment of Small Structures and Related Activities in Coastal Bodies of Water," Technical Report MTR-6916, The Mitre Corporation, McLean, Va., 1975.

Criteria for an evaluation of the environmental impact of various shoreline structures are given. Water turbidity, storm runoff, boat emissions, erosion, sedimentation impacts on biota, impacts on ecologically vital areas, air quality, and noise are some of the factors considered. Structures reviewed included riprap, bulkheads, groins, jetties, piers, dredge fill, outfalls, submerged lines and pipes, and aerial crossings.

26. CHAMBERS, C.V., and SPARKS, A.K., "An Ecological Survey of the Houston Ship Channel and Adjacent Bays," *Publications of the Institute of Marine Science*, Vol. 6, University of Texas, Austin, Tex., 1959, pp. 213-250.

In the ship channel a dissolved oxygen gradient existed from a low dissolved oxygen concentration in the upper channel to near normal concentrations at the lower boundary of the survey area. The dissolved oxygen in the ship channel below the mouth of the San Jacinto River is greatly influenced by the flow rate of the river which is, in turn, largely controlled by rainfall. Studies of

bottom samples demonstrated that extensive silting has occurred in the ship channel and bays. Low dissolved oxygen, hydrogen sulfide production, and high organic content of the mud in the channel, all indicative of organic pollution, prevent the establishment of a normal bottom fauna. In the bays adjacent to the channel the dissolved oxygen concentration is independent of the flow rate of the San Jacinto River, being dependent on phytoplankton production of oxygen and, at certain seasons of the year, fluctuating widely in a diurnal cycle. The concentration may range from supersaturation to extremely low concentrations in a relatively short period.

A small temperature gradient was found in the ship channel, 2° to 3° higher in the upper channel than in the lower part of the survey area. When the dissolved oxygen level is sufficient, a large and diverse population of fishes exists throughout the bays in the survey area and for a considerable distance above the Humble Oil & Refining Company's outfall. The species composition of this population varies with the season, with predominantly marine fishes during the summer when the salinity is high and predominantly freshwater fishes in the winter when the salinity is lower. Both the number of species and the diversity of fishes present decreased farther up the the channel.

27. CHAPMAN, C., "Channelization and Spoiling in Gulf Coast and South Atlantic Estuaries," *Proceedings of the Marsh and Estuary Management Symposium*, Louisiana State University, Baton Rouge, La., 1967, pp. 93-106.

Several methods of channel construction are used that permit varying degrees of control over the resulting spoil. Mechanical excavation with bucket dredges or draglines provides good spoil control on a small area. Hydraulic excavation, however, requires large spoil areas and affords poor control unless the spoil is removed from the construction site (hopper dredge) or retained within ring levees.

Disadvantages of channelization and spoil dumping include the segmentation of bays, which promotes shoaling; increased saltwater intrusion; increased flushing time; altered tidal exchange, mixing, and circulation; increased turbidity; and loss of submerged aquatic vegetation. However, none of these changes are as significant as the direct physical loss of a habitat.

Advantages of channels and spoil deposition include the connection of isolated waters and marshes, which make them available as fish nursery areas; the provision of routes of escape or refuge for fish during cold periods; the improvement of water exchange and circulation; and the release of nutrients trapped in bottom sediments.

Suggestions are made for planning channels and depositing spoil to reduce the loss of vital bay and marsh habitats.

28. CHASE, G.L., "Evaluation of Environmental Effects Associated with Sidecast Dredging," *Proceedings of the Eighth Annual Offshore Technology Conference*, Vol. 2, 1976, pp. 621-646.

Sidecast dredging has been employed annually in the New England region for the past 4 years. Operation of the dredge is restricted to inlet channels and ocean sand shoals. Physical and chemical analyses of sediment samples from 18 navigation projects confirmed that dredged material consists primarily of clean

fine to coarse sands. Some channels are characterized by eelgrass patches with subsequent higher percentages of fine-grained sediment. Preliminary studies by the U.S. Army Engineer Division, New England, have concentrated on evaluation of dredging effects on turbidity, dissolved oxygen, and mobilization of trace metal constituents. Four projects have been selected for comparison of predredging and postdredging impacts on benthic communities.

29. CLARK, J., et al., "Studies of Estuarine Dependence of Atlantic Coastal Fishes, Data Report II: Southern Section, New River Inlet, North Carolina, to Palm Beach, Florida," Technical Paper No. 59, U.S. Bureau of Sport Fisheries and Wildlife, Washington, D.C., 1970.

Studies conducted by the Sandy Hook Marine Laboratory determined the proportion of young, economically important Atlantic species of fish that enter estuaries their first year. The investigators surveyed the Atlantic Continental Shelf to locate the spawning areas and the season in which to follow the movements of larval and juvenile stages. This report presents temperature, salinity, zooplankton volume, and the surface meter net collection of juvenile fish data made on four cruises from New River, North Carolina, to Palm Beach Florida, during the second year of fieldwork.

30. CONGDON, J.C., "Fish Populations of Channelized and Unchannelized Sections of the Chariton River, Missouri," *Stream Channelization: A Symposium*, Special Publication No. 2, American Fisheries Society, Dec. 1971, pp. 52-62.

This study determines fish losses resulting from stream channelization on the Chariton River, Missouri. In the unchannelized section, 21 fish species were found compared with 13 species in the channelized section. The standing crop of fish in the unchannelized section was estimated to be 138 kilograms per acre compared with 24 kilograms per acre in the channelized section, an 83-percent reduction. In both the channelized and unchannelized sections carp, river carpsuckers, and channel catfish were the dominant species. The standing crop of catchable fish in the unchannelized section was estimated to be 85 kilograms per acre compared with 12 kilograms per acre in the channelized section, an 86-percent reduction. There were six species of catchable-size fish in the unchannelized section compared with four in the channelized section.

31. CONNER, W.G., and SIMON, J.L.,"The Effects of Oyster Shell Dredging on an Estuarine Benthic Community," *Estuarine and Coastal Marine Science*, Vol. 9, No. 6, Dec. 1979, pp. 749-758.

This paper describes the effects of physical disruptions associated with dredging fossil oystershell on the benthos. Two dredged areas and one undisturbed control area in Tampa Bay, Florida, were quantitatively sampled before dredging and for 1 year after dredging. The immediate effects of dredging on the soft-bottom community were reductions in the numbers of species (40-percent loss), densities of macrofauna (65-percent loss), and total biomass of invertebrates (90-percent loss). During the 6 to 12 months after dredging, an analysis showed no difference between the dredged and control areas in number of species, densities, or biomass. Community overlap between dredged and control areas was reduced directly after dredging, but after 6 months the predredging level of similarity was regained.

32. COPELAND, B.J., "Fauna of the Aransas Pass Inlet, Texas: I. Emigration as Shown by Tide Trap Collections," *Publications of the Institute of Marine Science*, Vol. 10, University of Texas, Austin, Tex., 1965, pp. 9-21.

A tide trap was used to sample the animals in the Aransas Pass Inlet, Texas. The net was lowered 3 days per week at maximum flood and ebb tides during the period 15 April 1963 to 15 April 1964. About 24 species of invertebrates and 55 species of fishes were collected with the tide trap during the study. The total catch of all organisms was greatest in May, June, and October. These large peaks were concomitant with the change in water level of the bays and changes in temperatures. Most organisms were caught on ebbtides, indicating a mass emigration of animals from the shallow, productive nursery areas. Only anchovies were consistently caught during floodtides. Six species of invertebrates and 11 species of fishes were considered to be common emigrants and were caught in the tide trap in large numbers. All these organisms demonstrated definite patterns in their emigration habits.

Computations of the tide collections showed that the net productivity of the bays was 233 kilograms per acre per year. About 3.9×10^6 kilograms per year of late juvenile penaeid shrimp emigrated through the Aransas Pass Inlet.

33. COPELAND, B.J., and BECHTEL, T.J., "Some Environmental Limits of Six Gulf Coast Estuarine Organisms," *Contributions in Marine Science*, Vol. 18, University of Texas, Austin, Tex., 1974, pp. 169-204.

Literature and data collections of six sport and commercially important species occupying gulf coast estuaries were analyzed utilizing a computerized sorting technique. Catch ratios, reflecting catches above a threshold value, were computed and sorted into temperature, salinity, seasonal and location classes, and into various interaction categories.

Gross temperature, salinity, location and season ranges, and optima were established for menhaden (*Brevoortia patronus*), sand trout (*Cynoscion arenarius*), blue crabs (*Callinectes sapidus*), white shrimp (*Penaeus setiferus*), pink shrimp (*Penaeus duorarum*), and brown shrimp (*Penaeus aztecus*). Analyses of interactions among the environmental variables verified several conclusions from the single factor analysis, but also delineated many details of habitat, migration, and estuarine utilization.

The technique developed is considered to be capable of describing outside limits and providing management criteria for estuarine programs.

34. COPELAND, B.J., and TRUITT, M.V., "Fauna of the Aransas Pass Inlet, Texas: II. Penaeid Shrimp Postlarvae," *Texas Journal of Science*, Vol. XVIII, No. 1, May 1966, pp. 65-74.

An investigation of the movement of postlarvae penaeid shrimp from the Gulf of Mexico into shallow bays was conducted for 1 year at the Aransas Pass Inlet, Texas. Two periods of peak abundance were observed, with *Penaeus aztecus* making up the spring peak and *Penaeus durorarum* making up the fall peak. These periods of influx occurred when there was a net inflow of water after previous periods of low water levels in the bays. Variations in postlarvae movement were observed, with greater catches during the floodtide, at night, and on the south side of the channel. The average length of postlarvae varied seasonally.

35. CORLESS, J., and TRENT, L., "Comparison of Phytoplankton Production Between Natural and Altered Areas in West Bay, Texas," *Fishery Bulletin*, Vol. 69, No. 4, 1971, pp. 829-832.

Phytoplankton production was compared among an undredged marsh area, a bay area, and an adjacent marsh area altered by channelization, bulkheading, and filling. The average gross production (milligrams of carbon per liter per day) in the altered area (canals) was 8 percent higher than in the marsh area and 48 percent higher than in the bay area during June, July, and August 1969. Gross and net productions were significantly higher in the canals and marsh than in the bay; differences between the canals and marsh were not significant.

36. CRONIN, L.E., GUNTER, G., and HOPKINS, S.H., "Effects of Engineering Activities on Coastal Ecology," Interim Report to the Office of the Chief of Engineers, U.S. Army, Corps of Engineers, Washington, D.C., 1969.

An interim report is presented of a tentative listing of pertinent Corps-related activities, with a preliminary analysis and evaluation of the ecological effects. The activities included dredging, filling, dams, diversions, jetties and groins, beach nourishment, land-cut canals, weed control, hurricane barriers, finger-type developments, and ocean disposal. Also, studies that would significantly improve comprehension, and therefore, the prediction of the effects of coastal engineering changes are listed with supplementary comments.

37. CRONIN, L.E., GUNTER, G., and HOPKINS, S.H., "Effects of Engineering Activities on Coastal Ecology," Report to the Office of the Chief of Engineers, U.S. Army, Corps of Engineers, Washington, D.C., 1971.

A team of consultants made a broad analysis of the effects that 13 types of engineering activities have on the ecology of coastal areas. Studies which would significantly improve the understanding of these effects also were identified. The following types of engineering activities were considered: dredging, filling, dams, levees and spillways, diversions, jetties and groins, beach nourishment, land-cut canals, weed control, hurricane barriers, finger-type developments, ocean disposal, and wetlands modification.

38. DAIBER, F.C., "Ecological Effects Upon Estuaries Resulting from Lagoon Construction, Dredging, Filling, and Bulkheading," Division of Fish and Wildlife, Department of Natural Resources and Environmental Control, State of Delaware, Dover, Del., 1975.

Benthic communities of tidal creeks, areas of the open bay, and dredged lagoons in Rehoboth Bay, Indian River Bay, and Little Assawaman Inlet, Delaware, were studied in an attempt to evaluate the biotic and environmental conditions and quality of the dredged areas. Several environmental parameters, including salinity, temperature, and dissolved oxygen of the bottom water, were measured to relate the benthic community structure to the physical and chemical conditions of the environment. Lagoon stations, as a group, were found to have lower numbers of individuals and species and lower species evenness and diversity than marsh or bay stations. These differences were only significant during the summer and fall.

39. DeCOURSEY, J., and VERNBERG, W.B., "The Effect of Dredging in a Polluted Estuary on the Physiology of Larvae Zooplankton," *Water Research*, Vol. 9, No. 2, Feb. 1975, pp. 149-154.

Water samples were obtained from three dredging locations in Charlestown Harbor and from undisturbed control areas. The samples for each location were taken from the dredge site, 183 meters downstream, and the site of the diked disposal area. *Daphinia* were used for location I with a salinity of 0 parts per thousand, *Paleomonetes* for location II with salinities of 8 to 15 parts per thousand, and *Polydora* for location III with salinities of 10 to 13 parts per thousand. Rates of survival, metabolism, and swimming activity of three test species were measured to determine the toxicity level of the water samples. Weir water proved the most toxic; the sample taken 183 meters downstream was intermediate in effect. The water from the dredge site was the least toxic.

40. DINEEN, C., and DARNELL, R.M, "The Effects of Shell Dredging on the Food Habits of Fishes in San Antonio Bay, Texas," *Environmental Impact Assessment of Shell Dredging in San Antonio Bay, Texas,* Vol. III, App. B10-E, Texas A & M Research Foundation, College Station, Tex., Sept. 1973. pp. 225-231.

The fishes of San Antonio Bay may be grouped into five general classes based on their presumed feeding habits. The field capture data show three of the species predominate in the populations inhabiting the bay--the bay anchovy, the large-scale menhaden, and the Atlantic Croaker. These belong to different feeding classes, and the rest of the fish community represents minor variations of these three feeding themes. Further analysis of the possible effects of dredging on the food habits of the fishes must take these factors into account.

41. DURBIN, A.G., "The Role of Fish Migration in Two Coastal Ecosystems: I. The Atlantic Menhaden, *Brevoortia tyrannus,* Narragansett Bay, Rhode Island, II. The Anadromous Alewife, *Alose pseudoharengus* in Rhode Island Ponds," *American Doctoral Dissertations,* University of Rhode Island, Kingston, R.I., 1975-76, and University Microfilms International, Ann Arbor, Mich., 1977.

The impact of the Atlantic menhaden and the anadramous alewife on plankton populations has been examined through laboratory observations of the feeding behavior and filtering rates. Adult menhaden were offered five species of phytoplankton and two species of zooplankton as food. The food ration of 4.5×10^6 kilograms of menhaden, a typical population size in Narragansett Bay, has been estimated both from the energy budget and by assuming that the fish consume an equivalent of 3 percent of their body weight per day. Menhaden are major zooplankton predators and would be capable of reducing zooplankton standing stocks in the upper bay to very low levels in a matter of days.

Sea-run alewives do not feed while in freshwater, and through mortality, excretion, and the release of spawning products, they contribute substantial amounts of nutrients of marine origin to the freshwater systems. Thus the alewife acts as a nutrient source to the system, rather than merely as a means of nutrient regeneration.

42. DURONSLET, J., LYON, J.M., and MARCELLO, F., "Vertical Distribution of Postlarval Brown, *Penaeus aztecus,* and White, *P. setiferus,* Shrimp During Immigration Through a Tidal Pass," *Transactions of the American Fisheries Society,* Vol. 101, No. 4, Oct. 1972, pp. 748-752.

Knowledge of the vertical distribution of postlarvae penaeid shrimp as

they immigrate through tidal passes during night and day is useful in developing accurate and efficient sampling techniques for measuring relative abundance. This study determined the vertical distribution of immigrating postlarval brown and white shrimp through Bolivar Roads Tidal Pass, the major entrance to Galveston Bay, Texas. The average catch of both brown and white postlarval shrimp was highest in the upper 2 meters of the water column at night and at middepths during the day. These depths would probably yield the most accurate abundance estimates of the postlarval populations.

43. EBERT, T.A., "An Experimental Analysis of Sea Urchin Dynamics and Community Interactions on a Rock Jetty," *Journal of Experimental Marine Biology and Ecology*, Vol. 27, No. 1, Apr. 1977, pp. 1-22.

During 1972-73 in Mission Bay, San Diego, California, the biomasses of *Strongylocentrotus purpuratus* (Stimpson) and *S. franciscanus* (A. Ag.) were manipulated in 21 experimental cells constructed on the rocks of the entrance channel breakwater. Cells were set up with *S. purpuratus* only, with *S. franciscanus* only, and with half of the biomass of each species. The rate of change of biomass was positively correlated with original density. Because barriers were not totally effective in restricting movement, the correlation is possibly best interpreted as one of diffusion rather than density-dependent mortality. The difference in the rate of loss between cells with single urchin species and with mixed species may indicate that intraspecific is more intense than interspecific competition.

Individual growth rates were determined and step-wise multiple regression analysis was used to examine the relationships between growth increment and initial size, total biomass, interaction of biomass and initial size, and position along the jetty. Only the original size and the total urchin biomass were significant.

The density of certain marine invertebrates was found to be correlated with urchin biomass. The hard-shelled sessile mollusks *Hinnites multirugosus* (Gage) and *Serpulorbis squamigerus* (Carpenter) were positively correlated, whereas the soft-bodied tunicates *Ciona intestinalis* (L) and *Styela* spp. were negatively correlated.

44. ELSER, A.A., "Fish Populations of a Trout Stream in Relation to Major Habitat Zones and Channel Alterations," *Transactions of the American Fishery Society*, Vol. 97, No. 4, Oct. 1968, pp. 389-397.

The relationship of fish populations to major habitat zones and channel alterations was studied in Little Prickly Pear Creek, Montana, during the summers of 1965 and 1966. Fish populations were estimated, using a simple mark-and-recapture census. Nontrout species were absent from the altered stream sections, but made up 30 and 58 percent of the total number and weight, respectively, in the unaltered stream sections. Trout were 78 percent more abundant in the unaltered sections than in the altered. A statistical test indicated a significant difference between the two trout populations.

