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OSME

الهيئة الوطنية لحماية الحياة الفطرية وإنمائها

NATIONAL COMMISSION FOR WILDLIFE CONSERVATION AND DEVELOPMENT

OSME

OSME was founded in 1978 as the successor to the Ornithological Society of Turkey. Its primary aims are,

- To collect, collate, and publish data on all aspects of the birds of the Middle East.
- To promote an interest in ornithology and bird conservation throughout the Middle East.
- To develop productive working relationships with other governmental and non-governmental organisations with an interest in conservation and/or natural history in the region.

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NATIONAL COMMISSION FOR WILDLIFE CONSERVATION AND DEVELOPMENT

Contents

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Foreword

THE ARABIAN GULF is important to the nations of Arabia in more ways than one. Just as important as its well known oil reserves are its role as a sustained source of livelihood for the coastal populations and its rich and varied biodiversity. Therefore the Kingdom of Saudi Arabia accords high priority to the environmental management of this sensitive and geologically young ecosystem.

The ecological damage caused by the massive oil spill during the war posed a formidable challenge to the National Commission for Wildlife Conservation and Development (NCWCD), the Kingdom's focal conservation agency. Fortunately the NCWCD, with the active support of a number of cooperating agencies, was able to respond quickly to the unprecedented environmental crisis by setting up a series of programmes for habitat restoration and wildlife rescue. These efforts together with various other oil-combat operations have helped to keep the level of ecological damage far below the predicted levels.

Marine birds are the taxa apparently destined to suffer the most in any oil spill, and the case was not different in the Gulf. This special issue of *Sandgrouse*, forming a compendium of studies on the effect of the oil spill on the bird fauna, offers a thorough impression of the subject. While it demonstrates the unpredictability of consequences in the event of an ecological emergency, it also points out the ecological resilience of the avian community. This publication is certainly a commendable contribution to the Gulf ecology and to the emerging discipline of ecological crisis management. I compliment the authors and the editorial team for producing such a theme issue of *Sandgrouse*. NCWCD, quite naturally, would be keen to follow up further on these studies.

Saud Al-Faisal

Minister of Foreign Affairs,
and Managing Director National Commission for Wildlife Conservation and Development, Kingdom of Saudi Arabia

Sandgrouse (1993) 15: 3–5.

An overview of the ornithology programme of the National Commission for Wildlife Conservation and Development

PROF. ABDULAZIZ H. ABUZINADA
Secretary General, NCWCD

ARABIA holds an ornithogeographically significant position. The species diversity, the large number of endemics, and the millions of transitory as well as wintering migrants all contribute to this significance. With a regime of protection in place, and with the addition of man-made wetlands, the diversity and abundance of birdlife in the Kingdom of Saudi Arabia is registering a steady increase.

The National Commission for Wildlife Conservation and Development (NCWCD), established by a Royal Decree in 1986, is mandated with the conservation and scientific study of the Kingdom's biological diversity and biophysical features. NCWCD's work is mainly focused on setting up and managing a system of protected areas and restoring populations of endangered native species. The initial network of protected areas established covers the major centres of biodiversity in the Kingdom. By basing the concept of protected areas on the traditional Hima system, NCWCD has been able to place its conservation endeavours in the proper socio-economic context. On the species conservation front, in addition to protecting wild populations, captive propagation of endangered species is also carried out. Three wildlife research centres established by NCWCD breed in captivity the native gazelles *Gazella*, Arabian Oryx *Oryx leucoryx*, Nubian Ibex *Capra ibex*, and Houbara Bustard *Chlamydotis undulata* for eventual reintroduction to the wild. Arabian Oryx and gazelles have already been reintroduced to some of their former habitats.

NCWCD is engaged in a wide range of research and conservation activities related to birds. The protected area programme is closely linked to bird conservation. A top criterion for identifying sites for protected areas is the characteristics of each site's avifauna. Specific bird programmes are conducted on the basis of species conservation strategies, some of which are outlined in the following section.

Houbara Bustard is a key species of the Kingdom's conservation concern because of its cultural and ecological importance. The bird's main habitat, Harrat Al-Harrah in the northern region, has been fully protected, and field studies on the ecology, population, and movement of the species have been conducted since 1987. The project is currently seeking to determine the origin of the wintering birds in al Harrah using satellite telemetry methods. With a view to help augment wild populations, NCWCD is running an intensive captive breeding programme on the species at its National Wildlife Research Center (NWRC) at Taif in the western mountains. The breeding project is progressing successfully and NWRC is presently experimenting with various methods of release and identifying sites for reintroduction.

Decline of the Houbara is taking place throughout its range and therefore conservation programmes in the Kingdom alone cannot help restore the populations of the bird. Realising this, NCWCD has initiated a process to conclude an Agreement within the framework of the Bonn Convention for the conservation of the species. A draft Agreement has been prepared and NCWCD is planning in the near future to host a meeting of the range states to discuss the draft and to formulate a management plan.

The Arabian Bustard *Ardeotis arabs* too has been of persistent interest to NCWCD. The bird was surveyed in the Tihama region in three successive years, and widespread though small numbers of resident birds have been reported (Shobrak and Rahmani 1991). Some of its actual or potential habitats are now earmarked for protection.

The juniper *Juniperus* habitats of the Asir mountains in the south-west of the Kingdom are of high ornithological interest, particularly in that they contain a large number of endemic species (about ten, depending on the taxonomic treatment). A protected area, Raydah, has already been established to conserve high-elevation juniper forests and a long-term study of forest birds has also been commenced. The study has confirmed the presence of Mountain Nightjar *Caprimulgus poliocephalus* (Symens *et al.* in press), and the behaviour and habitat preferences of the endemic Arabian Woodpecker *Dendrocopos (Picoides) dorae* were also investigated (Winkler *et al.* in press). An ornithological study was conducted in the foothills of the mountains to assess the impact of habitat degradation. The study, focusing on Lichtenstein's Sandgrouse *Pterocles lichtensteinii*, Chestnut-bellied Sandgrouse *P. exustus*, and Sand Partridge *Ammoperdix heyi*, and conducted with the aid of radio transmitters, has yielded substantial information for the development of a management plan.

Another interesting finding has been the sighting of Bald Ibis *Geronticus eremita* near Taif. These birds of the nearly extinct eastern race are thought to be breeding in this area. Recent observations have shown that the endangered Demoiselle Crane *Anthropoides virgo* passes through north-central Saudi Arabia on its migratory flight (Newton and Symens 1993), and systematic methods for surveying the migrating birds are being developed. The spring count of 1992 showed 4,500 birds and in 1993 this increased to 6,000. Following the finding of a breeding population of Lappet-faced Vulture *Torgos tracheliotus* at Mahazat As Said, a protected area near Taif (Weigeldt and Schulz 1992), a full-time project was set up to study the breeding biology and ecology of that species (Newton and Shobrak 1993) and of other avian scavengers in the plains of central Arabia. In the 1992–3 breeding season, Mahazat As Said supported a minimum of 15 breeding pairs of Lappet-faced Vulture.

NCWCD's bird ringing scheme, initiated in the autumn of 1990, had ringed over 13,000 birds prior to the summer of 1993. Bird ringing is conducted mainly on the Gulf coast, in the Asir mountains, at Taif, and at Al-Hair river in Riyadh. Regular ringing in the spring and autumn is expected to give a clearer picture of the timing, strategies, and routes of the migrants. NCWCD is seeking to expand the ringing programme to other Gulf Cooperation Council countries, with the involvement of the respective national conservation agencies.

NCWCD faced its greatest challenge at the time of the oil spill caused by the Gulf War, and some of the consequences of this ecological crisis are reported in the ensuing papers in this issue of *Sandgrouse*. NCWCD responded to the crisis by setting up an animal rescue centre and launching habitat restoration programmes, with the support of several other organisations. A long-term ecological restoration and monitoring programme was also developed (Abuzinada *et al.* 1991). Studies on the seabirds of the Gulf coast are continuing on a regular basis, and seasonal studies are carried out on the Red Sea coast as well.

NCWCD is keen to maintain fruitful international cooperation for bird studies and conservation. It has excellent working relations with BirdLife International (as evidenced by the ensuing papers), with the IUCN wetlands programme, and with several other conservation agencies and universities abroad. NCWCD also sponsors the *Atlas of Breeding Birds of Arabia* programme including its newsletter *Phoenix*. It supports too the Asian Waterfowl Census and the Important Bird Areas of the Middle East project. NCWCD is pleased to support OSME in publishing this special issue of *Sandgrouse* on Gulf ornithology.

As mentioned above, NCWCD has plans in the pipeline to play an active role in the Bonn Convention programmes and is at present preparing the necessary submission to the Board of Directors for the Kingdom to become a party to the Ramsar Convention. The candidate sites in the proposal would include two major seabird habitats: Gulf islands and the uninhabited islands of the Farasan archipelago in the Red Sea. The Kingdom is already following an effective system for regulating wildlife trade, in line with the provisions of CITES.

This overview of a cross-section of NCWCD's ornithological work will, I hope, set the following papers into perspective against a wide range of conservation and research activities in the Kingdom.

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Prof. Abdulaziz H. Abuzinada, National Commission for Wildlife Conservation and Development, PO Box 61681, Riyadh 11575, Saudi Arabia.

Sandgrouse (1993) 15: 6–17.

Effects of the Gulf War oil spills and well-head fires on the avifauna and environment of Kuwait

C. W. T. PILCHER and D. B. SEXTON

Summary A survey during May 1991 to assess the effects of the Gulf War oil spills and well-head fires on Kuwait's avifauna and environment found that despite enormous oil spills into the Gulf during the war, Kuwait's coastline was 95% clear of serious pollution, but the most heavily impacted shores were amongst those that are most important for waterfowl. The environmental impact was far greater inland: large oil lakes formed from sabotaged well-heads whilst burning wells poured tens of thousands of tonnes of smoke into the atmosphere daily. At least 25% of Kuwait's desert was covered in oil or heavy deposits of acidic, oily soot. Birds mistook the oil lakes for water and many were begrimed from flying through smoke or from their sooty surroundings. Probably 90% of Kuwait's desert surface was compacted, churned, or otherwise impacted by military activities and desertification was greatly exacerbated, though the widespread abundance of unexploded ordnance may now deter motorists and reduce pressure from grazing, thereby providing a period for recovery. Valuable farmland habitats were destroyed, some for a long time to come. All existing protected areas for nature conservation were damaged. In the National Park most habitats were impacted by military activities and most of its fencing and gates were destroyed.

THE GULF WAR of 1990–1 produced severe damage to both marine and inland environments of the northern Arabian Gulf. Kuwait bore the brunt of this—not only major oil spills, fires, and atmospheric pollution, but also extensive mechanical damage to the fragile desert crust and its ecosystem.