45. FAZIO, F.R., "The Effects of Dredging on the Nutrient Cycles of Goose Creek, New York," *American Doctoral Dissertations*, Fordham University, 1968-69, and University Microfilms International, Ann Arbor, Mich. 1977.

A study was conducted for 1 year to determine the effects of dredging on the cycle of nutrients in Goose Creek, New York. Parameters measured were phosphorus, nitrogen, silicate, and chlorophyll. Other variables monitored were temperature, salinity, oxygen, pH, and light. Dredging had no apparent

effect on hydrographic phenomena such as salinity and water currents. Phosphorus and nitrogen did not seem to be affected. Silicate and chlorophyll *a* were affected the most by dredging. Silicate was higher than the previous year in the bay. Chlorophyll *a* concentrations were high during the summer in the bay and channel. In the bay, these high concentrations seemed to be due to benthic rather than plankton algae.

46. FESTA, J.F., and HANSEN, D.V., "A Two-Dimensional Numerical Model of Estuarine Circulation: The Effects of Altering Depth and River Discharge," *Estuarine and Coastal Marine Science*, Vol. 4, No. 3, May 1976, pp. 309-323.

Steady-state numerical solutions are obtained for a two-dimensional, vertically stratified model of a partially mixed estuary. A number of cases are run for various estuarine parameters; the river transport and Rayleigh number being the two parameters that have the most pronounced effect. The river transport is varied by adjusting the mean freshwater velocity. Decreasing it allows salt and stagnant water to penetrate upstream. The estuarine circulation weakens, but expands over a larger part of the estuary. The position of the stagnation point with respect to the seaward boundary varies. Increasing the Rayleigh number by deepening the estuarine channel results in an increased circulation as well as strong intrusion of salinity and inward migration of the stagnation point. The horizontal location of the stagnation point is found to be proportional to the Rayleigh number and, therefore, varies with the channel depth.

47. FRENCH, R.R., and BAKKALA, R.G., "A New Model of Ocean Migration of Bristol Bay Sockeye Salmon," *Fishery Bulletin*, Vol. 72, No. 2, Apr. 1974, pp. 589-614.

A model is presented that describes the ocean migration of Bristol Bay sockeye salmon from the time the fish leave the estuary until they return as adults. Bristol Bay sockeye salmon inhabit extensive areas of the ocean during various stages of their life, ranging across most of the North Pacific Ocean from about longitude 140° W. to near longitude 167° E. and from near latitude 46° N. to latitude to 58° N. in the central Bering Sea. A direct relationship was not found between the distribution and migration of the sockeye salmon and the defined oceanographic features of the subarctic region of the north Pacific Ocean.

48. FUNK, J.L., and ROBINSON, J.W., "Changes in the Channel of the Lower Missouri River and Effects on Fish and Wildlife," Report No. Aquatic Ser-11, Missouri Department of Conservation, Jefferson City, Mo., Nov. 1974.

This report documents changes made in the channel of the Missouri River over the past 90 years and the loss of fish and wildlife habitat associated with these changes. The water surface area of the river between Rulo, Nebraska, and its mouth has been reduced by 50 percent. Islands have been virtually eliminated. The full volume of the river's flow is confined within a relatively narrow channel of rather uniform width. Both the fish of the river and the wildlife have been taken for granted and overexploited.

49. GAYMAN, W., "Offshore Dredging Study: Environmental Ecological Report," *Ocean Management*, Vol. 4, No. 1, Sept. 1978.

Report discusses Israel's plan to dredge 14 million cubic meters of kurkar, a soft calcareous sandstone, each year from the shallow sea floor

in Haifa Bay and off Netanya to supplement and eventually replace onshore sources of kurkar, which is utilized extensively for road construction and maintenance. During the first 10 years the proposed dredging should maximize the area of rock outcrop and the irregularity of the bottom and replace, as much as possible, the submerged ridges and rock outcrops lost by quarrying. All the fauna and flora inhabiting the dredged areas will be destroyed or displaced by the dredging. The new habitats will be partially repopulated with many of the same species that previously lived in the mined area. The dredging operation and the turbid plume generated will probably disrupt fishing in a large part of the bay. The nutrient contribution to the coastal waters and the adverse impact of salt brought ashore with the damp kurkar are not likely to be significant. The Netanya dredging site is closer to the beach than that in Haifa Bay and has a smaller, less diverse biota. However, the deterioration of water quality may be detrimental to its recreational and tourism values.

50. GERKE, R.J., and KACZNSKI, V.W., "Food of Juvenile Pink and Chum Salmon in Puget Sound, Washington," Technical Report No. 17, Washington Department of Fisheries, Olympia, Wash., 1972.

Pink and chum salmon (*Oncorhynchus gorbuscha* and *O. keta*) were collected from three widely separated offshore areas of Puget Sound during April, May, and June 1970 to determine the kinds and types of organisms in their diets. Sampling areas included: (1) Anderson Island (southern Puget Sound), (2) Port Susan (central Puget Sound), and (3) Toandos Peninsula (Hood Canal). Fish collected from the Anderson Island area fed almost exclusively on harpacticoid copepods (95 percent of the stomach contents). Food items consumed at the other sampling sites indicated a more variable diet, including gammarid amphipods, barnacle nauplii, euphausids, hapracticoid copepods, and eggs of invertebrate animals. Epibenthic forms were the predominant food type throughout the sampling period at Anderson Island and during the month of May at the other areas. Interspecific differences in the kinds of organisms consumed were uncommon. The distinct ecological zone that epibenthic forms inhabit makes them extremely susceptible to changes in the beach habitat brought about by domestic and industrial development of intertidal and subtidal areas. Piers, jetties, landfills, marinas, bulkheads, and other facilities that either disturb or destroy beach areas could be highly detrimental to aquatic life, especially the kind that lives in the bottom substrate. These saltwater installations not only remove the living area for economically important fishes, but also eliminate the habitat that supports the food these fish feed on. This could have a great impact on the future of Puget Sound pink and chum salmon stocks.

51. GILMORE, G., and TRENT, L., "Abundance of Benthic Macroinvertebrates in Natural and Altered Estuarine Areas," Technical Report NMFS SSRF-677, National Marine Fisheries Service, Galveston, Tex., Apr. 1974.

The abundance of benthic macroinvertebrates from March to October 1969 in West Bay, Texas, was compared between a natural marsh area, an adjacent marsh area altered by channelization, bulkheading, filling, and an open bay area. Abundance indexes, (area combined) of the four groups of phyla caught were 66.4 percent polychaetes, 29.6 percent crustaceans, 2.5 percent pelecypods, and 1.5 percent nemerteans; volumes were 44.0 percent polychaetes, 40.8 percent pelecypods, 10.7 percent nemerteans, and 4.4 percent crustaceans. All organisms combined were slightly more abundant numerically and more than twice as abundant volumetrically in the marsh than in the canals and were the least abundant in the bay. Polychaetes were most abundant in the canals and

least abundant in the bay; abundance was highest at stations with low to intermediate amounts of silt and clay or where vegetative matter was composed mostly of live seagrasses or detritus. Crustaceans were more abundant in the natural marsh than in the other two areas and showed a definite preference for the sandy substrate in marsh areas. Pelecypods were most abundant numerically in the bay but volumetrically the marsh had the highest standing crop. Nemerteans were most abundant in the marsh and least abundant in the bay.

In general, the seasonal abundance of polychaetes and nemerteans varied little during the study, whereas crustaceans and pelecypods were abundant only during the spring and early summer.

52. GODCHARLES, M.F., "A Study of the Effects of a Commercial Hydraulic Clam Dredge on Benthic Communities in Estuarine Areas," Technical Series No. 64, Florida Department of Natural Resources, Division of Marine Resources, St. Petersburg, Fla., July 1971.

A Maryland soft-shell escalator clam dredge, the *R/V Venus*, was used in a systematic sampling program to study its effect on representative bottom types (habitats) in Tampa Bay and to conduct clam exploration in Tampa and Boca Ciega Bays, the Cedar Keys area, and the Tarpon Springs vicinity. Six experimental stations established in Tampa Bay were visually inspected and sampled with a trynet before dredging and at various intervals after dredging. Benthic plug samples were taken at the final sampling. Sediment samples were also taken to assess textural changes by particle-size analysis. The collected fauna were identified, counted, and in most instances, measured.

After more than a year no recolonization of seagrasses, *Thalassia testudinum* and *Syringodium filiforme*, occurred in any dredged area. Some regrowth of *Caulerpa prolifera* was observed 86 days after dredging. No increase of clam set was detected during the study. Analyses of trynet hauls showed no faunal variations between dredge and control plots at any time after dredging, and benthic plug samples revealed marked faunal differences at only one station. Redredging with the *R/V Venus* revealed no faunal declines except for a marked decrease in quahogs, *Mercenaria campechiensis*, at one station.

53. GUNTER, G., "Mortality of Oysters and Abundance of Certain Associates as Related to Salinity," *Ecology*, Vol. 36, No. 4, Oct. 1955, pp. 601-605.

A field mortality experiment on oysters was carried out from July 1949 to January 1950 in Copano and Aransas Bays on the south Texas coast. Salinities were higher than usual during this period and the water temperatures during the fall and winter were much higher than normal. Mortality of oysters shielded from predators in baskets was low.

54. GUNTER, G., "Some Relations of Faunal Distribution to Salinity in Estuarine Water," *Ecology*, Vol. 37, No. 3, Oct. 1956.

55. GUNTER, G., "Some Relations of Estuarine Organisms to Salinity," *Limnology and Oceanography*, Vol. 6, No. 2, Apr. 1961, pp. 182-190.

Collectors often ignore salinity while carefully gathering other data for locality records of estuarine organisms. There has been a great deal of research indicating that salinity is a limiting factor to the distribution of many marine organisms, especially as it varies downward; these limits are often quite sharp. Some recent evidence is reviewed.

56. GUNTER, G., BALLARD, B.S., and VENKATARAMIAH, A., "Salinity Problems of Organisms in Coastal Areas Subject to the Effect of Engineering Works," Contract Report H-73-3, Office of the Chief of Engineers, U.S. Army, Corps of Engineers, Washington, D.C., 1973.

The nongaseous substances normally moving in and out of animal and plant cells are metabolites, water, and salts. The common salts in seawater determine both salinity and composition. The relationships of salinity to animals and to plants living in the coastal waters are reviewed, with emphasis on the estuaries of the Gulf of Mexico and the Atlantic coast of the United States. Each bay, sound, or estuary is an individual case with regard to salinity and should be appraised by biologists acquainted with the local fauna and flora to minimize and possibly even enhance their biotic potential in connection with salinity changes related to engineering projects.

57. GUNTER, G., CHRISTMAS, J.Y., and KILLEBREW, R., "Some Relations of Salinity to Population Distributions of Motile Estuarine Organisms, with Special Reference to Penaeid Shrimp," *Ecology*, Vol. 45, No. 1, 1964, pp. 181-185.

The types of shrimp species in coastal waters change with wet and dry years and also with wet and dry seasons as salinities either rise or fall. In waters of the northern gulf coast of the United States, the lower salinity limits of the commercial shrimp are: white shrimp (*Penaeus fluviatilis*), 0.42 part per thousand; brown shrimp (*P. aztecus*), 0.80 part per thousand; and pink shrimp (*P. duorarum*), 2.50 parts per thousand. The south Florida waters have very few white shrimp. The brown and pink shrimp are found in these waters and in waters with lower salinity. Investigations have shown that young white shrimp are most abundant in waters with salinities lower than 10 parts per thousand; brown shrimp are most abundant at salinities of 10 to 20 parts per thousand; and pink shrimp are most abundant at salinities of 18 parts per thousand and above. Commercial catch statistics show that the greatest amount of white shrimp are produced in the low salinity waters of Louisiana, the greatest amount of brown shrimp in the saltier bays of Texas, and the greatest amount of pink shrimp around the southern Florida islands where the salinities are oceanic. Three lines of evidence--lower salinity limits, abundance at various salinities by count, and commercial production from areas of different salinities--all indicate that the three commercial shrimp of the south Atlantic and gulf coasts of the United States may be ranked in order of adaptation or "preference" to salinity in the younger stages as low, intermediate, and high for the white, brown, and pink shrimp, respectively. Additionally, pink shrimp have been found in the hypersaline Laguna Madre at salinities of 65 parts per thousand; the other two species have not been found above 45 parts per thousand. This indicates that salinity is a limiting factor to the distribution and abundance of shallow-water penaeid shrimp.

58. GUSTAFSON, J.F., "Ecological Effects of Dredged Borrow Pits," *World Dredging and Marine Construction*, Vol. 8, No. 10, Sept. 1972, pp. 44-48.

Various studies on the effects of suspended sediment, dredge spoil, and borrow pits are reviewed, and a defense of the industry and criticisms of the studies are presented. The typical daily resuspension of bottom material by tides, currents, and winds dwarfs any of man's present activities, such as local dredging. Dredged borrow pits are examples of ecological enhancement and show the healing capacity of nature and the low detrimental effects of most dredge spoils. It is recommended that the industry improve its techniques to

reduce environmental damage and support studies to demonstrate the benefits of dredging.

59. HALES, L.S., and CALDER, D.R., "A Study of Fish and Shellfish Migration Across the Weir of Weir-Jetty, Murrells Inlet, South Carolina," Summary Report, Marine Resources Research Institute, South Carolina Wildlife and Marine Resources Department, Charleston, S.C., 1979.

The weir jetty system currently under construction at Murrells Inlet, South Carolina, embodies a unique new concept in the design of such structures and is one of several comparable jetty projects planned as navigational improvements in other coastal areas of the United States. One of the major environmental concerns in the construction of a jetty is its influence on the movement of aquatic species to and from estuarine nursery grounds. Jetties may have a significant impact on the migration of fishes and motile invertebrates, such as crabs and shrimp, into estuaries thereby affecting the commercial and recreational fisheries of an area. Because the weir section is underwater during a part of the tidal cycle, this jetty design conceivably presents less of a barrier to nektonic and planktonic species entering and leaving an inlet than a typical nonweir jetty. This report describes a study designed to monitor the movement of planktonic and nektonic species across a weir during periods of high tide.

60. HANSEN, D.R., and MUNCY, R.J., "Effects of Stream Channelization on Fishes and Bottom Fauna in the Little Sioux River, Iowa," Project No. A-035-IA, Iowa State Water Resources Research, Iowa State University, Ames, Iowa, June 1971.

Differences in certain physical factors, bottom fauna, and fish populations were evaluated in channelized and unchannelized parts of the Little Sioux River, Iowa, during 1969-71.

Composition of bottom fauna was similar in the two sections. Colonization of macroinvertebrates on artificial substrates suggested a lack of suitable attachment areas in the channelized section. The higher numbers of drift organisms in the channelized section were further evidence of this; the numbers of fish species were greater in the unchannelized section.

Unbaited hoopnet catches in the unchannelized section revealed the presence of more large channel catfish, the most important game species, than in the channelized section. Hoopnet catches and primacord explosive samples collected greater numbers of smaller channel catfish (less than 254 millimeters) in the channelized section during late summer and early fall. Because of a possible downstream movement from the unchannelized section into the channelized section, suggested by movement studies and similar growth rates, drastic differences in standing crops of fish were not measurable in comparisons of the two areas.

61. HARPER, D.E., "Effects of Siltation and Turbidity on the Benthos and Nektons," *Environmental Impact Assessment of Shell Dredging in San Antonio Bay, Texas*, Vol. V, App. D5, Texas A & M Research Foundation, Sept. 1973, pp. 114-123.

During dredging the average number of benthos was reduced compared with predredging samples. However, when the dredging stopped, the fauna in the affected area began to recover, aided by recruitment during the winter. At the time of the postdredging survey, there were about half as many individuals in the dredged area as in the control area. This indicates that recovery of benthos can occur quickly.

In winter the average number of nekton and their biomass were higher in turbid water than in clear water, while in summer the average number of nekton (and presumably the biomass) were similar in both turbid and clear water. Furthermore, only 1 of 12 dominant species in the experimental trawls appeared to be repelled by turbid water and this species may not actually be responding to the silt. The data indicate that the mud plume from an operating dredge is not repellent to nektonic organisms and may be beneficial by providing protection against predators.

62. HASTINGS, R.W., "The Origin and Seasonality of the Fish Fauna on a New Jetty in the Northeastern Gulf of Mexico," unpublished Ph.D. Dissertation, Florida State University, Tallahassee, Fla., 1972.

A 2.5-year study was conducted of successional and seasonal changes of fish fauna around a newly constructed jetty at East Pass, Choctawhatchee Bay, Florida. Information was obtained by diving observations and specimen collection. Observations were also made and compared with older jetty habitats. The jetties were colonized soon after construction by species common to the area originally, by species from other habitat areas such as offshore reefs, and by tropical species carried by currents.

63. HEADRICK, M.R., "Effects of Stream Channelization on Fish Populations in the Buena Vista Marsh, Portage County, Wisconsin," Wisconsin Cooperative Fishery Research Unit, Fish and Wildlife Service, Office of Biological Services, Steven Point, Wis., Sept. 1976.

Fish populations from ditches 6 to 8 years old and 52 to 62 years old within the Portage County Drainage District were compared with populations in adjacent parts of natural streams. Two study areas were selected: an upstream zone of plentiful brook trout (*Salvelinus fontinalis*) and a downstream zone in marginal trout waters where white suckers (*Catostomus commersoni*) were numerous. Each area included a new ditch, an old ditch, and a natural stream, all with similar discharge. Estimates of the annual production, population, and biomass of brook trout and white sucker, and the total catch records for other fish species were derived from electrofishing samples in June, August, and September 1974 and April, May, July, and September 1975. A creel survey was conducted during the 1975 trout season.