THE MARINE ENVIRONMENT

During the war the Iraqis released huge amounts of crude oil into the waters of the Gulf. On 19 January 1991, occupying forces in Kuwait began discharging oil from five tankers moored off the Mina Al-Ahmadi oil terminal and one or two days later they opened nearby pipelines. By 30 January the spilled oil had produced a slick extending south-eastwards over an estimated 1,550 km^2 (USGTF undated), and at this time another major slick was reported emanating from the Mina Al-Bakr terminal in Iraq (Dipper 1991). In addition to these spills, oil had been released from the Basrah refinery at the mouth of the Shatt Al-Arab, from refineries on the southern coast of Kuwait, and from the storage depot at Al-Khafji, just south of the Kuwait–Saudi Arabia border. It is widely accepted that the spills totalled some 6–8 million barrels of oil, by far the biggest marine oil spills in history.

The general direction of marine currents in the northern Gulf is anti-clockwise and the prevailing winds are north-westerly, although strong south and south-east winds are frequent. With huge slicks emanating from locations north and south of the country, in addition to those from its own installations, it seemed inevitable that Kuwait's coastline and offshore islands would be badly affected. The northernmost slick threatened the shores of Bubiyan island and Kuwait Bay (Figure 1). Heavy pollution of the productive mudflats of the bay would be especially serious for the large numbers of waders using them during overwintering or on migration. Moreover, Kuwait's only coastal nature reserve is located at Doha on the south shore of Kuwait Bay. The two northern islands of Failaka and Auha were also at particular risk from the Mina Al-Bakr spill.

The enormous slick produced by oil discharged from southern locations in Kuwait was expected to impact on the nearby coastline, including the mudflats of An-Naq and saltmarshes of Khawr Al-Muffatah. This ecologically important area supports numerous waders and has been proposed as a nature reserve (Omar *et al.* 1987). The coral islands of Kubbar, Qaruh, and Umm Al-Marradim, lying 25–33 km offshore also appeared to be directly endangered by this slick. Kubbar provides breeding habitats for significant numbers of White-cheeked Terns *Sterna repressa* and Bridled Terns *S. anaethetus,* in addition to Lesser Crested Terns *S. bengalensis* and Swift Terns *S. bergii* (Pilcher 1989).

For two weeks from 19 January strong prevailing north-west winds kept the Mina Al-Ahmadi slick offshore as it was carried south out of Kuwaiti waters into those of Saudi Arabia, where subsequently it was driven onto the coast between Al-Khafji

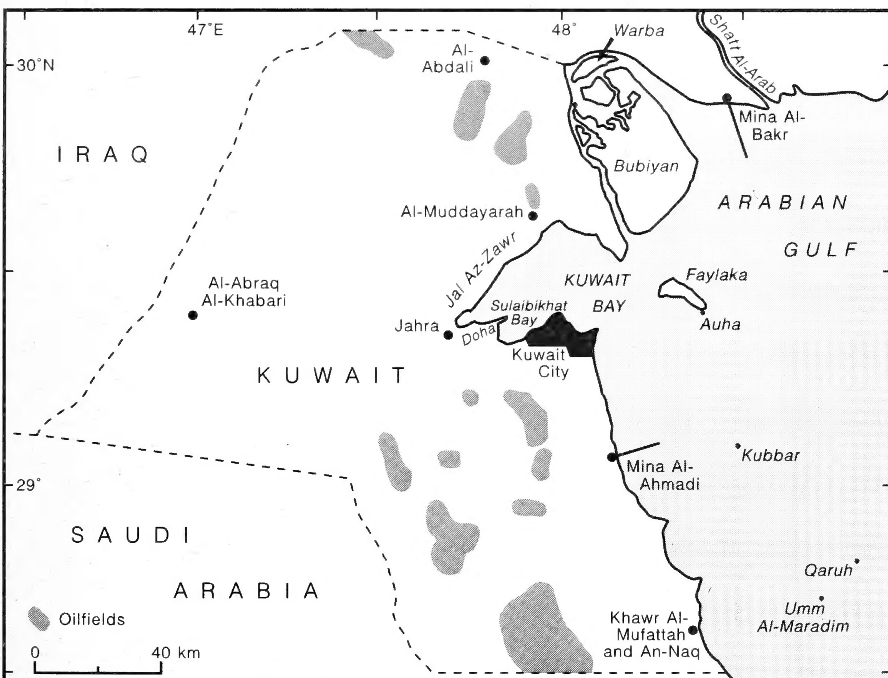

Figure 1. Kuwait, showing major oilfields (after Environment Protection Council 1991).

and Ras Abu Ali. Some 560 km of shoreline there were heavily impacted and over most of this stretch the intertidal flats were totally obliterated (Anon. 1991). A preliminary assessment in March 1991 (Heneman 1991) indicated that large numbers of intertidal birds had been affected by the oil along this coast, and in the following two months a more thorough study was conducted (Evans and Keijl 1993a, b).

THE INLAND ENVIRONMENT

Before withdrawing from Kuwait on 25 February, the Iraqi forces attempted to blow up all oil wells, tank farms, gathering centres, refineries, and other oil installations. The oilfields are distributed throughout the length of Kuwait, and virtually all lie in the eastern half of the country (Figure 1). Out of a total of 1,073 wells, 613 were left ablaze, 76 gushing, and 99 damaged (Al-Jassim 1991). By the beginning of May very few of the fires had been extinguished and most of the gushing wells continued to discharge oil. At the capping of the last well in November 1991, it was considered that 25–30 million barrels had been spilled onto the land (Environment Protection Council 1991) and the larger of the numerous oil lakes were estimated to cover an area totalling about 19 km^2 (N. M. Hussein *in litt.* to World Conservation Monitoring Centre, Cambridge).

In addition to the oil gushing from sabotaged wells, it was calculated that 13,700 tonnes of smoke poured daily into the atmosphere from those on fire (Browning *et al.* 1991). Much of the heavier particulate matter was deposited within the oilfields but the lighter particles were carried far, polluting the desert and coating vegetation with a layer of oily soot. This is a new phenomenon, and the effects on desert

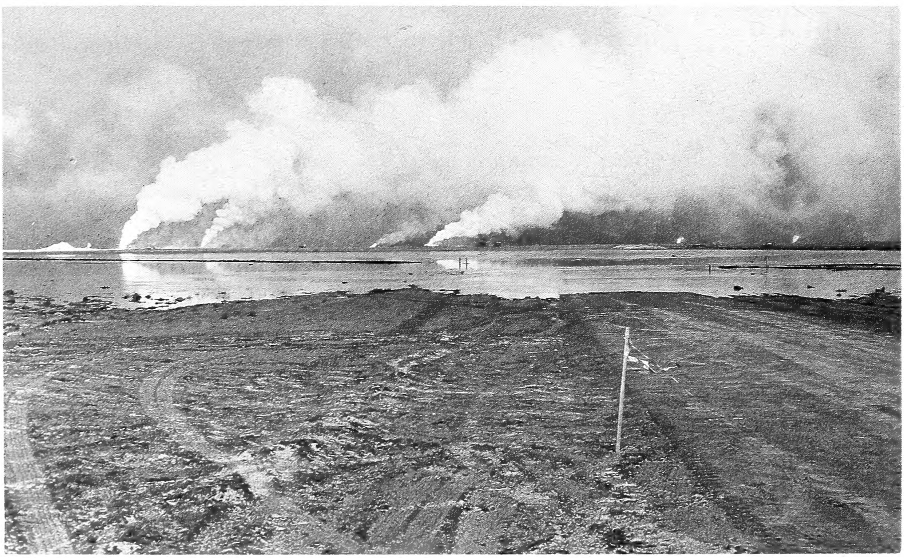

Plate 1. Oil lake and burning wells in the Ahmadi oilfield of southern Kuwait, May 1991. *(C. W. T. Pilcher)*

ecosystems in the long term are unknown.

Just a few months before the Iraqi invasion on 2 August 1990, Kuwait had established three long-awaited protected areas: a National Park in the Jal Az-Zawr region (comprising 250 km^2), a Nature Reserve at Jahra Pools (of 2·5 km^2), and a coastal Nature Reserve on Doha peninsula (of 4·5 km^2). Each area was surrounded with chain-link fencing and both the National Park and Jahra Pools reserve had 'wardens' on site. All three reserves lie between the major oil-fields of southern Kuwait and a cluster of fields to the north (Figure 1).

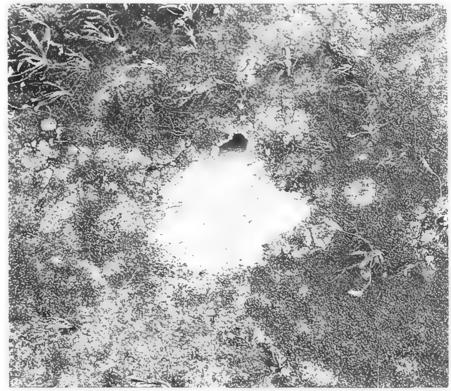

Plate 2. Sooty fallout in the Kuwait desert, contrasting with fresh spoil from a small mammal burrow, May 1991. (*C. W. T. Pilcher*)

SURVEY METHODS

During May 1991, on behalf of BirdLife International with financial support from the Royal Society for the Protection of Birds (RSPB, UK), we undertook a project to assess the damage caused by the Gulf War on the natural environment of Kuwait. The primary objectives were as follows.

- To assess the extent of pollution from oil spillage of Kuwait's coastline and islands, and its impact on birds.
- To examine the condition of habitats, gates, and fencing of the National Park, Jahra Pools Nature Reserve, and Doha Peninsula Nature Reserve.
- To assess the extent of damage to the desert environment resulting from soot deposition, oil spillage, and compaction by vehicular movements and to study the effects on birds.
- To provide information useful to the Environment Protection Council of Kuwait in rehabilitating its nature reserves and in developing future conservation strategies.

The numerous minefields and widespread abundance of other unexploded ordnance, both on the coast and inland, imposed certain constraints on the fieldwork that could be undertaken. However, extensive aerial surveys by helicopter were made, totalling 6–7 hours flying time, and many sites, including the country's three protected areas, were successfully studied on the ground.

Aerial surveys

Initially, the entire coastline from the border with Saudi Arabia in the south to that with Iraq in the north was surveyed in a single mission. This was flown at 1,000–1,200 feet (305–365 m), mostly within 0·5 km of the shoreline and at 100 knots (185 km/hr). Oiled stretches were noted and photographed. Similar surveys were made of the southern islands and oilfields. In subsequent analyses distances were determined using an opisometer with 1:250,000 maps.

Aerial surveys were also made use of in an attempt to quantify the extent of surface damage caused by tanks, defence excavations, and other military activities. Western Kuwait did not show evidence of serious oiling or soot fallout and seven locations were selected there for assessment. At each location two or three photographs (35 mm format) of the desert surface were taken from an altitude of 800 ft (243 m) using a Minolta Rokkor 50 mm lens. This lens has a field of view of 27 × 40° (N. Whitfield pers. comm.), and it can be shown by trigonometry (with certain assumptions) that a rectangular area of 20,782 m² would be represented within the frame if the plane of the lens was parallel to the surface of the ground. In practice, photographs could not be taken vertically but were obtained through the open door of the aircraft, and the axis of the lens was assumed to be 20° off vertical, the ground area thereby represented on film being calculated as 26,150 m². Large prints (212 × 152 mm) were made, losing 7% of the width of the original negative.