64. HELFRICH, P., "An Assessment of the Expected Impact of a Dredging Project for Pala Lagoon, American Samoa," UNIH 1-SEAGRANT-TR-76-02, University of Hawaii, Honolulu, Hawaii, Oct. 1975.

Dredging of the harbor at Pala Lagoon in American Samoa would have detrimental environmental effects. Altering of the sill near the lagoon entrance would affect the biota. It also was concluded that the flow of raw sewage into Pala Lagoon could be dangerous to persons swimming in and collecting seafood from the lagoon.

65. HENEGAN, D.L., and HARMON, K.W., "A Review of References to Channelization and Its Environmental Impact," *Stream Channelization; A Symposium*, Special Publication No. 2, American Fisheries Society, Dec. 1971, pp. 79-83.

References to stream channelization and its environmental impacts are not easy to locate. Few such studies find their way into the formal literature. This report provides the references that are available.

66. HERBICH, J.B., "Environmental Effects of Dredging," *Proceedings of the Fifth World Dredging Conference*, June 1973, pp. 699-719.

This paper summarizes the present state-of-the-art of the effects of dredging on the environment. The possible advantageous effects include: removal of polluted bottom sediment for storage or treatment, change in flow patterns, reoxygenation of sediments and the water columns, and resuspension of nutrients. The possible deleterious effects include: removal or burial of habitats, change in the flow pattern, resuspension of polluted bottom sediments, and a possible barrier to the movement of marine life.

67. HILLMAN, R.E., "Effects of Dredging on Marine Ecology," *World Dredging and Marine Construction*, Vol. 7, No. 7, June 1971, pp. 25-27.

Several techniques for collecting samples for the assessment of the impact of dredging on the environment are discussed. Techniques for data sampling before, during, and after dredging will pinpoint the ecological effects of dredging on aquatic organisms. These techniques are utilized with the goal of producing data suitable for use in constructing mathematical models that stimulate events occurring in nature and give the models predictive capability.

68. HIRSCH, N.D., DiSALVO, L.H., and PEDDICORD, R., "Effects of Dredging and Disposal on Aquatic Organisms,"Vicksburg, Miss., Technical Report DS-78-5. *Dredged Material Research Program*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., 1978.

This report synthesizes data from the U.S. Army, Corps of Engineers' Dredged Material Research Program (Task 1D) that investigated the direct and indirect effects of dredging and the disposal of dredged material on aquatic organisms. Direct effects of dredging and disposal are restricted to the immediate area of operation. They include the removal of organisms at dredging sites and the burial of organisms at disposal sites. Data indicate that the recovery of disturbed sites occurs over periods of weeks, months, or years. Possible mechanisms of recolonization include lateral and vertical migration of organisms and larval recruitment. Disturbed sites may be recolonized by opportunistic species, which are not normally the dominant species occurring at nearby undisturbed sites.

Most organisms studied were relatively insensitive to the effects of sediment suspension in the water. Dredging-induced turbidity is probably not of major environmental concern in most cases, but may be an esthetic problem. The formation of fluid mud due to dredging and disposal is a poorly understood process and is of probable environmental concern. Available data indicate that suspensions of highly contaminated sediments have a greater potential for adverse effects than uncontaminated or lightly contaminated sediments.

Bioavailability of sediment-absorbed heavy metals is low. The release of

sediment-associated heavy metals and their uptake into organism tissues have been found to be the exception rather than the rule. Research results suggest that there is little or no correlation between the bulk sediment content of heavy metals and the environmental impact. Oil and grease residues, like the heavy metals, seem tightly bound to sediment particles and accumulation of these residues by organisms is minimal.

69. HOESE, H.D., "Effects of Higher than Normal Salinities on Salt Marshes," *Contributions in Marine Science*, University of Texas, Austin, Tex., Vol. 12, July 1967, pp. 249-261.

Salt marshes exist in a variety of salinity conditions including: (a) where salinity seldom falls below 30 parts per thousand, (b) where waters may become fresh at times, and (c) where salinity may exceed 40 parts per thousand. Most, however, exist in waters between about 10 to 30 parts per thousand. Increasing salinity may move the salt-brackish-freshwater boundaries landward as has occurred in Louisiana.

Increase in salinity allows many high salinity organisms to invade landward, which may cause immediate harm to fisheries. The effects of rising salinities are unknown for all salt marsh animals and plants and may differ. Also, as salinity rises there are changes in other important factors that vary among salt marshes. There is little proof that primary productivity will increase with rising salinity, but it may follow different channels. The U.S. Atlantic and Gulf of Mexico salt marsh system is based on *Spartina alterniflora* and would probably be destroyed if salinity approached 50 parts per thousand. The effects of lower salinities are much less certain and require intensive study.

70. HOESE, H.D., "Fauna of the Aransas Pass Inlet, Texas: III Diel and Seasonal Variations in Trawlable Organisms of the Adjacent Area," *The Texas Journal of Science*, Vol. XX, No. 1, May 1968, pp. 33-60.

This study had three objectives: (a) to study catch variations during a 24-hour period each season, (b) to compare these seasonal changes with daytime monthly collections of invertebrates, and (c) to estimate the growth of organisms taken in the bay. The first objective was undertaken to determine the diel occurrence in relation to seasonal life stages and environmental conditions. The second objective was undertaken to equate diel differences with previous trawl collections made during the day so that more realistic population measurements could be derived. Four 24-hour trawl samples consisting of 10-minute trawls every hour were conducted on 20-21 October 1964, and 8-9 February, 29-30 April, and 18-19 August 1965 in the Aransas Bay. One 24-hour trawl sample, consisting of a 10-minute trawl every 6 hours, was conducted at 6 and 9 fathoms in the Gulf of Mexico on 12-13 November 1965. Seasonal trawl collections were made from February 1964 through January 1965 at 3, 6, 9, 12, and 15 fathoms in the Gulf of Mexico and at the station in Aransas Bay that was sampled for diel differences.

71. HOHN, M.H., "The Use of Diatom Populations as a Measure of Water Quality in Selected Areas of Galveston and Chocolate Bays, Texas," *Publications of the Institute of Marine Science*, Vol. 6, University of Texas, Austin, Tex., 1959, pp. 206-212.

Analyses have been made of the diatom populations from several areas in Chocolate and Galveston Bays, Texas. The results of these analyses were compared with the results of concurrent biological surveys. A chi-square test indicated the Catherwood Diatometer developed random, reproducible samples of diatoms. The drastic change in the shape of the diatom curve in polluted environments was correlated with a similar change in the species diversity. The structure of the diatom flora was the same as that previously found in Chesapeake Bay, Maryland, under similar ecological and chemical conditions.

72. HOPKINS, S.H., "Use of the Clam *Rangia cuneata* as an Indicator of Ecological Effects of Salinity Changes is Brackish Coastal Waters," Report to the Office of the Chief of Engineers, U.S. Army, Corps of Engineers, Washington D.C., Jan. 1973.

The clam *Rangia cuneata* lives in the low salinity brackish zone of tidal rivers and bays from Maryland to Texas (and Mexico). In this zone, where the clam may make up 99 percent of the benthic biomass, it is a key species in the ecosystem, converting algae and plant debris to meat used by many fishes, crustaceans, wild fowls and man. It is also an important commercial species worth tens of millions of dollars annually for shell and meat.

Because the clam requires variable salinity between 2 and 10 parts per thousand for successful reproduction, it can be used as an indicator of salinity and of the ecological effects of salinity changes. Measurements of a large sample of the population will show whether recruitment is occurring, and how often. The Corps' Mermenteau project in Louisiana is used as an example to show how this information can be applied in the management of a coastal engineering project.

73. HUGHES, D.A., "Orientations of Migrating Pink Shrimp," *National Geographic Society Research Reports: 1966 Projects*, P.H. Oehser, ed., National Geographic Society, Washington, D.C., 1966, pp. 127-129.

This study determines the movements of postlarvae and juvenile pink shrimp within inshore waters where there are distinct ebbtides and floodtides. Field sampling indicates that postlarvae entering the estuaries are caught almost exclusively in floodtides and juveniles leaving the estuaries are caught predominantly in ebbtides. The mechanism causing this discrimination between tides and the utilization of the tides by the shrimp were examined. Early experiments on this project yielded negative results when the "preference" of postlarvae for waters of different salinity and ionic constitution was tested in a Y-maze situation.

The behavior of postlarvae and juveniles was observed in the laboratory within currents of water, the "quality" of which was altered during the experiments. Preliminary results showed that salinity changes affect the levels of activity and the direction of swimming with respect to the current of both postlarvae and juveniles.

74. HUGHES, D.A., "On the Mechanisms Underlying Tide-Associated Movements of *Penaeus duorarum* (Burkenroad)," Food and Agriculture Organization of the United Nations, Fisheries Report, Vol. 3, No. 57, 1967, pp. 867-874.

Postlarval shrimp move inshore in floodtides while juveniles move in ebbtides. This appears to be caused by the postlarvae and juveniles response to

changes in salinity. Juveniles are positively rheotactic within a current of water. However, when the salinity of that water is decreased, downstream swimming ensues. There is evidence that the responsiveness of juveniles to decreases in salinity is under rhythmic control. The postlarvae respond to a decrease in salinity by dropping to the substrate, where they remain inactive and evade displacement by the ebbtide. When the salinity increases (floodtide) they become active in the water column and are displaced inshore.

The apparent dependence of tide-associated movements on changes in salinity is indicated by the extent of rainfall in the vicinity of "nursery" areas and the commercial catch of the following year.

75. HURME, A.K., "Rubble-Mound Structures as Artificial Reefs," *Proceedings of the Specialty Conference on Coastal Structures 79*, American Society of Civil Engineers, Vol. 2, Mar. 1979, pp. 1042-1051 (also Reprint 79-4, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Aug. 1979, NTIS A073277).

Structures armored with rubble can have a positive effect on coastal ecology by functioning as artificial reefs, particularly when they are placed in areas with a barren bottom. The desirable qualities of these reef structures are frequently overlooked. Many people think of rubble groins, jetties, and breakwaters as desirable places to fish, but do not realize that the structures themselves have a major influence on the success of their fishing.

Creating fishing reefs through the placement of solid materials in coastal waters has a long history of success and has helped support a fishery that contributes millions of dollars to coastal recreation. Rubble-mound structures (constructed by the U.S. Army, Corps of Engineers) are ideal artificial reefs. They are built of natural stone and have many varying sized cracks and crevices exposed to the entire water column so they can be colonized by the greatest diversity of reef dwellers. Most potential environmental problems can be overcome by careful planning and site selection. Although benefits appear great, quantifying them is a difficult task. From both the standpoint of biomass and sport-fishing success, rubble-mound reefs are biologically highly productive.

76. HUTTON, R.F., "The Ecology of Boca Ciega Bay With Special Reference to Dredging and Filling Operations," Technical Series, Vol. 17, No. 1, Florida State Board of Conservation, Tallahassee, Fla., 1956.

The study shows that the proposed "furen fill" and the proposed "green fill" would seriously damage the sports and commercial fishing in the Boca Ciega Bay area. The bay provides protected animal habitats, breeding, and feeding grounds for marine animals. The greatest variety and number of animals occur in areas where attached turtle grass is abundant. Dredging and filling operations on submerged banks of turtle grass are harmful to the associated plant life and destroy feeding and breeding grounds. There is some evidence that dredging operations, under certain conditions, may be beneficial to filter feeders such as some echinoderms, ascidians, and sponges.

77. INGLE, R.M., "Studies on the Effects of Dredging Operations Upon Fish and Shellfish," Technical Series No. 5, Florida State Board of Conservation, Division of Oyster Culture, Tallahassee, Fla., Oct. 1952.

Scalefish and mobile crustacea were not damaged within 23 to 46 meters of an active dredge. In the immediate vicinity of the dredge, large mud particles damaged the bottom, but the effect did not extend beyond 366 meters. Controlled dredging is suggested as the method whereby local conditions, spatial and temporal, are considered. Shellfish did not suffer damage when they were suspended from the dredge itself. Sediment transport is considered in detail. Because of water currents, fine particles would probably not remain on oyster reefs long enough to cause mortality of oysters.

78. IPPEN, A.T., "Saltwater, Freshwater Relationships in Tidal Channels," *Proceedings of the Second Annual Conference on American Water Resources*, Nov. 1966, pp. 47-55.

The interaction of tidal currents and riverflow in estuaries and tidal canals has been subject to extensive analytical studies. The most important engineering conclusions concerning salinity intrusion into tidal channels as a result of density differences between saltwater and freshwater are reviewed. Changes in the salinity environment and associated shoaling patterns due to man's interference are now predictable in recent research.

79. JAMES, W.P., et al., "Environmental Considerations Relating to Operation and Maintenance of the Texas Gulf Intracoastal Waterway," Sea Grant Report TAMU-SG-78-204, Texas A&M University, College Station, Tex., Nov. 1977.

This study identifies potentially adverse environmental factors other than dredging associated with the operation and maintenance of the Texas Gulf of Mexico Intracoastal Waterway. Field sampling was conducted to ascertain the background water and sediment quality. A numerical model study was done to analyze the flow between Galveston Bay and Sabine Lake. Satellite imagery was used in the lower Laguna Madre to study the circulation patterns and sedimentation rates.

80. JOHNSON, G.F., and DeWIT, L.A., "Ecological Effects of an Artificial Island, Rincon Island, Punta Gorda, California," MR 78-3, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Sept. 1978.

This study documents marine ecological conditions at Rincon Island, located approximately 0.8 kilometer offshore between Ventura and Santa Barbara, California. The island was constructed between 1957 and 1958 to serve as a permanent platform for oil and gas production.

81. JOHNSON, R.K., "Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal. Appendix I. Production and Distribution of Fish Eggs and Larvae in C and D Canal," Report No. NRI-REF-72-16, University of Maryland, National Resources Institute, Solomons, Md., Sept. 1973.

The Chesapeake and Delaware (C and D) Canal connecting the Delaware River estuary with the Chesapeake Bay is one of the more important spawning and nursery areas for striped bass in the Chesapeake Bay region. Eggs, larvae, and juveniles of 20 species of fishes and young fishes of varying (by season) species are found in the canal area throughout the year. An analysis of data resulting from 2 years of sampling effort has revealed this area to be

a low salinity nursery area for fish species that spawn in fresh, brackish, or marine waters. An analysis of all available data failed to indicate if hydraulic effects of the canal enlargement, presently underway, will be detrimental to the reproduction of any species of fish utilizing this area.

82. JUNE, F.C., and CHAMBERLIN, J.L., "The Role of the Estuary in the Life History and Biology of the Atlantic Mehaden," *Proceedings of the 11th Annual Session of the Gulf and Carribean Fish Institute,* 1959, pp. 41-45.

This summary of findings is from a 6-year study of Indian River, Delaware, and 34 other east coast estuaries on the relationship between the estuaries and the life history of the Atlantic menhaden. Food availablilty, salinity, soil quality, and water temperature are all characteristics of the estuaries that govern the distribution, development, growth, and emigration of the fish. Problems in studying the estuaries are discussed.

83. KAPLAN, E.H., WELKER, J.R., and KRAUS, M.G., "Some Effects of Dredging on Populations of Macrobenthic Organisms," *Fishery Bulletin,* Vol. 72, No. 2, 1974, pp. 445-480.

Populations of epifauna and infauna were studied from 10 months before to 11 months after a navigation channel was dredged through a small, shallow lagoon. Current velocities and sedimentation patterns were changed due to an altered distribution of tidal currents, although flushing time was not appreciably altered. Values of certain particulate and dissolved nutrients changed after dredging, but no correlation was observed between animal populations and fluctuations in nutrients. Productivity of the study area was calculated at 89.87 grams per square meter per year before dredging and 31.18 grams per square meter per year after dredging. Productivity figures for the mixed peripheral marsh were calculated and the annual loss due to replacement of 10.87 hectare of marsh by spoil areas was estimated at 49,487 kilograms. Altered land usage patterns tended to fix this loss on a permanent basis.

84. KAPLAN, E.H., "Some Factors Affecting the Colonization of a Dredged Channel," *Marine Biology,* Vol. 32, No. 2, Sept. 1975, pp. 193-204.

Standing crop, population size, and species diversity of the macrobenthic organisms in an estuarine channel were studied before and after dredging. A new suction corer, which sampled an area 0.1 square meter to a depth of 30 centimeters, was used to insure the inclusion of large, deep-dwelling animals. Eleven months after dredging, the biomass and the number of species and specimens had not recovered to predredging levels. Colonization began with relatively large, mobile forms such as the polychaete *Nereis succinea* and the crab *Neopanope texana.* Stations in silt and mud regions recovered more slowly than those in sandier sediments. The previously abundant polychaetes *Notomastus latericeus* and *Clymenella torquata* had virtually disappeared. Only relatively uncommon lamellibranches such as *Tellina agilis, Lyonsia hyalina,* and *Mulinia lateralis* increased after dredging. Distribution of sediment types changed as the result of modified tidal velocities in the channel. Mud and silt were removed by the dredge, exposing the sand underneath, and sandy stations became muddier as the result of lowered current velocities. Marked changes in species composition reflected this change in sediment character.

85. KEITH, J.M., and SKJEI, R.E., "Engineering and Ecological Evaluation of Artificial Island Design, Rincon Island, Punta Gorda, California," TM-43, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Mar. 1974.

Rincon Island is a manmade offshore island composed of armor rock and tetrapod revetments enclosing a sand core. An evaluation after 14 years showed: no damage by waves, littoral transport has been unaffected, little subsidence has occurred; and a thriving community of marine organisms has developed.

86. KING, B.D., III, "Study of Migratory Pattern of Fish and Shellfish Through a Natural Pass," Technical Series No. 9, Texas Parks and Wildlife Department, Austin, Tex., 1971.