A grid was prepared photographically on transparent plastic such that one grid square represented approximately a 4·5-m square on the desert surface. The grid was laid over each print and the number of squares in which there were signs of disturbance was counted. Surface disturbance was reported as a percentage of the total number of 4·5-m squares represented by the print. Although it was not necessary therefore to know absolute measurements, it was considered of value to estimate areas as reliably as possible for each site.

Ground surveys

During this immediate post-war period vehicles that worked were at a premium and up to eight days were lost owing to mechanical, administrative, and other logistical problems. Nevertheless, a four-wheel drive vehicle was available, which

Plate 3. Heron *Ardea* trapped alive in an oil lake, Kuwait, May 1991. (*C. W. T. Pilcher*)

enabled counts to be carried out at sites known to be important for waders and other species (Pilcher 1987) whenever logistically possible. Visits largely focused on the coast at Sulaibikhat and Doha peninsula and the freshwater habitat of Jahra Pools Reserve. However, important farmland habitats at Al-Abraq Al-Khabari in the west and Al-Abdali in the north were surveyed in addition to widely scattered desert areas. Kuwait's three protected areas, the National Park, and Jahra Pools and Doha Peninsula Nature Reserves, were examined as fully as possible and the condition of habitats, fencing, and gates noted.

Except for the tern populations of Kubbar island, no large flocks of birds were encountered and reliable numbers could readily be obtained by simple counting. In so far as light conditions and distance allowed, all birds seen were recorded as being clean, or with less than 10% or more than 10% of their plumage oiled. In the tern colonies the island was divided into zones, each one being counted for nests at least twice by different observers and a mean value taken.

At the time of the survey large lakes had already formed in all of the major oilfields and were continuing to grow. Most of these lakes could not be surveyed for safety reasons but a small one adjacent to the As-Subiyah road at Al-Muddayarah was readily accessible and was selected for monitoring. Three visits were made to this lake during the study period.

RESULTS AND DISCUSSION

Coastal oil pollution

Between Kuwait City and Nuwaiseeb in the south the most significant pollution was in the tidal inlet of Khawr Al-Mufattah (Al-Khiran), where oil had been deposited in a band 2–3 m wide along about 0·5 km of the banks of the main creek. Because of safety considerations it was not possible to determine if the oil had been carried into the smaller and ornithologically more important branches of the creek. Elsewhere along this southern stretch of coast there were smaller, scattered deposits around piers and on peninsulas.

The most serious pollution was discovered in Sulaibikhat Bay, a sub-system of Kuwait Bay, where a 10-m band of oil had been deposited at the high water mark along 17 km of the shoreline, from Mina Shuweikh to the middle reaches of Doha peninsula. Fortunately, along most of this stretch the valuable intertidal zone comprising some 2,250 ha of productive mudflats was spared, unlike the situation in Saudi Arabia (Evans and Keijl 1993b). However, the important saltmarsh roost of the Doha Reserve, which is used by thousands of wintering and passage waders, including Ringed Plover *Charadrius hiaticula*, Kentish Plover *C. alexandrinus*, Lesser Sand Plover *C. mongolus*, Greater Sand Plover *C. leschenaultii*, and Grey Plover *Pluvialis squatarola* (Pilcher 1987), had been impacted and the vegetation damaged. Although the survey was too late to observe large numbers of waders at the site, it can be safely assumed that many using it during the previous month would have become oiled.

All of the remaining coastline of Kuwait Bay and islands of Bubiyan and Warba were essentially clear of oil, in contrast to the situation in March, two months earlier, when the islands had been heavily oiled (Al-Hassan 1992). Failaka and Auha islands were not surveyed. The mainland coastline, plus that of Bubiyan and Warba, was conservatively measured as 401 km, of which an estimated 20 km in all had been impacted. Therefore it was concluded that 95% of Kuwait's shores were free of persisting, serious pollution from the marine oil spills.

The counts of waders and seabirds are shown in Table 1, where it will be seen that relatively small numbers of herons (66), gulls (281), and identifiable waders (2,050) were observed during the survey. The waders comprised 25 species and about 17% were oiled. Only a few corpses were found at or near the coast, and these were of birds that appeared to be unaffected by oiling.

Table 1. Assessments of oiling in birds seen in Kuwait during May 1991, following the Gulf War. Except for total numbers oiled (%), figures are numbers of birds, categorized as clean or with less or more than 10% of their plumage oiled.

	Clean	Oiled			Sample	Notes
		<10%	>10%	Total (%)		
Ardeidae (7 species)	44	3	15	29	62	
Raptors (10 species)	17	3	4	29	24	
Oystercatcher *Haematopus ostralegus*	63	4	5	13	72	
Crab Plover *Dromas ardeola*	31	1	3	11	35	
Kentish Plover *Charadrius alexandrinus*	49	3	1	8	53	
Grey Plover *Pluvialis squatarola*	164	4	1	3	169	
Little Stint *Calidris minuta*	225	1	41	16	267	1 shot
Curlew Sandpiper *Calidris ferruginea*	80	5	56	43	141	
Curlew *Numenius arquata*	104	13	10	18	127	
Wood Sandpiper *Tringa glareola*	34	4	22	43	60	
Terek Sandpiper *Xenus cinereus*	87	0	15	15	102	1 dead at lake
Turnstone *Arenaria interpres*	78	1	10	12	89	
Other identified waders (15 species)	92	15	20	27	129	
Unidentified waders (too distant, poor light, 100% oiled, etc.)	698	0	108	13	806	108 dead at lake; 23 shot
Slender-billed Gull *Larus genei*	196	7	75	29	278	
Caspian Tern *Sterna caspia*	54	0	1	2	55	
Lesser Crested Tern *Sterna bengalensis*	512	1	0	<1	513	
White-cheeked Tern *Sterna repressa*	590	4	0	1	594	
Bridled Tern *Sterna anaethetus*	1,335	0	0	0	1,335	
White-winged Black Tern *Chlidonias leucopterus*	75	7	2	11	84	
Other Laridae (7 species)	41	2	2	9	45	
Other waterbirds (7 species)	10	0	3	23	13	
Nightjars *Caprimulgus*	0	0	7	100	7	Dead in lake
Blue-cheeked Bee-eater *Merops superciliosus*	3	0	18	86	21	All 18 dead or dying at lake
Roller *Coracias garrulus*	0	0	1	100	1	
Other non-passerines (7 species)	11	9	4	54	24	
Sand Martin *Riparia riparia*	16	0	18	53	34	
Other hirundines[1]	0	0	103	100	103	Dead in lake
Other passerines	22	11	43	71	76	16 species

[1] 1,500+ not assessed for oiling (mostly Swallows *Hirundo rustica*).

The southern islands

Kubbar, Umm Al-Maradim, and Qaruh were free of oil. Kubbar is the largest tern breeding colony, usually supporting around 2,500 pairs (Pilcher 1989), while Umm Al-Maradim is used by 100–200 pairs and Qaruh none. On Kubbar the populations of terns during the survey were similar to those of the last two censuses in 1987 (Pilcher 1989) and 1990. The total numbers of terns counted are shown in Table 1; ten species were recorded and less than 1% of birds were oiled. This agreed very closely with the findings of a simultaneous survey of Saudi Arabian breeding terns (Symens and Evans 1993).

Oil pollution inland

The aerial surveys indicated that pollution from leaking wells was extensive and lakes of oil were already covering several square kilometres in the major fields. These lakes were apparently mistaken for water by birds that landed on or drank from the oil. At the small lake at Al-Muddayarah over 200 dead or dying birds, representing at least 15 species, were counted: Little Bittern *Ixobrychus minutus,* Grey Heron *Ardea cinerea,* Teal *Anas crecca,* Shoveler *A. clypeata,* Sparrowhawk *Accipiter nisus,* Steppe Eagle *Aquila nipalensis,* Wood Sandpiper *Tringa glareola,* Terek Sandpiper *Xenus cinereus,* sandgrouse *Pterocles,* nightjar *Caprimulgus,* Blue-cheeked Bee-eater *Merops superciliosus,* Swallow *Hirundo rustica,* Sand Martin *Riparia riparia,* a shrike *Lanius,* and a warbler (Sylviidae).

Plate 4. Oiled Swallow *Hirundo rustica,* Kuwait, November 1991. (*A. V. Cross*)

It is not clear how faithfully the number of fatalities at Al-Muddayarah may have reflected the total at the numerous other lakes across the country. Casual counts around the margins of several very much larger lakes in Magwa and North Burgan produced a surprisingly small number of corpses. One suggestion was that the location of Al-Muddayarah, near the coast and (to a northbound migrant) on the far side of Kuwait Bay, may have caused more birds to be attracted. However, a survey by CWTP in October 1991, of two tiny oil lakes in south Wafra, which is well inland, produced numbers approximating to those at Al-Muddayarah, suggesting that size of the lake might be an important factor in determining the density of shoreline corpses.

Fallout of oily soot occurred over the entire country and the worst affected areas are depicted in Figure 2, where it will be seen that the whole of southern Kuwait and an area in the north-east were heavily polluted. The prevailing north-west winds ensured that western regions remained relatively free of this type of pollution. A number of species including Collared Dove *Streptopelia decaocto*, Crested Lark *Galerida cristata*, Swallow, Sand Martin, Red-backed Shrike *L. collurio*, and House Sparrow *Passer domesticus* were sooty in appearance and had presumably become begrimed as a result of flying through the smoke or by foraging in soot-covered surroundings. The extent of debilitation caused by soot ingested when preening and feeding can only be a matter of speculation.

Surface destruction

Casual observations during flights and ground travel gave the impression that there were virtually no areas in the interior that were not compacted or churned up by vehicular movement and military activities. The aerial survey attempted to provide a quantitative assessment, and Table 2 shows the results obtained, which are also indicated on the map in Figure 2. The most extensive surface damage was at site 5, where in one sample area only six of the 1,260 4·5-m grid squares were