The movements of commercially important species of fish and crustaceans through Cedar Bayou Inlet, Texas, were monitored to determine the spatial distribution and seasonality of each species and to identify environmental factors that cause or affect movements between oceanic and estuarine waters. The species studied included the brown shrimp, pink shrimp, white shrimp, blue crab, red drum, southern flounder, sheepshead, and spotted sea trout.

Data concerning the seasonal abundance and vertical and horizontal distribution of each species are presented, and the results of a statistical analysis of correlated environmental variables are discussed.

87. KOHLENSTEIN, L.C., "On the Proportion of the Chesapeake Bay Stock of Striped Bass that Migrate into the Coastal Fishery," *Proceedings of Session on Advances in Striped Bass Life History and Population Dynamics*, 108th Annual Meeting, American Fisheries Society, Aug. 1978.

Past observations of year-class patterns and racial characteristics have indicated that the Chesapeake Bay spawning grounds provide the principal support of the coastal striped bass fishery. However, past tagging studies indicate that only a few percent of the striped bass leave the bay. These observations are contradictory since a few percent of the Chesapeake Bay stock could not support the majority of the coastal fisheries.

The present work includes a reexamination of the tagging studies conducted during the 1957-61 period by the Chesapeake Biological Laboratory in the Potomac River. The studies examined age-specific sex ratios at several positions in the Potomac River during the spawning season. The analysis indicates that few young males leave the bay and that approximately one-half of the 3-year-old females migrate to coastal waters.

88. KOMAR, P.D., and TERICH, T.A., "Changes Due to Jetties at Tillamook Bay, Oregon," *Proceedings of the 15th Conference on Coastal Engineering*, ASCE, American Society of Civil Engineers, Vol. II, July 1976, pp. 1791-1811.

Bayocean Spit, separating Tillamook Bay from the Pacific Ocean on the north Oregon coast, underwent severe erosion following construction of a north jetty at the bay entrance in 1914-17. The shoreline north of the north jetty advanced seaward by about 600 meters. This pattern of erosion and deposition following jetty construction has generally been interpreted as the jetty blocking the north to south net littoral drift in the area. A study of the shoreline changes and

patterns of erosion and deposition following jetty construction disagreed with the earlier study and it was concluded that the changes resulted from local rearrangements of the beach due to the disrupted equilibrium following jetty construction, but at the same time maintaining an overall condition of zero net littoral drift. Thus, severe coastal erosion can result from jetty construction, even in areas of zero net littoral drift.

A new south jetty has been recently completed. This jetty has resulted in further realinement of the shoreline with accretion and shoreline advance immediately south of the south jetty. This provides further evidence that a zero net littoral drift exists in the area.

89. KUENZLER, E.J., et al., "Water Quality in North Carolina Plains Streams and Effects of Channelization," Report No. 127, University of North Carolina, Water Resources Research Institute, Chapel Hill, N.C., Oct. 1977.

A study was made of the physical and chemical characteristics of seven small Coastal Plain streams in eastern North Carolina. Three natural streams were compared with four streams that had been channelized to reduce agricultural losses caused by flooding. Two or three sampling stations were established on each stream. Some stations on natural streams were essentially pristine, but others received point-source inputs of livestock farm wastes. The natural streams had broad flood plains and low stream velocities, even during flood stages. Freshets occurred in all seasons, but high discharge and concomitant flooding of natural swamps were usually greatest during the winter and spring. The waters of channelized streams, however, were restricted; they attained higher velocities, carried greater particulate loads, and were more turbid than natural streams. Some channelized streams were enriched by sewage, by livestock wastes, or by agricultural fertilizer.

90. KUTKUHN, J.H., COOK, H.L., and BAXTER, K.N., "Distribution and Density of Prejuvenile *Penaeus* Shrimp in Galveston Entrance and the Nearby Gulf of Mexico (Texas)," Food and Agriculture Organization of the United Nations Fisheries Report No. 57, Vol. 3, 1967, pp. 1075-1099.

In early 1959 the Bureau of Commercial Fisheries began a study to determine when, from what direction, at what stage of development, under what conditions, and in what quantity prejuvenile shrimp of the commercially important *Penaeus* enter the extensive Galveston (Texas) estuary. The findings were to aid in circumscribing offshore spawning areas and thereby provide information on the degree to which the progeny of shrimp reproducing in each area are nurtured in specific estuaries bordering the northern Gulf of Mexico.

An analysis of more than 3,000 samples collected systematically during a 1-year period revealed the following: the frequency of sampling, although high, was insufficient to trace the rapid onshore movement of recently hatched broods of *Penaeus;* the gross horizontal distribution of *Penaeus* larvae and postlarvae in the gulf and vertical distribution of postlarvae in the Galveston entrance changed markedly from season to season; *Penaeus* larvae rarely occurred within 10 kilometers of shore and were not bottom dwellers; *Penaeus* postlarvae did not frequent the bottom in winter and otherwise were usually more abundant at middepths than at the bottom. For estimating density of prejuvenile penaeids, the study's sampling scheme was relatively efficient in controlling spatial variation, but comparatively inefficient in accounting for wide temporal variation in organism abundance.

91. KYTE, M.H., AVERILL, P., and HENDERSHOTT, T., "The Impact of the Hydraulic Escalator Shellfish Harvester on an Intertidal Soft-Shell Clam Flat in the Harruseeket River, Maine," Project NOAA - NMFS-3-170-R, Main State Department of Marine Resources, Augusta, Me., Mar. 1975.

A hydraulic escalator shellfish harvester originally developed by Fletcher Banks in Maryland has been the basis of a significant fishery on *Mya arenaria*, the soft-shell clam, for the last 20 years in the Chesapeake Bay. The similarity to actual dredging has caused much concern to be expressed over the impact of the harvester on the stocks of clams and on the associated biota and environment. An attempt was made to establish an escalator harvester fishery in Maine. The rather alarming appearance of a turbidity plume and the harvesting scars prompted the initiation of an impact study. The report details that study. The development, impact study, and fishery history are briefly reviewed. The impact study performed in Maine was specifically located in an area characterized by a silt-clay mudflat.

92. LEATHEM, W., "Effect on Spoil Disposal or Benthic Communities Near the Mouth of Delaware Bay," *Marine Pollution Bulletin*, Vol. 4, No. 8, Aug. 1973, pp. 122-125.

Hydrualic dredging and spoil disposal behind the inner breakwater in Delaware Bay had an impact at distances over several kilometers from the site of operations. While the dissolved oxygen and the density of animals fell in the areas immediately affected, the total impact of this operation appears to have been small. There might have been some recruitment of animals to the spoil areas after the operations. The greatest damage to benthic macroinvertebrates occurred in the dredging and dump sites, which demonstrated significant changes in community structure due to reduced numbers. However, oxygen saturation returned to predredging values within 3 months, indicating that potential damage to the benthos was probably negligible.

93. LEHMAN, E.J., "Dredging: Biological Effects," *Citation*, National Technical Information Service, Springfield, Va., Dec. 1979.

This is a citation of federally funded research covering the relationship of dredging to biology in estuaries, marshes, harbors, channels, and waterways. Some of the topics include the wildlife habitat of dredge spoil sites, ecosystem studies, and the detrimental effects of dredge material.

94. LEVINGS, C.D., "Consequences of Training Walls and Jetties for Aquatic Habitats at Two British Columbia Estuaries," *Coastal Engineering*, Vol. 4, Elsevier Scientific Publishing Company, Amsterdam, 1980, pp. 111-136.

The effects of training walls and river channelization on macroinvertebrates and their habitats were studied at the Squamish and Fraser River estuaries in southwestern British Columbia. A similar, but undisturbed estuary, the Homathko, was also examined. Training walls deflected freshwater from sectors of the Fraser and Squamish estuaries, whereas the Homathko salinity distributions were uniform across the delta front. At the Squamish estuary, the training wall has allowed penetration of a salt wedge into a former river channel; the flow of water in culverts through the wall has only a local mitigative effect. Erosion is continuing in the trained part of the Squamish River, but important intertidal habitats behind the wall have remained unchanged for 6 to 7 years. Sediments stabilized or redistributed by river channelization

at Squamish have been rapidly colonized by invertebrates. To assist in the design of programs to monitor the environmental effects, a table showing the time scale of various impacts is presented.

95. LIMOGES, L.D., "In Tampa Bay: Dredge Fill Replaces Estuaries," *World Dredging and Marine Construction*, Vol. 12, No. 12, Nov. 1976, pp. 10-14.

A shallow-water bay and a marshy shoreline impeded Tampa Bay's development. The two most utilized methods of modifying the bay's environment are dredging and filling, generally within the limits of the bay itself or its marshy shoreline. The utilization of fill in Tampa Bay has stimulated controversy among developers, preservationists, public officials, and the general public.

96. LINDALL, W.N., Jr., "Alterations of Estuaries of South Florida: A Threat to Its Fish Resources," *Marine Fisheries Review*, Vol. 35, No. 10, 1973, pp. 26-33.

Based on unpublished data from 1966 to 1970, about 85 percent of the commercial fish and shellfish caught in south Florida consist of estuarine-dependent species. The annual harvest of these species averaged more than 36 million pounds. It is estimated that the majority of the species taken by anglers are estuarine dependent and are responsible for about $575 million of the State's annual tourist industry. Man's alterations of the estuaries are threatening these fish resources. Some of the major alterations, reduction of freshwater runoff, domestic and industrial pollution, pesticide contamination, thermal addition, dredging, and filling are discussed.

97. LINDALL, W.N., HALL, J.R., and SALOMON, C.H., "Fishes, Macroinvertebrates, and Hydrological Conditions of Upland Canals in Tampa Bay, Florida," *Fishery Bulletin*,Vol. 7, No. 1, 1973, pp. 155-163.

Faced with statutory restraints that prohibit dredging and filling of estuarine bottoms, coastal developers have turned to alternate methods of providing waterfront property for homesites. One method, recently used in Tampa Bay, Florida, is the construction of access canals that lead from open water to upland acreage. This paper presents biological and hydrological data from new upland canals together with some comparative data from older upland and bay-fill canals. In all types of presently engineered canals, stratified, stagnant water causes low levels of dissolved oxygen in the summer months, resulting in mortality or emigration among resident organisms. Means of alleviating the problems are discussed.

98. LONGWORTH, C.R., and FERGUSON, N.J., "Ecological and Environmental Aspects of Dredging and Port Construction," *SEATEC 77: The Dredging and Construction of Ports for Developing Countries, Singapore*, Intel Press, Ltd., 1977.

This paper discusses the general planning and environmental considerations associated with dredging and port works, including appropriate examples . As a practical approach to planning, economic considerations are an important part of both environmental and engineering problems.

99. MACKIN, J.G., "Canal Dredging and Silting in Louisiana Bays," *Publications of the Institute of Marine Science*, Vol. 8, University of Texas, Austin, Tex., 1962, pp. 262-312.

The effects of dredging on oysters were studied in the shallow bays of Louisiana and discussed relative to the normally high turbidities of an eroding marsh area. Data were taken from unpublished reports of the Texas A & M Research Foundation. Three case histories of dredging were followed: a hydraulic dredge depositing a spoil island, a clam dredge operating in a canal, and a hydraulic dredge depositing in a half-fan circle. Turbidities beyond a few hundred meters of the dredges did not exceed the natural levels and experiments showed no harmful effects on the oysters that were tested.

Experiments indicate that dead oysters did not consume oxygen during decomposition at rates much greater than live oysters. The oxygen demand of sediments dispersed in dredging was relatively less than that of surface sediments. Oxygen depletion with dredging in Louisiana marshes was found to be a relatively minor factor not responsible for mortality.

Cores were compared microscopically in control areas, in areas receiving light silt from dredging, and in areas of heavy silt deposit in spoil deposition. Soft silt conditions affecting the distribution of oyster reefs were traced to marsh erosion, disintegration, and subsidence, with cores unmistakably different from those in spoil deposits.

100. MANNING, J.H., "The Maryland Soft Shell Clam Industry and Its Effects on Tidewater Resources," Research Study Report 11, Maryland Department of Resources and Education, Annapolis, Md., 1957.

Hydraulic clam dredging results in: (a) Displacement and deposition of measurable quantities of sediment up to about 23 meters downcurrent from the dredged area; (b) essentially the complete mortality of oysters within the dredged area; (c) significant mortality of oysters 8 meters downstream from the dredged area; (d) possible mortality of oyster spat up to 23 meters downcurrent; and (e) no mortality of oysters or spat at distances greater than 23 meters from the dredged area. Effective revegetation of commercially productive clam bottoms is not to be expected because dredging intervals will be too frequent to permit repopulation by plants.

101. MARSH, J.A., Jr., and GORDON, G.D., "Marine Environmental Effects of Dredging and Power-Plant Construction in Piti Bay and Piti Channel, Guam," Technical Report 8, Guam College Marine Laboratory, Agana, Guam, May 1974.

Effects of construction activities in Tepungan Channel and the adjacent reef flats of West Piti Bay were investigated with the use of a telethermometer, sampling programs, and dye tracer studies. The major long-term environmental effect caused by the dredging and construction activities was the inadvertent damage to the coral community in the western end of Piti Bay. The coral community has now been replaced by an algae-echinoderm community. The outlook for eventual restoration of the original coral community is uncertain. The biological community in the newly enlarged channel itself is rather sparse. Water turbidities on the Piti reef flats have returned more or less to normal. No evidence was found that operations of the Piti plant or construction activi-

ties for the Cabras Island plant were affecting levels of dissolved oxygen, phosphorous, nitrate, nitrite, salinity, or pH in the outfall areas.

102. MARSHALL, A.R., "Dredging and Filling," *Proceedings of the Marsh and Estuary Management Symposium*, Louisiana State University, 1968, pp. 107-113.

The direct and indirect effects of dredging and filling on the fish and wildlife resources of Florida's estuarine and freshwater habitats are discussed. The problems discussed include: direct destruction of swamp marsh and bay bottom habitat in the immediate project area; destruction of spawning and nursery habitat by siltation; reduction of light penetration in the water; creation of anerobic bottom conditions; and reduction of nutrient outflow from Tampa Bay, Biscayne Bay, Indian River, and the St. Johns River illustrate the impacts of these operations on Florida's fish and wildlife resources.

103. MASSEY, L.L., et al., "Bibliography of Coastal Residential Canals with Selected Annotations," Sea Grant Publication MASGP-76-003, Mississippi - Alabama Sea Grant Consortium, 1976.

Bibliographic references are presented that relate to coastal residential canals directly or that indirectly address ecological and geological topics concerning the adverse effects of coastal canals. The bibliographic section is followed by selected annotations of articles published in open journals, which report ecological investigations conducted within existing canals.

104. MAY, E.B., "Environmental Effects of Hydraulic Dredging in Estuaries," *Alabama Marine Resources Bulletin*, Apr. 1973, pp. 1-85.

Hydraulic channel and shell dredging and open-water spoil disposal have little significant immediate effect on the water quality in Alabama estuaries. Most of the sediment discharge by dredges settles rapidly and is transported by gravity along the bottom as a separate flocculated layer and potentially harmful components of the mud are not dissolved in the water. There is a limited, temporary reduction in benthic organisms in areas affected by dredging. Spoil piles from channel dredges can indirectly affect the ecology and the usefulness of estuaries by interfering with water circulation thereby altering salinity. The basic hydrological concepts that determine the effects of dredging should apply in other areas. Extensive regulations apparently are not necessary to protect the water quality in open-water dredging situations, but spoil disposal practices from channel dredges must be reconsidered and new disposal plans developed.

105. MAY, E.B., "Effects on Water Quality When Dredging a Polluted Harbor Using Confined Spoil Disposal," *Alabama Marine Resources Bulletin*, No. 10, May 1974, pp. 1-7.

Dredging a polluted harbor using confined spoil disposal did not degrade the water quality. The quality of water returned to the waterway was better than that in the stream before or during dredging due to an increase in the dissolved oxygen and the removal of solids and hydrogen sulfide. There was no significant increase in trace elements.

106. McCALL, P.L., "Community Patterns and Adaptive Strategies of the Infaunal Benthos of Long Island Sound," *Journal of Marine Research*, Vol. 35, No. 2, May 1977, pp. 221-266.

This study examines the importance of disturbances of the sea floor, which result in the local mortality of infaunal benthos, as a cause for spatial and temporal faunal changes commonly observed in nearshore benthic communities. The role of disturbance in ecological succession was examined by in situ experiments in central Long Island Sound.

Differences in the distribution and abundance of benthic organisms in central Long Island Sound may be explained in terms of two different adaptive strategies--opportunistic or equilibrium. The relative opportunism of the Long Island Sound benthos is closely related to the mobility and living and feeding position to the substratum. Sedentary animals and those living or feeding close to the sediment-water interface are more likely to be opportunistic and less predictable in space and time. Mobile animals and those living or retreating deep into the sediment are more likely to be equilibristic, and generally tend to have populations that are more predictable in space and time.

107. McCAULEY, J.E., and BELLA, D.A., "Environmental Considerations for Estuarine Dredging Operations," *Proceedings of the World Dredging Conference IV*, 1972, pp. 457-482.

A conceptual model of estuarine benthic systems is described. The model includes a look at the organic and inorganic deposits found in estuarine areas; the plant and animal life, including filter and deposit feeders; food webs; and suspended particles and transport mechanisms. The range of man's impact on estuarine benthic systems is also surveyed. Particular emphasis is placed on the role of dredging operations as they affect changes in organic deposition, turbidity, tidelands, and estuarine hydrodynamics. The limits of current knowledge on the possible adverse effects of operations such as dredging seem to make it advisable to preserve estuarine systems in a relatively undeveloped state. Such preservation would allow the continued study of estuarine ecosystems in their natural state and would reduce the probability of widespread irreversible damage.