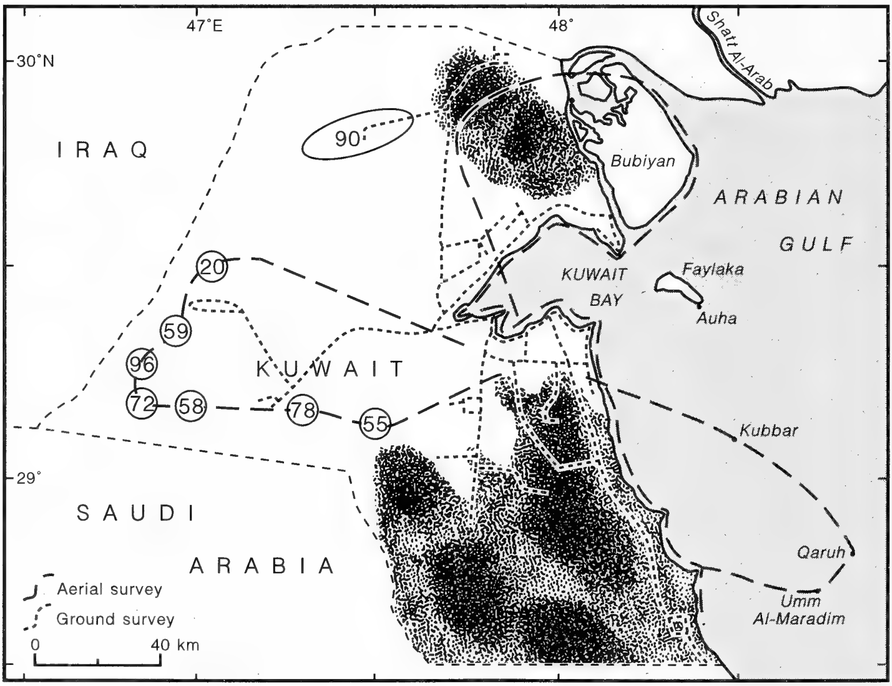

Figure 2. Kuwait, showing survey routes and surface damage resulting from the Gulf War. Stippled areas represent ground covered by oil or heavy soot fallout: areas are estimated subjectively, and density of stippling is a rough assessment of severity of pollution. Numbers in circles indicate percentage extent of surface compaction or disturbance at that location as estimated from aerial surveys (see Table 2 and text). The value in the elliptical area in the north-west was estimated from a ground survey.

noted as undisturbed and the mean for the site was 96·2%. Some or all areas of sites 1, 3, 4, 6, and 7 produced spuriously low values because of obliteration of surface features by drifted sand: inspection of the photographs frequently showed tracks ending suddenly at the edge of uniform, featureless areas. At site 7 most of the two areas sampled had been affected in this way and the value of 19·8% is certainly a great underestimate. Despite these low values, however, the mean result for surface destruction in western Kuwait was 62·6%.

Prior to the war, accelerating desertification caused by overgrazing and ever-increasing motor traffic had already become a matter of concern to conservation bodies in Kuwait. In fact, proposals had been made as early as 1987 to establish a protected area of some 575 km² in the western desert and another of 155 km² in the north-east (Omar *et al.* 1987). It is possible that the widespread presence of unexploded ordnance in these regions, a danger that may persist for many years, will deter motorists, shepherds, and hunters and permit a period of recovery for the vegetation and the soil.

Table 2. Extent of surface destruction in western Kuwait resulting from the Gulf War, 1990–1. For each numbered site two or three areas (of 26,150 m²) were sampled, and disturbance is calculated as a percentage of 4·5-m squares showing signs of disturbance (see text). See Figure 2 for location of sites.

		Disturbance	
Site	Location	Samples	Mean
1	29°05′N 47°30′E	60.7	55.4
		50.2	
2	29°07′N 47°15′E	65.4	77.5
		89.6	
3	29°08′N 47°00′E	67.5	58.3
		50.8	
		50.5	
4	29°08′N 46°50′E	89.1	72.3
		77.9	
		49.8	
5	29°13′N 46°50′E	99.3	96.2
		96.7	
		49.8	
6	29°18′N 46°55′E	54.4	59.1
		63.8	
7	29°30′N 47°05′E	18.4	19.8
		21.1	
Overall mean			62.6

Protected areas

The survey found fencing and gates at all protected areas to be badly damaged. Perimeter fencing of the National Park on all sides except the south had either been destroyed or removed entirely and long sections had been carefully rolled up, presumably in preparation for removal to Iraq. Habitats of the National Park and Doha Reserve were seriously impacted by military activities such as bunker construction, excavations, and vehicular movements. Apart from removal of the warden's hut and damage to the fences, the actual freshwater habitat at Jahra Pools Reserve was relatively undisturbed, but in the outer zone there was scattered unexploded ordnance, a problem common to the other protected areas.

Pollution from soot fallout appeared slight at Doha and Jahra Pools reserves, and despite its proximity to major oilfields the National Park was not seriously affected. However, the eastern area of the Park, which would be expected to have the worst of such pollution, was not surveyed extensively. Tracked vehicles had churned the ground to an impassable state and there was the danger of mines and other ordnance.

The valuable habitats provided by farmland at Al-Abdali and Al-Abraq Al-Khabari were found to have suffered badly. Irrigation had ceased and well-pumps, generators, and other equipment had been looted. Less hardy vegetation was already dead or would not survive the subsequent summer. Deep bunkers had been excavated under the tall tamarisk *Tamarix* trees, destroying much of their root systems. The survival of these trees, which had been planted around all fields as windbreaks, was in doubt even in the unlikely event of an early restoration of irrigation. At Al-Abraq Al-Khabari, bombing by Allied forces had destroyed a plantation of date palms *Phoenix,* and here, as on other farms, scattered unexploded ordnance was a danger.

CONCLUSIONS

The survey concluded with a number of recommendations to the Kuwaiti authorities.