108. McCAULEY, J.E., PARR, R.A., and HANCOCK, D.R., "Benthic Infauna and Maintenance Dredging: A Case Study," *Water Search*, Vol. 11, Pergamon Press, Oxford, England, 1977, pp. 233-242.

Studies of a small maintenance dredging operation in Coos Bay, Oregon, showed that significant decreases of benthic infaunal abundance immediately after dredging extended at least 100 meters from the site of the actual dredging. The infauna readjusted to predredging conditions within 28 days in the dredged area and within 14 days in the adjacent areas. At the spoil site a similar decrease was followed by a 2-week recovery period. The authors suggest that an area subjected to maintenance dredging is also subjected to frequent disturbances from ship movements and other harbor activities, and that the infauna is well adapted to this; thus, maintenance dredging is a relatively normal event and should not be expected to have catastrophic effects.

109. McCLEAVE, J.D., "Rhythmic Aspects of Estuarine Migration of Hatchery-Reared Atlantic Salmon (*Salmo salar*) Smolts," *Journal of Fisheries Biology*, Vol. 12, No. 6, June 1978, pp. 559-570.

Seasonal, diel and tidal rhythmic activities of hatchery-reared Atlantic salmon (*Salmo salar*) smolts migrating through a large estuary were studied by ultrasonic tracking of 46 individuals during two seasons. Prior to 10 May each year most smolts were inactive and remained nearshore in shallow water. After 10 May nearly all smolts moved away from the release point into swift water and made rapid seaward progress. Initiation of migration each year occurred when the river and hatchery water temperatures rose above 9° Celsius. Migration in the estuary was largely passive drift, and as a result there were distinct tidal rhythms of groundspeed (swimming) and net seaward travel. There were no diel rhythms in groundspeed or net seaward travel.

110. MENZEL, R.W., "Effect of Man's Activities on Estuarine Fisheries," *Underwater Naturalist*, Vol. 7, No. 2, 1971, pp. 19-31.

The function and the importance of an estuary are discussed. Adverse effects by man as the result of dredging and filling, damming of rivers, and pollution are also discussed. Emphasis is placed on the adverse effects on oysters, shrimp, spotted sea trout, and striped bass.

111. MIDDLE ATLANTIC COASTAL FISHERIES CENTER, "An Environmental Survey of Effects of Dredging and Spoil Disposal, New London, Connecticut," Informal Report No. 107, U.S. National Marine Fisheries Service, Highlands, N.J., Apr. 1976.

The Middle Atlantic Coastal Fisheries Center presented comparative data on benthic macrofauna populations of June 1974 versus June 1975, and October 1974 versus October 1975. At a station representing the original disposal point, significant decreases (according to 95 percent confidence limits) were found between June 1974 and June 1975 in the number of individuals (N), number of species (S) and Shannon-Weaver species diversity (H'). Significant decreases in the number of individuals were also found at stations located 0.5 nautical mile southeast and northwest of the disposal buoy, and at a control station 2 nautical miles northwest of the buoy; there was a significant increase in the number of individuals at a station 1 nautical mile west-northwest of the disposal buoy. No species had systematic increases or decreases which might dictate their use as indicators of spoiling impacts. Changes in the number of species between June 1974 and June 1975 were slightly smaller than those for the number of individuals, though patterns of change for the two parameters were identical.

Preliminary comparisons of October 1974 versus October 1975 samples again revealed apparently random, rather than spoil-related, changes outside of the spoil pile itself. Recolonization of the spoils was well underway by October 1975; the number of individuals, species, and the Shannon-Weaver species diversity index were all significantly higher than values that had been found in the fresh spoils a year earlier. Amphipod crustaceans were the most abundant of the colonizing forms because they had been in the predisposal sediments. Reappearance of these species may imply that (a) the dominant benthos can tolerate the spoil materials, (b) an eventual return to a near natural assemblage can be expected on the spoil piles, and (c) the tubes of these organisms may aid in stabilizing the spoil against erosion. It is also noteworthy that communities of the amphipods, which are known to be very important in the diets of the

area's finfish, have apparently not been altered at stations where large amounts of spoil are not present.

112. MORTON, J.W., "Ecological Impacts of Dredging and Dredge Spoil Disposal: A Literature Review," M.S. Thesis, Cornell University, Ithaca, N.Y., 1976.

A comprehensive review of literature on the physical, chemical, and biological impacts of dredging and spoil disposal in estuaries and the identification of alternative spoil disposal methods is presented. Although direct burial and habitat destruction are the most obvious biological impacts of dredging and dumping, these impacts can be minimized by careful timing and placement of the dredging and disposal operations. A critical problem requiring further study is the uptake, accumulation, and recycling of contaminants associated with polluted dredge spoils by marsh vegetation, phytoplankton, zooplankton, benthos, and fish.

113. MORTON, J.W., "Ecological Effects of Dredging and Dredge Spoil Disposal: A Literature Review," *Technical Papers of the United States Fish and Wildlife Service*, No. 94, 1977.

This study is a comprehensive review of the literature on the physical, chemical, and biological effects of dredging and spoil disposal in estuaries and identifies alternative spoil disposal methods. The specific objectives were to identify the most critical problems relating to dredging and spoil disposal and to summarize the progress made to date.

An important physical effect of dredging and open-water spoil disposal is the alternation of circulation patterns. A second important effect is the uncontrolled redistribution of sediments. Changes in the chemistry of the sediments at the dredging and disposal sites and of the water overlying these areas are likely to result from dredging and dumping. Although direct burial of organisms and destruction of the habitat are the two obvious biological effects of dredging and dumping, the effects can be reduced by careful timing of the dredging and placement of the spoil.

114. MORRIS, L.A., et al., "Effects of Main Stem Impoundments and Channelization Upon the Limnology of the Missouri River, Nebraska," *Transactions of the American Fishery Society*, Vol. 97, No. 4, Oct. 1968, pp. 380-388.

Rigid control has been imposed on the Missouri River by impounding more than one-half of the upper 1,500 miles and by channeling most of the remaining river within permanent, narrow banks. These controls have caused environmental changes in the lower Missouri River of adjacent, unchannelized and channelized sections of river below the main stem impoundments. Impoundments have regulated flow discharges and improved the downstream water quality. In addition, the impoundments have contributed a limnetic cladoceran, *Leptodora kindti*, to the drift and have affected the distribution of benthos through the modification of turbidity.

Channelization of the river has reduced both the size and variety of the aquatic habitat by destroying key productive areas. The average standing crops of benthos were similar in the unchannelized and channelized river, but the benthic area was reduced 67 percent by channelization. There was little

similarity between the organisms of the drift and benthos; however, there was similarity between the organisms in the drift and the aufwuchs.

115. MURAWSKI, W.S., "A Study of Submerged Dredged Holes in New Jersey Estuaries with Respect to Their Fitness as Finfish Habitat," Miscellaneous Report, No. 2M, New Jersey Department of Conservation and Economic Development, Trenton, N.J., Oct. 1969.

Thirty-eight submerged dredged holes located in a New Jersey estuary were examined to determine their fitness as a finfish habitat. Twenty-one of the holes had dissolved oxygen or hydrogen sulfide conditions that would not sustain healthy aquatic life. Twenty of the holes lacked benthic animals. Reasons for the stagnant dredged holes were: (a) too great a depth in relation to natural estuary depths, (b) intrusion of poor quality ground water, (c) high accumulation of detritus in the dredged holes, and (d) lack of mixing by wind because of a sheltering shoreline.

116. NICHOLS, M.M., "Effect of Channel Deepening on Salinity in the James Estuary," *Proceedings of the 11th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, 1969, pp. 1439-1441.

The effect of a 3 meter channel deepening on the salinity distribution and net flow was studied in the James Estuary to predict estuarine-wide changes that might disturb the natural conditions favorable to oyster production. A hydraulic model was employed to determine the physical changes. The potential biological consequences were evaluated by integrating the model data with corollary field and laboratory observations.

117. NYBAKKEN, J., and STEPHENSON, M., "Effects of Engineering Activities on the Ecology of Pismo Clams," MP 8-75, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Sept. 1975.

Three aspects of the ecology of Pismo clams (*Tivela stultorum*) were investigated in Monterey Bay, California: distribution, reproduction cycle, and age and growth. Pismo clam populations were found to be restricted to bay areas betweem the Salinas River and Santa Cruz. The highest densities recorded were intertidal; subtidal clam beds were few and with low densities. Most clams appeared randomly dispersed and different size classes did not show a vertical separation. The presence and absence of clams were shown to be correlated with the beach slope and grain size. Pismo clams mature in their second year in Monterey Bay, and the primary spawning time is in September and October. The growth rate is more rapid in young clams and varies throughout the year in all size classes, but is most rapid in the summer and fall.

118. O'CONNOR, J.M., NEUMANN, D.A., and SHERK, J.A., Jr., "Lethal Effects of Suspended Sediments on Estuarine Fish," TP 76-20, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Dec. 1976.

This study provides base-line information for preproject decisionmaking based on the anticipated concentration of suspended sediments at the project site and the effect of various lengths of exposure on estuarine fish of different life-history stages and habitat preference.

119. O'CONNOR, J.M., NEUMANN, D.A., and SHERK, J.A., Jr., "Sublethal Effects of Suspended Sediments on Estuarine Fish," TP 77-3, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Feb. 1977.

The objective of this study was to determine the effects, if any, of sublethal concentrations of suspended materials on the fish in estuarine systems. The suspensions were of natural sediment, obtained from the Patuxent River estuary, Maryland, or commercially available fuller's earth.

120. O'CONNER, J.M., and SHERK, J.A., Jr., "The Responses of Some Estuarine Organisms to Suspended Solids," *Proceedings of the Seventh Dredging Seminar*, Center for Dredging Studies, Texas A & M University, College Station, Tex., Sept. 1975, pp. 215-234.

Potential environmental hazards from dredging may be estimated accurately by knowing, prior to operation, the particle-size distribution of the material to be dredged and the volume of material to be removed; the sufficient physical characteristics of the area to estimate accurately the settling time and aerial dilution of the finest particles to be resuspended; and the biota of the affected area--phytoplankton, zooplankton, fish and benthos--and their ecology.

This study shows that suspended solids have a significant effect on primary productivity, zooplankton feeding rates, fish survival, and the physiological state of fishes. The effects of suspended sediments on phytoplankton and zooplankton appeared to be related to particle concentrations rather than to particle size.

It was concluded that dredging and spoiling operations are capable of producing suspended-solid concentrations capable of affecting the natural function of organisms and ecosystems as a whole.

121. ODUM, H.T., "Productivity Measurements in Texas Turtle Grass and the Effects of Dredging an Intracoastal Channel," *Publication of the Institute of Marine Science*, University of Texas, Austin, Tex., Vol. 9, 1963, pp. 48-53.

Benthic chlorophyll *a* and diurnal oxygen productivity were measured in turtlegrass beds containing *Thalassia testudium* and *Diplanthera wrightii* in Redish Bay, Texas, both before and after the dredging of an intracoastal canal. Moderate values of photosynthesis (2 to 8 grams of oxygen per square meter per day) were observed in the spring of 1959 following a period of shading by turbid dredge waters, but exceptionally high values (12 to 38 grams per square meter per day) were recorded the following spring in those areas not smothered with silt. Chlorophyll *a* averaged 0.0338 gram per square meter in 1959, but increased to 0.68 gram per square meter the following summer.

122. OLIVER, J.S., and SLATTERY, P.N., "Effects of Dredging and Disposal on Some Benthos at Monterey Bay, California," TP 76-15, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Oct. 1976.

The specific objectives of this study were to document: (a) natural temporal variations in benthic assemblages and changes related to substrate

stability, (b) the initial effects of dredging and subsequent recolonization, (c) the effects of disposal of dredged material on the benthos and subsequent recovery of the fauna, and (d) the role of fauna distribution and reproductive abilities on the recovery or recolonization of disturbed areas. Experimental burial and dredging were conducted. The results suggest that the underwater disposal of dredged material should be made in unstable areas, if possible. Also, the ultimate recovery or recolonization of a dredged area or a disposal area depends on the timing of the action in relation to the reproductive cycles and distributive abilities of the benthic organisms present in and around the area.

123. ORTOLANO, L., and HILL, W.W., "An Analysis of Environmental Statements for Corps of Engineers Water Projects," Report No. 72-3, Institute of Water Resources, Washington, D.C., 1972.

This study presents the results of an intensive analysis of 234 Corps of Engineers Environmental Impact Statements prepared according to Section 102(2)(C) of the National Environmental Policy Act (NEPA). The analysis includes a detailed catalog and summary of impacts included in the statement for: projects on coastal waters, including dredging, spoil disposal, breakwaters, jetties and groins, revetments, dikes and barriers; and projects on inland waters including channelization, dams and reservoirs, levees, dredging spoil disposal, construction and other miscellaneous structures and activities. In addition, the analysis catalogs and summarizes the impacts of various project purposes. A summary of the coverage of other points required by Section 102(2)(C) of NEPA is also included. The proper role of environmental statements is suggested and, within that context, an assessment of the 134 statements is rendered, together with suggestions for improvement.

124. PARR, R.A., "Harbor Dredging and Benthic Infauna; A Case Study," unpublished M.S. Thesis, Oregon State University, Corvallis, Oreg., 1973.

This study of the localized effects of a small dredging operation on the benthic invertebrate community in the shipping channel of Coos Bay, Oregon, was designed (a) to measure the extent of the physical removal of benthic macrofauna and meiofauna by hopper dredging, (b) to record the subsequent benthic response effects of midchannel spoiling, and (c) to monitor the rate and pattern of biological readjustments in the affected areas. Samples were taken before and after dredging. Faunal abundance, taxa composition, species diversity, and qualitative sediment characteristics were studied. Immediate declines in faunal abundance were temporary and readjusted to predredging levels within 28 days. Temporary increases in diversity reflected changes in the relative abundance of taxa arising from siltation and burial of organisms. Following readjustment, populations increased in all areas except the dredge channel. Localized population declines are hypothesized to have resulted from the unsuitability of newly exposed sediment for settlement of pelagic larvae. It is also hypothesized that periodic disruption of the sediment surface by small-scale maintenance dredging may have less direct effect on the benthic community than the daily presence of heavy shipping and industrial and domestic pollution.

125. PEDDICORD, R., and McFARLAND, V., "Effects of Suspended Dredged Material on the Commercial Crab, *Cancer magister*," *Proceedings of the Specialty Conference on Dredging and Its Environmental Effects*, Mobile, Ala., Jan. 1976, pp. 633-644.

The impact of suspended sediment on juvenile *Cancer magister*, the commercial crab of the central and northern Pacific coast of the United States, was evaluated. Suspended-sediment concentrations covered a wide range, with a maximum not exceeding the highest concentration documented for dredging operations. Death was selected as the primary measured response to establish the outer limits of tolerance. Only crabs 30 to 40 millimeters in carapace width were studied. The absence of death in some cases does not imply that the animals were not affected or that other life stages might not have been killed.

126. PEQUEGNAT, W.E., "Meiobenthos Ecosystems as Indicators of the Effects of Dredging," *Estuarine Research*, Vol. 2, 1975, pp. 573-583.

Critical data for assessing the long-term effects of marine dredging activities on the benthos are analyzed. Meiobenthos constituents respond definitely and for prolonged periods to mass sediment disruptions as evidenced by changes in generation time, numbers, and diversity. Amelioration of these responses may prove to be a true indicator of habitat reconstruction, in part because of the close relationship of meiobenthos with sediment properties and their intrinsic short-cycle properties. It was concluded that an investigation of the significance of the response difference between the macrobenthos and meiobenthos is needed.

127. PFITZENMEYER, H.T., "Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal. Appendix III. Benthos of Maryland Waters In and Near C and D Canal," Report No. NRI-REF-73-113, University of Maryland, National Resources Institute, Solomons, Md., Sept. 1973.

This study was undertaken to determine the seasonal occurrence and biomass of species of benthic invertebrates inhabiting the C and D Canal and Elk River. This information was used to assess the effects of enlargement of the canal.

128. PFITZENMEYER, H.T., "The Effects of Shallow-Water Channel Dredging on the Community of Benthic Animals and Plants: Phase I. Survey of Previously Dredged Areas and Observation on the Physical and Biological Effects," Report No. 75-69, University of Maryland, Center for Environmental and Estuarine Studies, Solomons, Md., 1975.

This study was designed as a preliminary investigation into the effects of shallow-water channel dredging on the community of benthic animals and plants. The objective of this phase was to determine through quantitative means whether differences in the biota could be measured between channels and corresponding reference areas. The physical qualities of the sediments at each sampling station were also analyzed. No major damage was found to the populations of benthic invertebrates in channels 2 to 4 years after dredging, though no rooted vegetation was found in dredged areas.

129. PFITZENMEYER, H.T., "The Effects of Shallow-Water Channel Dredging on the Community of Benthic Animals and Plants: Phase II. A Study of

Immediate Effects and Rates of Recovery," Report No. UMCEES 76-23cBL, University of Maryland, Center for Environmental and Estuarine Studies, Solomons, Md., 1977.

This report discusses the first half of an ongoing project to assess the effects of dredging in shallow-water tributaries of the Chesapeake Bay. It outlines the establishment of sampling stations and the taking of initial samples at two sites--Horn Point and Lewis Creek. An analysis of sediment and organic carbon samples obtained is presented in tabular form. A list of species of benthic invertebrates found at the two study sites is also included.

130. PISAPIA, R.C., "Biological Implications of Dredge Holes," unpublished report. U.S. Fish and Wildlife Service, Annapolis, Md.

This paper discusses the environments in holes resulting from dredging activities. Holes significantly deeper than the surrounding bottom can become traps for sediments, organic materials, and pollutants. A number of examples are cited to demonstrate the types of accumulations in dredge holes and their adverse biological impacts. Recommendations to reduce the impacts of dredge holes are provided.

131. POMEROY, W.M., and STOCKNER, J.G., "Effects of Environmental Disturbance on the Distribution and Primary Production of Benthic Algae on a British Columbia Estuary," *Journal of the Fishery Research Board of Canada*, Vol. 33, No. 5, May 1976, pp. 1175-1187.

Construction of a river training dike at Squamish, British, Columbia, has resulted in strong salinity, water transparency, and sedimentation gradients across the estuary face that have significantly affected the distribution and primary production of benthic algae. The estuary west of the dike is now a very unstable habitat for algal colonization and growth because of heavy sedimentation and salinities less than 3 parts per thousand during river freshets. At other times of the year, a salinity range of up to 25 parts per thousand is common over a tidal cycle so algae in this area are generally strongly euryhaline. The eastern part of the estuary has a more stable benthic environment; lower sedimentation and higher salinity result in greater species diversity, biomass, and primary production. Algae tend to be weakly euryhaline, with optimum salinities between 15 and 30 parts per thousand. Recent intrusion of *Fucus vesiculosus* strongly indicates that the eastern estuary is developing into a more marine habitat.

132. PULLEN, E.J., and TRENT, W.L., "White Shrimp Emigration in Relation to Size, Sex, Temperature and Salinity," Food and Agriculture Organization of the United Nations Fisheries Report, Vol. 3, No. 57, 1969, pp. 1001-1014.

This study was conducted on juvenile and subadult white shrimp, *Penaeus setiferus* (Linnaeus), emigrating from Galveston Bay, Texas, to the Gulf of Mexico. Surface, midwater, and bottom tows were made with a 3-meter otter trawl on ebbtides from 1 August 1966 to 27 January 1967, usually during the day. Five peaks of emigration occurred from 19 October to 25 December, coinciding with water temperatures between 19° and 8° Celsius in the tidal pass. The catch increased significantly from the surface to the bottom of the water column. Sharp drops in water temperature appeared to stimulate shrimp emigration. The mean lengths of shrimp caught were similar between water depths

and sexes on a given sampling date, but decreased with the progress of the season and decreasing temperature; there was no obvious relation between length and salinity. Of the 2,964 white shrimp caught in the tidal pass, 55.1 percent were females, but the sex ratio was not significantly different from 1:1.

133. REES, C., "The Ecological Impact of Dredging Operations," *SEATEC 77: The Dredging and Construction of Ports for Developing Countries, Singapore*, Intel Press, Ltd., 1977.

Dredging, embracing mineral recovery, navigation, and beach nourishment operations usually have physical, chemical, and biological repercussions. Major physiochemical problems arise when dredging radically changes the coastal sediment budget, sediment supply to the coast, and nearshore wave refraction and diffraction patterns. Serious damage to some biological communities may be anticipated since coastal zones are often highly productive and responsible for sustaining sizable commercial fisheries.

134. REES, W.H., "Effects of Stream Dredging on Young Silver Salmon, *Orcorhynchus Kisutch* and Bottom Fauna," Fishery Research Paper No. 2, Washington Department of Fisheries, Olympia, Wash., Mar. 1959, pp. 53-65.

A program was begun in July 1952 and terminated in August 1953 to measure how dredging and stream channeling affect fish and bottom organisms in Little Bear Creek, northeast of Seattle. Random bottom samples were taken periodically in test and control areas to measure population changes in food organisms. Dredging in September 1952 eliminated 97 percent of the bottom organisms in the test area. The dredged area had a reduced fauna for 5 months and then began to recover in February 1953. It had recovered completely by July 1953. The stomach contents of young silver salmon yielded more dipterous larvae than other bottom organisms, even during periods when production of diptera was low. The author estimated that immediately after dredging in September 1952 the zero group silver salmon decreased 69 percent and the trout fingerlings 81 percent.

135. REID, G.K., "Ecological Investigations in a Disturbed Texas Coastal Estuary," *The Texas Journal of Science*, Vol. 8, No. 3, Sept. 1956, pp. 296-327.

Rollover Pass, a cut through Bolivar Peninsula on the gulf coast of eastern Texas, was constructed in January 1955 and introduced gulf waters of high salinity into the upper part of East Bay. A study of some of the hydrographic and biologic aspects was made in June and July 1954, prior to the construction of the pass. The present study was concerned with determining what changes occurred in the physical, chemical, and biological characteristics of the bay following the excavation of the pass. Field investigations, carried on from 7 June to 30 June 1955, noted marked differences between the salinity in June 1954 and June 1955 in East Bay. The number of species of fishes in 1955 (51 species) was nearly the same as for 1954 (50 species); however, 9 species recorded in 1954 were not noted in 1955. Ten species were found in 1955 that were not caught in 1954, and some of these were marine species whose presence reflected the increased salinity in the bay. Three species of shrimps were found in the bay during the 1955 study. The brown shrimp was less abundant and the white shrimp was more abundant than in 1954. The sea bob, not caught in 1954, was taken in 1955.

136. REID, G.K., "Biologic and Hydrographic Adjustment in a Disturbed Gulf Coast Estuary," *Limnology and Oceanography*, Vol. 2, No. 3, May 1957, pp. 198-212.

East Bay, an arm of the Galveston Bay system of Texas, was studied during the summers of 1954, 1955, and 1956. The first was made with the Bay in its natural state, the second investigation followed the excavation of a pass (Rollover Pass) that permitted considerable interchange between the Gulf of Mexico and East Bay, and the third study was subsequent to partial blocking of the Pass.

Evidence from salinity distribution and fluctuations in population density of the dominant fish and shrimp species suggests a rapid physical and biological reversion toward the natural condition, following the blocking of the pass. In addition, the presence or absence of certain fish and shrimp forms was correlated with changes in the bay.

137. REISH, D.J., "Effect of Pollution on Marine Life," *Industrial Wastes*, Vol. 2, Sept.-Oct. 1957, pp. 114-118.

A physical, chemical, and biological description was made before and after dredging in a polluted region of Los Angeles Port Harbor. The organic carbon content of the substrate varied from 0.6 to 10.7 percent. At the stations within the dredged area the organic carbon increased with respect to time. The effect of dredging on bottom-dwelling animals is summarized. The number of species increased shortly after dredging; however, the number decreased with each successive survey.

138. REISH, D.J., "A Study of Benthic Fauna in a Recently Constructed Boat Harbor in Southern California," *Ecology*, Vol. 42, No. 1, 1961, pp. 84-91.

A periodic quantitative study was made in a newly dredged marine boat harbor to determine if the subtidal benthic faunal succession occurred on the bottom. Polychaetes, mollusks, crustaceans, and nemerteans were the important groups collected. A peak in the number of species and specimens was recorded about 2 years after the seawater was first let in. The population decreased markedly in the following year. Various explanations for the reduction in the number of specimens are offered. There was no evidence of succession.

139. REISH, D.J., "Discussion of the *Mytilus californianus* Community on Newly Constructed Rock Jetties in Southern California (Mollusca:Bivalvia)," *The Veliger*, Vol. 7, No. 2, 1969, pp. 99-101.

The growth and development of the California sea mussel (*Mytilus californianus*) community on newly constructed rock jetties was studied in Ventura and Playa Del Rey marinas. Organisms were collected periodically over a 2-year period from three sites on the inside of the south jetty of the Ventura County marina and from one site at Playa Del Rey. Data collected indicated that green alga (*Ulva dactylifera*) was the earliest macroscopic inhabitant, regardless of the time of year the rocks were initially exposed to seawater. *Mytilus californianus* settled on the rocks during the spring months. The number of specimens and species of plants and animals associated with the population of *Mytilus californianus* was larger and more diverse during the summer months and smaller and less diverse during the winter months. The population of *Mytilus californianus* disappeared from the inside of the south jetty at Ventura County Marina after 2 years, but was still present at the end of the north jetty. This was ascribed to the presence of a sandy beach along the oceanside of the jetty,

which created an unsuitable habitat for the mussel. After 2 years a population of *M. californianus* was still present on the jetties at Playa Del Rey marina. The difference in population of *M. californianus* at the two marinas was not explained.

140. REYNOLDS, T.D., HANN, R.W., Jr., and PRIEBE, W.F., "Benthic Oxygen Demands of Houston Ship Channel Sediments," Sea Grant Publication TAMU-SG-73-204, Texas A & M University, College Station, Tex., 1973.

This research was to determine the benthic oxygen demand of the sediment deposits in the Houston ship channel for use in modeling. The scope of the study included: (a) collection of bottom samples; (b) determining the characteristics of the sludge, such as biochemical oxygen demand (BOD), heavy metals, etc.; (c) use of galvanic oxygen cells in determining the oxygen uptake rates in grams of oxygen per hour per square meter, or other units; (d) determination of the benthic demands at different temperatures to obtain a demand versus temperature correlation; and (e) the determination of mixing effects.

141. RINGO, R.D., "Distribution and Abundance of Postlarval and Early Juvenile Stages of the Brown Shrimp in Galveston Bay, Texas," *Proceedings of the 18th Annual Conference of the Southeastern Association of Game and Fish Commissioners*, Oct. 1964.

The early life history of the brown shrimp (*Penceus aztecus*) in Galveston Bay was investigated during 1963 and 1964. Postlarvae, after entering from the gulf, were most abundant in the channels and deeper waters as they moved into the upper reaches of the estuary. In each season of study, they were observed to spread throughout the estuary and become concentrated in surrounding marshes and bayous within about 2 weeks of the first entry. After spending 2 to 4 weeks in these peripheral areas, where they grew rapidly, the young shrimp, now juveniles, once again dispersed throughout the estuary before eventually returning to the gulf. Observations also indicated that the estuarine life history phase of the brown shrimp is quite variable, with its duration probably being related in large measure to the prevailing water temperature.

142. RITCHIC, D.E., Jr., and KOO, T.S., "Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal. Appendix VIII. Fish Movements, Maryland Study," Report No. NRI-REF-74-42, University of Maryland, National Resources Institute, Solomons, Md., Sept. 1973.

A summary is given of the results of a massive fish tagging operation in the C and D Canal region in 1971-73. Direct evidence was found that fish either move within or migrate back and forth through the canal.

143. ROGERS, R.M., and DARNELL, R.M., "The Effects of Shell Dredging on the Distribution of Meiobenthic Organisms in San Antonio Bay, Texas," *Environmental Impact Assessment of Shell Dredging in San Antonio Bay, Texas*, Vol. III, App. BIO-B, Texas A & M Research Foundation, College Station, Tex., Sept. 1973, pp. 159-167.

The present study has demonstrated that dredge cuts reduce the population of meiobenthic animals to about one-third of their former levels and that recovery is only above 80 percent complete more than a decade later. The study has further pointed to the fact that modification of the particle structure of the sediments is probably the prime causative factor, Once a new dredge cut is made, it is gradually filled with waterborne suspended matter

of which the finer material (the clay fraction) is predominant. Silt and sand accumulate more slowly, and the fine particle bottom is less consolidated.

144. ROSE, C.D., "Mortality of Market-Sized Oysters *Crossostrea virginica* in the Vicinity of a Dredging Operation," *Chesapeake Science*, Vol. 14, No. 2, June 1973, pp. 135-138.

The average mortality of market-sized oysters collected at seven sampling stations within 595 meters of a spoil bank crossing an oyster lease was 57 percent as compared with an average mortality of 17 percent on the remainder of the lease. Sediment commonly covered oysters taken from the affected area. Theoretical mortality (mortality that would have been produced by sedimentation resulting from dredging operations if other mortality-inducing factors had been inoperative) was estimated to be 48 percent.

145. ROSENBERG, R., "Effects of Dredging Operations on Estuarine Benthic Macrofauna," *Marine Pollution Bulletin*, Vol. 8, No. 5, May 1977, pp. 102-104.

Dredging operations in a Swedish estuary reduced the number and diversity of benthic species. The larval recruitment in the vicinity of the dredged area was strongly affected. An overall increase in concentrations of mercury, cadmium, zinc, copper, lead, and nickel was recorded in benthic fauna. One and a half years after termination of dredging, the benthic community structure was nearly restored and high concentrations of heavy metals had decreased considerably.

146. SHANLAR, N.J., and MASCH, F.D., "Influence of Tidal Inlets on Salinity and Related Phenomena in Estuaries," Technical Report HYD 16-7001, Hydraulic Engineering Laboratory, University of Texas, Austin, Tex., Mar. 1970.

This study presents mathematical hydrodynamic and salinity transport models applicable to the analysis of the effects of tidal inlets on bays and estuaries having the typical morphology encountered in the U.S. coastal regions of the Gulf of Mexico. The practical utility of these models has been demonstrated.

147. SHERK, J.A., Jr., O'CONNOR, J.M. and NEUMANN, D.A., "Effects of Suspended Solids on Selected Estuarine Plankton," MR 76-1, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Jan. 1976.

A 3-year laboratory study identified biological components of selected populations of estuarine organisms most sensitive to the effects of different suspended sediments.

148. SIMMONS, E.G., and HOESE, H.D., "Studies on the Hydrography and Fish Migration of Cedar Bayou, A Natural Tidal Inlet on the Central Texas Coast," *Publications of the Institute of Marine Science*, University of Texas, Austin, Tex., Vol. 6, 1959, pp. 56-80.

Cedar Bayou Pass, a natural tidal inlet on the Texas coast, was the subject of studies in 1950-51 and 1957-58. In 1950-51, when the pass was open, it was utilized extensively by fishes, crabs, and shrimp as a passageway to and from the Gulf of Mexico. Most movement was nocturnal and more fish moved to the gulf than to the bay. The fish taken in the largest numbers was the Atlantic croaker, which migrated gulfward during the summer months. Sea trout were frequently captured but these were normally following schools of shrimp. An outward movement of the southern flounder was intense during the

fall months, but an expected heavy migration of redfish and black drum did not occur. In 1957-58 when the pass was closed, many of the same species were found. These normally appeared at a later date than when the pass was open. Many typical gulf species were not present in 1958.

It is suggested that discharge from the Guadalupe River, together with northern storms, is responsible for maintaining this inlet, which is prone to close during periods of drought.

149. SLEIGHT, H., III, "Effects of Suspended Marine Sediments on Selected Commercially-Valuable Fishes and Shellfish of Massachusetts," *Proceedings of the Seventh Annual Offshore Technology Conference*, Vol. 1, 1975, pp. 133-141.

As part of the Commonwealth of Massachusetts' research into the environmental effects of offshore sand and gravel mining, acute bioassays were performed on several commercially valuable marine fish and shellfish utilizing various levels of suspended, fine-grained marine sediment. The species tested displayed a remarkable tolerance for short-term exposures to the levels of suspended sediments that they might encounter in the dredge plume of an offshore sand and gravel mining operation.

150. SLOTTA, L.S., et al., "Effects of Hopper Dredging and In-Channel Spoiling (October 4, 1972) in Coos Bay, Oregon," Interdisciplinary Studies of the Oregon State University School of Engineering and School of Oceanography, Corvallis, Oreg., July 1973.

The chemical, physical, and biological effects associated with the dredging and disposal methods of a hopper dredge were studied. Field investigations and subsequent laboratory analyses were organized to evaluate the nature and magnitude of environmental changes resulting from dredging activities on 4 October 1972 at Coos Bay, Oregon. Assessment methods and evaluation techniques are discussed, and postdredging conditions are compared with a predredging base line.

151. SLOTTA, L.S. et al., "An Examination of Some Physical and Biological Impacts of Dredging in Estuaries," RANN GRANT G1 34346, Oregon State University, National Sciences Foundation, Corvallis, Oreg., Dec. 1974.

This research was focused on four major topics: (a) The effects of dredging on estuarine systems, (b) the system properties of estuaries, (c) the ways in which estuarine research can be used effectively by user groups, and (d) the development of concepts and techniques for monitoring impacts of dredging and other alterations to estuaries. Emphasis has been placed on benthic rather than pelagic systems because changes in the sediments are less transitory than those in the overlying water and because dredging, by its nature, involves the estuarine bottom.

Specific examples include the study of the concepts of estuarine stability that has led to specific questions about the role of subtidal clam populations, probable impacts of dredging, and the role of activities such as marine traffic.

152. SMITH, G.F., "Observations on the Effects of Dredging to Subtidal Communities at Keystone Harbor Whidbey Island, Washington," Huxley College of Environmental Studies, Western Washington State College, Bellingham, Wash., 1976.

This report presents the results of observations on the effects of dredging on subtidal communities at Keystone Harbor on Whidbey Island, Washington. Main-

tenance dredging of the harbor entrance was carried out from 26 January to 20 February 1976 using a hydraulic pipeline. The dredged material was placed along a 213-meter section of beach between the harbor's protective breakwater and an abandoned wharf. Observations of three subtidal regions were made before, during, and after the completion of dredging using scuba equipment. The breakwater, abandoned wharf, and nearshore bottom between these two structures were observed. Turbidity, sedimentation, mortality, and behavioral effects of dredging on organisms were observed. Only the inner areas of the breakwater showed signs of sedimentation and no behavioral effects or mortalities were observed due to its presence. Sedimentation in this area had little effect on the settling of larval invertebrates or the growth of new algae. It was assumed that all sediment on the breakwater would disperse over time and all effects were short-term, as no sediment was found prior to the 1976 dredging.

153. SMITH, R.W., et al., "Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal, Appendix IX, Delaware Fish Migration," Final Report, University of Maryland, National Resources Institute, Solomons, Md., 1973.

Tag and recapture data are given in the different fish species that used the Chesapeake and Delaware Canal in migrations and movement during the period 1971 to 1973.

154. SNYDER, G.R., "Effects of Dredging on Aquatic Organisms with Special Application to Areas Adjacent to the Northeastern Pacific Ocean," *Marine Fisheries Review*, Vol. 38, No. 11, Nov. 1976, pp. 34-38.

Dredging can be accomplished by using one of three processes of dredging: hydraulic, mechanical, or a combination of the two. Several types of impacts on aquatic organisms from these three dredging processes are discussed, including the mechanical effects, turbidity, and other miscellaneous effects.

155. SOLLITT, C.K., and CRANE, S.D., "Physical Changes in Estuarine Sediments Accompanying Channel Dredging," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, June 1974, pp. 1289-1303.

The physical characteristics of estuarine sediments provide useful information about sediment sources, the nature of bottom surface stresses, and sediment transport mechanisms. Changes in sediment composition and state are also useful indicators for estimating the effects of unnatural stresses on dependent chemical and biological activities. In this study, the changes in several sediment properties have been monitored for an isolated estuarine dredging project.

156. SOLOMON, D.J., "Migration of Smolts of Atlantic Salmon (*Salmo salar* L.) and Sea Trout (*Salmo truta* L.) in a Chalkstream," *Environmental Biology of Fishes*, Vol. 3, No. 2, June 1978, pp. 223-229.

The migration of smolts in the River Piddle, Dorset, was studied over 3 years in relation to factors that could influence downstream movement. The river originates mostly from ground-water springs, resulting in stable flows and low turbidity, except in rainy weather. Fish were intercepted at the tidal limit in a fixed trap-net and measurements of water temperature, discharge, turbidity, barometric pressure, rainfall, and solar radiation were taken nearby. The slightly increased turbidity and discharge following heavy rain initiated major movements during 2 (nights) of the 55 days studied. At other times large-scale movements took place during sunny, warm afternoons. Both solar radiation

and water temperature were correlated with intensity and timing of movement. The pattern of migration was different from that reported on other rivers, reflecting the relatively stable flow regime of the chalk stream.

157. SOULE, D.F., "Marine Studies of San Pedro Bay, California: Part II: Potential Effects of Dredging on the Biota of Outer Los Angeles Harbor," University of Southern California, Institute of Marine and Coastal Studies, Los Angeles, Calif., 1976.

Specific investigations discussed in this report are: the potential ecological effects of hydraulic dredging in Los Angeles Harbor; resuspended-sediment elutriate studies on the northern anchovy (*Engraulis mordax*); the effects of Los Angeles Harbor sediment elutriate on the California killfish (*Fundulus parvipinnis*) and white croaker (*Genyonemus lineatus*); the toxicity and heavy metals in three species of crustacea from the harbor sediments; the bioassay and heavy metal uptake investigations of resuspended sediment on two species of polychaetous annelids; biomass and recolonization studies in the outer Los Angeles Harbor; and the water quality evaluation of dredged material disposal from Los Angeles Harbor.

158. ST. AMANT, L.S., "A Discussion of the Effects of Shell Dredging on the Ecosystems of Northern Gulf of Mexico Embayments," *Symposium on Ocean Mining*, OSM II, World Dredging Conference Association, 1973, pp. 139-149.

Shell dredging on the coast of Louisiana has not caused serious effects on the overall fishery, because disturbances associated with dredging are highly localized and confined to within several hundred yards of the operating dredge. The local disturbance to free-swimming marine life appears to be transitory and disappears within a few hours after the dredging ceases. Dredging can be demonstrated to have a direct physical effect on live oyster reefs by direct destruction or severe siltation if allowed to operate in or very near such reefs. Benthic organisms in the path of the dredge will obviously be severely disturbed or destroyed, but these short-lived, rapidly reproducing animals tend to repopulate the area within a reasonable length of time after dredging is completed. Dredging can be conducted without harm to the fish and shellfish industries if it is properly regulated and supervised.

159. STERN, E.M., and STICKLE, W.B., "Effects of Turbidity and Suspended Material in Aquatic Environments: Literature Review," Technical Report D-78-21, *Dredged Material Research Program*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., June 1978.

This literature reviews the effects of turbidity and suspended material in aquatic environments covering the following subjects: definitions, units of measure and methods of measurement; origins; and the effects on aquatic environments.

The literature indicates that turbidity and suspended solids conditions typically created by most dredging and disposal operations are of short duration and are unlikely to produce severe or irreversible ecological effects. The possible exceptions to this generalization are coral reefs and other communities that are especially sensitive to turbidity. Any possible effects of turbidity and suspended material in aquatic environments may be minimized further by careful selection of disposal sites keying operations to seasonal cycles in biological activity and special consideration to areas that serve as nursery grounds.

160. STICKNEY, R.R., "Length-weight Relationships for Several Fishes and Invertebrates in Georgia Coastal Waters with Condition Factors for Fish Species," Technical Report Series No. 72-3, Georgia Marine Science Center, University System of Georgia, Skidaway Island, Ga., Apr. 1972.

This project, in part, involved determination of the effects, if any, of dredging of the Intracoastal Waterway in Georgia on estuarine organisms. Emphasis was placed on fishes and macroinvertebrates as obtained through otter trawling. The data were partially analyzed by several computer programs; length-weight relationships and condition factors were included. The current report presents length-weight data for several fishes and invertebrates and also the condition factors for those fish for which length-weight relationships were obtained.

161. STICKNEY, R.R., "Effects of Intracoastal Waterway Dredging on Ichthyofauna and Benthic Macroinvertebrates," Technical Report Series No. 72-4, Georgia Marine Science Center, University System of Georgia, Skidaway Island, Ga., July 1972.

Collections of fishes and invertebrates made by otter trawl from November 1970 through December 1971 from stations within the Georgia coastal estuarine system were evaluated in terms of effects of hydraulic dredging activities associated with the Intracoastal Waterway on the biota collected. The patterns of seasonal occurrence and dominance of specific organisms appeared to be consistent regardless of whether or not dredging had occurred in the area sampled. Variability among the stations seemed to be associated with natural hydrographic and physiographic characteristics, as well as sampling variability. Some changes in the population structure or standing crop may have been associated with the dredging, but these effects were transient, lasting no longer than 1 or 2 months following dredging.

162. STICKNEY, R.R., "Effects of Hydraulic Dredging on Estuarine Animals Studied," *World Dredging and Marine Construction*, Vol. 9, No. 9, July 1973, pp. 34-37.

This study focused on the immediate and long-term effects of hydraulic dredging on two estuarine communities of animals. The evidence obtained from the studies indicates no gross or long-term effects of the Atlantic Intracoastal Waterway (AIWW) dredging on fishes and macroinvertebrates. Maintenance dredging of the AIWW is not comparable with dredging of polluted and possibly toxic sediments.

163. STOCKLEY, C., "Salmon Migrants and Shellfish Habitat in Relation to Marinas, Breakwaters, Bulkheads and Land Fills in the Columbia River and Coastal Bays," Washington Department of Fisheries, Olympia, Wash., unpublished, 1974.

This paper describes possible adverse effects on water quality and fish and shellfish habitats as a result of marinas, breakwaters, bulkheads, and landfills at a number of locations on the lower Columbia River and several Washington coastal bays. The main concern was water quality deterioration and predator buildup as factors that affect juvenile migrating salmon. Recommendations for design criteria of future structures are made that will alleviate these adverse effects.

164. STUART, T.A., "The Influence of Drainage Works, Levees, Dykes, Dredging, etc., on the Aquatic Environment and Stocks," *Proceedings of the Inter-*

national Union for Conservation of Nature and Natural Resources Technical Meeting, Athens, Greece, Vol. 4, 1957, pp. 337-345.

This paper deals primarily with the dangers to salmonid stocks, their food supplies, shelter, and access to and from spawning grounds following drainage activities. Both beneficial and deleterious effects of drainage activities are examined and compared with conditions obtained in natural waters. The possibility of combining the desirable features of both systems with a view toward conservation and improvement of stocks in artificial channels is discussed. Suggestions are made and experiments described that would achieve this result without interference, but possibly with benefit to other legitimate uses of land and water. No conclusions were made pending results of continuing studies.

165. SULLIVAN, B., and HANCOCK, D.R., "Zooplankton and Dredging: Literature Review and Suggestions for Research," NSF RANN GRANT G1 34346, App. 6-1, Oregon State University, Corvallis, Oreg., Dec. 1974, pp. 199-209.

This report includes a theoretical discussion of the reasons to suspect dredging effects on zooplankton and a review of the available evidence to make judgments on including zooplankton in future dredging research proposals. It describes zooplankton biology that might be influenced by dredging and reviews the literature that relates to these areas.

166. SYKES, J.E., and HALL, J.R., "Comparative Distribution of Mollusks in Dredged and Undredged Portions of an Estuary, with a Systematic List of Species," *Fishery Bulletin*, Vol. 68, No. 2, Feb. 1971, pp. 299-306.

A survey of benthic mollusks in Boca Ciega Bay, Florida, showed a smaller number and variety of species in the soft sediments in dredged canals than in the predominantly sand and shell sediments in undredged areas. Samples contained an average of 60.5 live mollusks and 3.8 species in undredged areas and 1.1 individuals and 0.6 species in dredged canals. A list of mollusks collected in this survey and in past studies included in an appendix.

167. TANNER, S.H., and PULLEN, E.J., "Hurricane Barrier Environmental Planning in Texas," *Journal of the Waterways, Harbors and Coastal Engineering Division*, Vol. 99, No. WW4, Nov. 1973, pp. 459-470.

Major environmental factors involved in planning coastal flood barrier systems along the Texas coast are present in this paper. The intent is to highlight important environmental aspects to be considered when planning a protective system. This paper is not a treatise on the complexities of design and construction of such a system. In this paper environmental aspects are categorized: (a) ecological--man's habitat; (b) cultural--man's heritage; and (c) esthetic--man's sensory perception of the environment.

168. TANNER, S.J., and JUNSON, J.B., "A Preliminary Check-List of the Marine Algae of the Moss Landing Jetty, an Annotated Floristic Compilation," Technical Publication 73-7, Moss Landing Marine Laboratories, Moss Landing, Calif., May 1973.

This checklist represents a summary of floristic data collected over a period of 9 months (September 1971 to July 1972) in connection with a study of the jetty at Moss Landing, California. It provides a list of algal species

present, but does not represent a compilation of ecological data, although some passages are on an ecological nature. This study establishes a basic flora on which ecological analysis may begin.

169. TARPLER, W.H., Jr., LAUDER, D.E., and WILSON, A.J., "Evaluation of the Effects of Channelization on Fish Populations in North Carolina Coastal Plains Streams," Hearing, 92d Cong., 1st Sess., 1971, pp. 188-201.

This study was designed to determine the degree of damage to fish populations resulting from channelization and to determine the rate of recovery if the damage was significant. The study points out the detrimental effects stream channelization has on fish populations and on the flora and bottom fauna of streams. The study also indicates that following channelization, and with no channel maintenance or further alternations of the streambed, banks, forest canopy, or aquatic vegetation, nature can restore a stream and its fish population to a stage reasonably near its natural condition over a period of approximately 15 years.

170. TARVER, J.W., and DUGAS, R.J., "A Study of the Clam, *Rangia cuneata*, in Lake Pontchartrain and Lake Maurepas, Louisiana," Report No. IWIFC-Technical Bulletin 5, Louisiana Wildlife and Fisheries Commission, Division of Oysters, Water Bottoms, and Seafoods, New Orleans, La., Feb. 1973.

Samples of *Rangia cuneata* were taken by using a Peterson grab and modified oyster dredge throughout Lakes Pontchartrain and Maurepas to determine the occurrence, distribution, and density of clam populations. Hydrological, sedimentological, and plankton samples were analyzed in an effort to determine some of the factors affecting the distribution, density, and growth of *R. cuneata*. Mortality and the effects of dredging operations on the environment are briefly discussed. Annual shell production and overfishing factors are discussed and recommendations to the industry are also proposed.

171. TAYLOR, J.L., HALL, J.R., and SALOMAN, C.H., "Mollusks and Benthic Environments in Hillsborough Bay, Florida," *Fishery Bulletin*, Vol. 68, No. 2, Apr. 1970, pp. 191-202.

Analysis of benthic mollusks and sediments at 45 stations showed that the diversity and abundance of mollusks was affected by bottom conditions, which were influenced in varying degrees by domestic and industrial pollution and dredging. Nineteen stations had no living mollusks, 18 stations had one or more of the four mollusk species that were predominant, and 8 stations had mollusks well represented by numerous species and large numbers of individuals. Stations with no living mollusks were termed unhealthy; others were designated marginal or healthy on the basis of the mollusks present. From station data, isopleths connecting similar areas indicated that 42 percent of the bay bottom was unhealthy, 36 percent marginal, and 22 percent healthy. Infrequent occurrence of the American oyster (*Crassostrea virginica*) further suggests that the major part of Hillsborough Bay was seriously contaminated. An appendix has a checklist of the 64 species of mollusks collected in the bay.

172. TAYLOR, J.L., and SALOMAN, C.H., "Some Effects of Hydraulic Dredging and Coastal Development in Boca Ciega Bay, Florida," *Fishery Bulletin*, Vol. 67, No. 2, Oct. 1968, pp. 213-241.

Filling of 1400 hectares of the bay by hydraulic dredging has reduced the area of Boca Ciega Bay, Florida, by about 20 percent since 1950. An estimate of the annual standing crop destroyed is 1 133 metric tons (798 kilograms per hectare, dry whole weight) of seagrass and about 1 812 metric tons (1 277 kilograms per hectare, dry weight) of associated infauna. In terms of annual production, the loss of biological resources is far greater--minimum estimates are 25 841 metric tons of seagrass, 73 metric tons of fishery products, and 1 091 metric tons of infauna, exclusive of meiofauna. Natural areas remaining in the bay support local and offshore fisheries and are of value for recreation, public utilities, commerce, and industry. At an estimated value of $988 per hectare per year, the worth of the estuarine area already eliminated is $1.4 million annually. In addition, inestimable secondary losses occur, principally from sedimentation, turbidity, and domestic sewage.

173. TAYLOR, M.H., et. al., "Hydrographic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal. Appendix IV. Benthos of Delaware Waters in and Near C and D Canal," Final Report, University of Maryland, National Resources Institute, Solomons, Md., Sept. 1973.

This report presents the test results of grab and dredge samples from 25 stations in the Delaware part of the C and D Canal system during 1971-72. Patterns of distribution within the study area were identified. Possible effects of the enlargement of the canal are discussed.

174. THORSEN, G., "Animal Migrations Through the Suez Canal in the Past, Recent Years and the Future," *Vie Milieu*, Marine Biological Laboratory, Elsinore, Denmark, Supp. Vol. 22, 1968-71, pp. 841-846.

From 1869 (completion of the Suez Canal) to 1929, only 15 valid species migrated from the Red Sea to the Mediterranean and none vice versa. There were extreme salinity differences, hypersalinity of the Bitter Lakes, and exceptionally high summer temperatures. Nile waterflow and tidal currents previously served as passage barriers, but dredging and deepening, salt dissolution, and construction of the Aswan High Dam facilitated migration with almost nine times more Red Sea species passing the canal over the past 40 years than during the preceding 60 years. Improved conditions for the passage of pelagic larvae increased invasion of the eastern Mediterranean Basin by Red Sea biota.

175. TRAUTMAN, M.B., "The Effects of Man-Made Modifications on the Fish Fauna in Lost and Gordon Creeks, Ohio, Between 1887-1938," *Ohio Journal of Science*, Vol. 39, No. 5, Oct. 1939, pp. 275-288.

To demonstrate the deleterious effects of dredging, the author compares seining results obtained in 1938 to those made in 1887. The physical changes of various parts of the creeks due to dredging are discussed. The article also deals with the impact of the dredging of creeks on fish species composition and abundance.

176. TRENT, L., "Size of Brown Shrimp and Time of Emigration from the Galveston Bay System, Texas," *Proceedings of the Gulf and Caribbean Fisheries Institute*, 19th Annual Session, Nov. 1966, pp. 7-16.

A study was made to determine the time period of emigration, the vertical distribution, and the size of the juvenile and subadult brown shrimp leaving the Galveston Bay system, Texas, through the Bolivar Roads tidal pass to the Gulf of

Mexico. Samples were taken both day and night on ebbtides from 18 May to 1 August 1966.

Brown shrimp were caught throughout the sampling period. Two peaks occurred--one in May and one in June. Estimates of the mean catch per unit effort indicated that the shrimp were near the surface at night and near the bottom during the day.

The mean lengths of the brown shrimp taken during the day and night with bottom and surface trawls in the same sampling date were similar. The size of the emigrating shrimp increased significantly as the season progressed.

177. TRENT, W.L., PULLEN, E.J., and MOORE, D., "Waterfront Housing Developments: Their Effects on the Ecology of a Texas Estuarine Area," *Fishing News, Ltd.*, Marine Pollution and Sea Life, Dec. 1972.

Studies were conducted during 1969 to compare the ecology of a natural estuarine area (marsh and bay) with the ecology of an adjacent estuarine area altered by channelization, bulkheading, and filling. In each area, hydrographic factors, fishes, crustaceans, and benthic macroinvertebrates were sampled periodically from March to October. Setting, growth, and mortality rates of juvenile oysters (*Crassostrea virginica*) were measured from February to October, and phytoplankton productivity was determined from June to August.

Values of oxygen, nitrite, and kjeldahl nitrogen were significantly higher in the natural area; total phosphorus was significantly higher in the altered area. Although 64 species of fishes and crustaceans were collected by trawl, 6 species comprised 88.8 percent of the total catch. *Brevoortia patronus*, *Anchoa mitchilli*, and *Micropogon undulatus* were most abundant in the altered area; *Penaeus aztecus*, *P. setiferus*, and *Leiostomus xanthurus* were most abundant in the natural area. The setting rate of oyster spat was 14 times, and the rate of growth of juvenile oysters was 1.8 times, greater in the natural than in the altered area. Oyster mortality was significantly greater in the altered area during the summer.

Gross production of phytoplankton in the surface waters averaged 2.24, 2.06, and 1.17 milligrams of carbon per liter per day in the altered, marsh, and bay areas, respectively. In part of the altered area, extremely high phytoplankton production, which caused low dissolved oxygen, reduced the abundance of fishes and invertebrates in the summer.

178. TRENT, L., PULLEN, E.J., and PROCTOR, R., "Abundance of Macrocrustaceans in a Natural Marsh and a Marsh Altered by Dredging, Bulkheading, and Filling," *Fishery Bulletin*, Vol. 74, No. 1, Jan. 1976, pp. 195-200.

Indexes of abundance of macrocrustaceans from March to October 1969 in West Bay, Texas, were determined for day and night and statistically compared between (a) a natural marsh area, (b) upland and bayward canal areas of a housing development, and (c) an open bay area. Significance levels of 5 or 1 percent were used in the statistical comparisons. Catches of brown shrimp, *Penaeus aztecus*, white shrimp, *P. setiferus*, blue crab, *Callinectes sapidus*, and pink shrimp, *P. duorarum*, were significantly greater at night than during the day at one or more stations in the marsh. More grass shrimp, *Palaemonetes sp.*,

were caught at night than during the day, but the differences were not statistically significant. Individuals of each species appeared to migrate into the shallower areas of the marsh at night. At night, brown shrimp and blue crabs were more abundant in the marsh and bayward canal areas than in the upland canal and bay areas, white shrimp were more abundant in the marsh area than in the other three areas, and pink shrimp were more abundant in the marsh than in the upland and bayward canal areas. During the day, brown shrimp were more abundant in the bayward canal area than in the upland canal and bay areas, while pink shrimp were more abundant in the marsh area than in the upland canal area. The generally lower catches of each species in the open bay and upland canal areas, when compared with the marsh and bayward canal areas, were attributed to: (a) Permanent loss of intertidal vegetation in the housing development; (b) low abundance of detrital material and benthic macroinvertebrates in the open bay and upland canal areas; and (c) eutrophic conditions in the upland canal areas.

179. U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, "Effects of Dredging and Disposal on Aquatic Organisms," EM 1110-2-5013, Corps of Engineers, Washington, D.C., Nov. 1979.

This report describes research carried out under the U.S. Army Engineer Waterways Experiment Station's Dredged Material Research Program. The objective was to determine direct and indirect effects of dredging and disposal on aquatic organisms. Dredging and disposal research were carried out in different locations throughout the United States.

180. U.S. ARMY ENGINEER DISTRICT, WILMINGTON, "Oregon Inlet Larval Transport Sensitivity Study," Wilmington, N.C., unpublished, 1980.

This report discusses the results of a physical model used to predict the probable pathways followed by larval aquatic organisms that are transported from the ocean through Oregon Inlet into Pamlico Sound, North Carolina. The results should help evaluate construction of jetties at Oregon Inlet.

181. U.S. DEPARTMENT OF INTERIOR, "Effects on Fish Resources of Dredging and Spoil Disposal in San Francisco and San Pablo, California," Special Report, Government Printing Office, Washington D.C., Nov. 1970.

Field and laboratory studies were conducted during the period September 1967 to August 1969 to determine the effects that dredging and spoil disposal would have on fish and wildlife environments in selected and representative reaches of San Francisco and San Pablo Bays. These studies were restricted to key indicator species.

Study results indicated that variables, such as rapidly fluctuating salinities, influence the variety and size of the biological communities. The effects of dredging and spoil disposal were not clearly apparent in certain localities, such as deep channel areas near Mare Island and shallow parts of San Pablo Bay. Data collected in more stable areas indicated dredging and spoil disposal significantly reduced the number and species composition of various benthic organisms, bottom associated invertebrates, and fishes. While certain species were reestablished in a period of a few months after the spoiling, the "general health" of the environment in this area, as measured by the diversity of benthic organisms, was not restored during the study period.

182. U.S., NATIONAL MARINE FISHERIES SERVICE, "An Environmental Survey of Effects of Dredging and Spoil Disposal, New London, Connecticut," Report No. MAF-Informal-49, Government Reports Announcement, Vol. 75, No. 23, Oct. 1975.

The report considers activities and findings of several integrated research projects designed to monitor the environmental effects of dredging in the Thames River and dredge spoil disposal at the New London dumping ground. The report addresses field activities conducted and results obtained. University of Connecticut completed three additional cruises in the Thames River to investigate suspended material transport. Progress has been made toward selecting a circulation model for determining dredging-induced variations and toward characterizing the average loads of suspended sediments during autumn. The University of Connecticut report contains photos of spoils at the dump site and evidence of past dumping. Scuba surveys conducted in late November and early December found no major changes in the bottom conditions. The New York Ocean Science Laboratory reports establish predisposal values for the physical and chemical oceanography of the dump site and describe changes found in September and December, as well as effects of single dumping events at those times. The report also presents predisposal concentrations of heavy metals in benthic animals.

183. UNIVERSITY OF MARYLAND, NATURAL RESOURCES INSTITUTE, "Hydraulic and Ecological Effects of Enlargement of the Chesapeake and Delaware Canal, Summary of Research Findings," Final Report No. CONTRIB-566, Solomons, Md., Sept. 1973.

An estimate of the ecological effects of the enlargement of the Chesapeake and Delaware Canal from control dimensions of 8 meters by 76 meters to 11 meters by 137 meters is given. Serious constraints exist as the study was initiated late in the process of canal enlargement and the time available for the study was short. Specific subgoals were identified as objectives for the described research program. These dealt with the salinity and flow patterns of the canal; its value as a nursery for fish; the movements of fish throughout the canal; and the populations of other organisms within it. In each case, the effects of the enlargement were sought and the most advantageous operation of the canal from various ecological points of view were considered. Basically, all our studies can be grouped under two major headings: one dealing with the hydrographic effects and the other with the ecological effects of canal enlargement. Findings and results are discussed in detail in each of the 14 appendixes that cover a specific study..

184. VAUGHAN, R., and KIMBER, C., "Maintenance Dredging Effects on Vegetation Adjacent to the Gulf Intracoastal Waterway - Cedar Lakes Section," Sea Grant Publication TAMU-SG-77-207, Texas A & M University, Geography Department, College Station, Tex., June 1977.

The relationship of spoil deposition and bank erosion to habitat conditions and vegetation is examined in six sites along the gulf Intracoastal Waterway in Brazoria County, Texas. Fourteen mappable plant assemblages were identified and verified in the field. Species frequencies are presented and compared with environmental data collected along the same transects. Vegetation maps depict the pattern of assemblages for each site.

Vegetation and habitat data from the individual sites indicate that soil moisture is the limiting factor for both past and present plant growth. Deposition of spoil on the canal banks has led to less uniform and more dynamic conditions of soil moisture and has increased the range of soil moisture potentials. These effects are observable in the vegetation pattern. Alternatives for the placement and management of spoil materials are presented that allow some control over the distribution and composition of vegetation.

185. VENKATARAMIAH, A., LASKSMI, G.J., and GUNTER, G., "Studies on the Effects of Salinity and Temperature on the Commercial Shrimp, *Penaeus aztecus* Ives, with Special Regard to Survival Limits, Growth, Oxygen Consumption and Ionic Regulation," Report H-74-2, Office of the Chief of Engineers, U.S. Army, Corps of Engineers, Washington, D.C., 1974.

The distribution and abundance of most commercial and sports marine fisheries species of the Middle Atlantic to Gulf Coast States are dependent on estuarine areas. Some species such as the oyster *Crassostrea virginica* and the clam *Rangia cuneata* spend their entire lives in the estuaries, while several motile species use this habitat as a nursery ground. Species living in low salinities avoid many enemies, parasites, and predators that do not invade low salinity waters. The low salinity estuaries are essential to many species, and they are certainly conducive to the normal development of the young stages. It was observed that low salinity waters were essential for the faster growth and better survival of young brown shrimp. The juvenile shrimp in their estuarine life stage require low salinity and warm waters for normal growth and survival, rather than high salinity and low temperature.

186. VENKATARAMIAH, A., et al., "Studies on the Time Course of Salinity and Temperature Adaptation in the Commercial Brown Shrimp *Penaeus aztecus* Ives," Report H-77-1, Office of the Chief of Engineers, U.S. Army, Corps of Engineers, Washington, D.C., 1977.

The period of time it takes brown shrimp, *Penaeus aztecus*, to adapt to changes in salinity and temperature was determined by analyses of certain behavioral and physiological responses, respiratory rates, and osmotic and ionic regulation. In brown shrimp, salinity and temperature requirements are shown to be size-dependent. The optima for subadult shrimp (95-millimeter mean length) seem to exist above 10 parts per thousand, preferably between 15 and 25 parts per thousand, and below 25° Celsius. In contrast the juveniles (70-millimeter mean length) in previous studies have shown preferences for salinities lower than 17 parts per thousand and for temperatures slightly higher than 26° Celsius. The possible existence of seasonal salinity and temperature optimal rhythms is discussed in relation to the life cycle of brown shrimp.

187. VITTOR, B.A., "Effects of Channel Dredging on Biota of a Shallow Alabama Estuary," *Journal of Marine Science*, Vol. 2, No. 3, Sept., 1974, pp. 111-134.

Channel dredging had temporary and localized direct effects on turbidity in D'Olive Bay. It had no effect on water temperature, dissolved oxygen, salinity, or circulation. A late summer dike break caused a 2.8-hectare mudflow, which significantly reduced primary productivity of pelagic algae, and destroyed most submerged vegetation and benthic fauna. These effects persisted for at least 8 months after the accident occurred. Most benthic animals in the channel

site were removed or destroyed during dredging. Eight months after dredging, biomass at seven of the effected stations was 28 percent lower than at "control" stations. Species diversity was not significantly different at effected and uneffected locations. Channel dredging has had no long-term influence on vertebrate wildlife populations in D'Olive Bay.

188. WAKEMAN, T.H., "The Biological Ramifications of Dredging and Disposal Activities," Dredging: Environmental Effects and Technology," *Proceedings of the World Dredging Conference*, July 1976, pp. 55-68.

This discussion concerns the environmental ramifications of dredging and disposal activities in San Francisco Bay. The investigation examined the impact that operations generated on water quality, sediment heavy metal release, and benthic and pelagic organisms, both in terms of physical and chemical effects. In the upper water column neither dredging nor disposal operations cause significant changes in water quality. Plumes were observed, but these were generally of short duration and seldom contained high suspended-solid concentrations. The physical impact of various particle concentrations with changes in temperature and dissolved oxygen was investigated using several San Francisco Bay benthic and pelagic species. In general, the results showed that the levels observed in the field would not cause adverse effects on adult benthic species at saturated oxygen and winter temperatures (10° Celsius). Effects were more pronounced at higher temperatures and lower dissolved oxygen concentrations. Pelagic species could be negatively impacted by the solids concentrations found at disposal sites with increasing effects as temperature and dissolved oxygen conditions became more adverse. Investigations of desorption phenomena showed that cadmium, lead, zinc, and copper can be emitted from resuspended San Francisco Bay sediments under oxygen-rich conditions. Biological investigations showed that dissolved heavy metals ions can be accumulated during low salinity periods and desorbed as the salinity increases. Heavy metals may be absorbed and accumulated by organisms following dredging and disposal activities via chemical reactions in the water column causing increased ambient concentrations or by ingesting and breaking down organic matter containing metals.

189. WAKEMAN, T.H., and FONG, C.C., "Biological Impacts of Dredge Material Disposal in the San Francisco Bay," *Proceedings of the Seventh Annual Offshore Technology Conference*, May 1975, pp. 93-102.

Studies were conducted to determine the effects of dredging and disposal operations on the main ship channel across the San Francisco Bay. Disturbance of a basically sandy substrate causes little ecological disruption of the marine benthos. Organisms associated with such an environment have evolved with an unstable substrate and are able to survive disturbances.

190. WATER AND AIR RESEARCH, INC., "A Study on the Effects of Maintenance Dredging on Selected Ecological Parameters in Gulfport Harbor, Mississippi," Gainesville, Fla., July 1975.

This report assesses the environmental effects of maintenance dredging in Mississippi Sound in 1974. Background conditions were measured before and after dredging, and extensive monitoring was conducted during the dredging operation. It was found that dredging had no significant or lasting effect on any of the conditions evaluated in this investigation. Turbidities and suspended solids were measured and the size and dispersion of the discharge

plume were defined. Distributions and levels of bacteria and heavy metals were studied to measure their release from the sediments.

191. WELKER, B.D., "Movements of Marked Channel Catfish in the Little Sioux River, Iowa," *Transaction of the American Fishery Society*, Vol. 96, No. 3, July 1967, pp. 351-353.

Investigation of the movement of marked channel catfish *Ictalurus punctatus* in relation to channelization was initiated in 1964 on the Little Sioux River. The U.S., Army Corps of Engineers completed rechanneling the lower 56 kilometers of the river in 1957. The study area included the lower 96 kilometers so that movement could be studied in both straightened and unstraightened sections. There was no major difference in the direction of catfish movement between the straightened and unstraightened sections of the river. Disregarding local movement, 23.7 percent of recaptures in the unstraightened area moved upstream, 69.6 percent moved downstream, and 6.7 percent were recaptured at their release site. In the straightened section, 25.8 percent moved upstream, 39.8 percent moved downstream, and 24.4 percent were recaptured at their release site.

192. WHITTEN, H.L., ROSENE, H.F., and HEDGPETH, J., "The Invertebrate Fauna of Texas Coast Jetties; A Preliminary Survey," *Publications of the Institute of Marine Science*, Vol. 1, No. 2, University of Texas, Austin, Tex., 1950, pp. 53-87.

An ecological survey of the marine invertebrate fauna was conducted on the jetties of the Texas coast during June and July in 1938, 1939, and 1940. The jetties studied are located at five tidal passes; these rocky areas constitute a minor percentage of the total 644-kilometer-long Texas coast. This study was confined primarily to the intertidal communities of the jetties. There was a north-south change in the relative abundance of the major species of jetty fauna related to salinity and wave action. The fauna on the jetty represent a composite colonization from various habitats. A few species owe their colonization to their free-living larvae.

193. WINDOM, H.L., "Environmental Aspects of Dredging in Estuaries," *Journal of the Waterways, Harbors and Coastal Engineering Division*, Vol. 98, No. WW4, 1972, pp. 475-487.

The chemical response of salt marsh estuarine sediments in the Intracoastal Waterway to deposition of dredge materials was studied, along with the effect of dredging and sediment deposition on water quality. Salt marsh plants were destroyed by spoil deposition and the rate of reequilibration of marsh sediments to their original state was dependent on the depth of dredge spoil deposit. In natural and relatively unpolluted areas, dredging did not affect the water quality.

194. WINDOM, H.L., "Environmental Aspects of Dredging and Filling," *Proceedings of the Seminar on Planning and Engineering in the Coastal Zone*, Coastal Plains Center for Marine Development Service, Seminar Series No. 2, Wilmington, N.C., 1972, pp. 53-61.

Coastal zone alteration of habitats due to deposition of dredged material and water quality impairment of the surrounding water during a dredging operation are examined. Marsh areas that have been covered with spoil material will

return rapidly to their original chemical characteristics if proper consideration is given to the depth of the spoil material deposited. With the proper approach and using the proper criteria, natural and possibly artificial marsh regeneration can be accelerated. In unpolluted areas where undiked spoil deposition techniques are used, no significant water quality impairment in marine environments appears to have taken place in the general area of the dredging activity, in relation to the parameters studied. Dredge spoil deposition using diked confinement techniques is potentially more environmentally dangerous than undiked techniques.

196. WONG, V.D., "Moss Landing Harbor, California: A Case History," *Shore and Beach*, Vol. 38, No. 2, Oct. 1970, pp. 26-39.

The coastal environment is a delicate system of shore processes which at best, only reaches a state of dynamic equilibrium. A manmade structure may upset the natural balances, resulting in dramatic changes in the coastline. This is a report on the construction and maintenance of the entrance channel and protective jetties at Moss Landing Harbor, California, and the effects these structures may have had on the nearby coastal environment. Basic shore processes pertinent to the area before the construction of Moss Landing Harbor are described. The problems at Moss Landing Harbor were not as great as initially anticipated due to unique littoral current patterns and the presence of an offshore canyon.

197. WORLD DREDGING CONFERENCE, "Dredging: Environmental Effects and Technology," *Proceedings of the Seventh World Dredging Conference*, 1976.

These proceedings of Session 2 of the 1976 World Dredging Conference contain 53 papers on the environmental effects and technology of dredging.

198. WRIGHT, T.D., "Aquatic Dredged Material Disposal Impacts," *Dredged Material Research Program*, Technical Report DS-78-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Aug. 1978.

Studies of the impact of dredged material disposal in open-water systems were conducted at five locations: New York (Eatons Neck), Ohio (Ashtabula River), Texas (Galveston), Oregon (Columbia River), and Washington (Dunwamish Waterway). The sites represented a variety of disposal practices, dredged materials, and aquatic habitats. Disposal did not occur during the course of Eatons Neck study, but did at the other four sites. This report summarizes the findings of the investigations.

199. ZEIN-ELDIN, Z.P., "Effect of Salinity on Growth of Postlarval Penaeid Shrimp," *Biological Bulletin*, Vol. 125, No. 1, Aug. 1963, pp. 188-196.

The effect of salinity on the growth and survival of postlarvae of white shrimp, *Penacus setiferus*, and grooved shrimp, *P. aztecus* or *P. duorarum*, has been studied in the laboratory. The growth rate did not differ significantly among shrimp held at 2, 5, 10, 25, or 40 parts per thousand. Survival was generally excellent at all salinity levels tested, including 40 parts per thousand. The results suggest that salinity, per se, does not limit growth of young shrimp.

IV. SUBJECT INDEX

Ford, Julie C.

An annotated bibliography on the biological effects of constructing channels, jetties, and other coastal structures / by Julie C. Ford, Arthur K. Hurme, and Edward J. Pullen.--Fort Belvoir, Va. : U.S. Army, Corps of Engineers, Coastal Engineering Research Center ; Springfield Va. : available from NTIS, 1983.

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