- To complete removal and treatment of oil lakes throughout the oilfields, specifically to lessen the danger to migrating birds and damage to resident fauna.
- To repair fences and gates of the three main protected areas, all of which have serious damage resulting from the Iraqi occupation. Information signs at main entrance gates and at other perimeter points should also be replaced.
- To encourage the retention of barbed wire defences at Jahra Pools and Doha Peninsula reserves. This will contribute to the much-needed protection from hunters required by these sites.
- To encourage the curtailment of all shooting at Jahra Pools and Doha Peninsula reserves particularly, and also to discourage this activity at all important wildlife sites in Kuwait. This may be possible through adequate fencing of the sites and provision of a warden/ranger (perhaps retired Kuwaiti military personnel) on site. The ranger should be properly trained and equipped.
- To encourage the rapid adoption of sites proposed for protection before the war and to promote the establishment of further protected areas to preserve Kuwait's wildlife and natural heritage. Special significance should be given to the offshore islands.
- To promote a greater understanding and appreciation of Kuwait's wildlife amongst citizens by a combination of means including an extended field-based education programme for schools and by encouraging the local populace to take an interest in the nature reserves and wildlife. This may be facilitated by provision of adequate visitor facilities including birdwatching hides, information boards, an information warden, and car park facilities.
- To continue to monitor bird migration through 1993 with logistical and technical support from BirdLife International and RSPB.

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Impact of Gulf War oil spills on Saudi Arabian breeding populations of terns *Sterna* in the Arabian Gulf, 1991

P. SYMENS and M. I. EVANS

Summary The breeding populations of terns *Sterna* on five Saudi Arabian islands (Harqus, Karan, Kurayn, Jana, and Jurayd) in the Arabian Gulf were investigated during May–June 1991. An estimated total of 66,660 pairs of terns was found, comprising 3,229 pairs of Swift Tern *S. bergii*, 20,501 pairs of Lesser Crested Tern *S. bengalensis*, 34,000 pairs of Bridled Tern *S. anaethetus*, and 8,930 pairs of White-cheeked Tern *S. repressa*. The numbers of Lesser Crested Tern and Bridled Tern are of international importance. Compared to a previous survey in 1986, tern numbers overall had increased by 39% and Bridled Terns by 270%, while Lesser Crested and White-cheeked Terns had decreased by 22% and 28% respectively. Reasons for the changes cannot yet be advanced, but it was obvious that the massive oil and smoke pollution of the marine environment during the 1991 Gulf War did not have any major impact on overall breeding success, which ranged from 72% to 91% in the different species. This was because most of the pollution occurred well before the terns arrived on their breeding grounds. Conservation of the breeding tern populations is discussed.

ONE OF the most important ornithological aspects of the Arabian Gulf is the large number of breeding seabirds on the offshore islands (e.g. Gallagher *et al.* 1984), and the northern coral islands off Saudi Arabia are known to be of international importance for breeding *Sterna* terns (Zwarts 1987; Bundy *et al.* 1989).

In 1991 the National Commission for Wildlife Conservation and Development of Saudi Arabia (NCWCD) and BirdLife International (known at the time as the International Council for Bird Preservation) set up a joint project to assess the extent of damage to birds caused by the massive oil spills that occurred that year in the Gulf during the Iraq–Kuwait conflict (the Gulf War) and to gather further data on

Plate 1. Kurayn island in the Arabian Gulf, *c.* 300 m across. (*Arnoud B. van den Berg*)

Plate 2. Bridled Terns *Sterna anaethetus* over colony in *Suaeda* on Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

the under-studied bird populations of this region. An important aspect of the project was the monitoring of terns breeding on offshore islands, and from June to August 1991 six islands off the northern Gulf coast of Saudi Arabia were surveyed in order to gather baseline data on population sizes of the various species and to assess the effects of the oil pollution on the terns and on their breeding activities.

THE ISLANDS

Islands visited during this survey were Harqus, Karan, Kurayn, Jana, Jurayd, and al-Arabiyah (Figure 1). All six are formed from coral and have an elevation of less than 3 m above the high tide line. Harqus, the smallest, is very low and lacks any terrestrial plant life, while the others are covered by halophytic vegetation, dominated by *Suaeda vermiculata* and *Salsola baryosma*

Figure 1. Location of islands in the northern Arabian Gulf.

bushes and (only on Karan and Kurayn) the annual *Mesembryanthemum nudiflorum*. In some places the vegetation is up to 1 m high and very dense. The vegetated, central area of the islands is surrounded by a narrow, bare beach platform, covered in nesting pits of sea turtles, from which a moderately steep sand beach descends to the water (Figure 2). Around much of the perimeter of the islands a storm berm occurs at the top of the beach slope, and on most islands the densest vegetation lies in the protected zone just behind this. Beach rock occurs in some areas of Karan and Jana along the lower portion of the beach and in the upper intertidal zone.

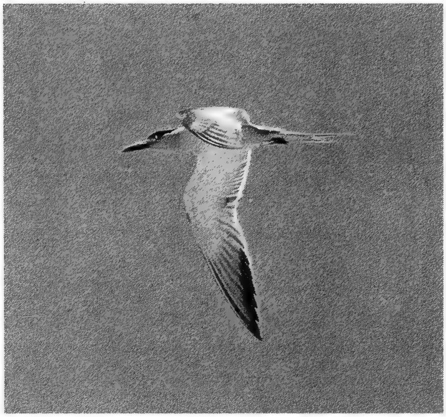

Plate 3. Swift Tern *Sterna bergii*, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

All islands except al-Arabiyah are aligned near the edge of the Gulf's increase in depth to 35 m, and their distances from the mainland vary from 35 to 90 km. Al-Arabiyah is located in deeper seas, 125 km from the coastline, and close to Iranian territorial waters. Although this island had important breeding colonies of seabirds in the past (Gallagher *et al.* 1984), it has been taken over by a coastguard station which occupies almost the entire surface and has consequently been abandoned by all breeding seabirds.

A preliminary survey of the islands by helicopter on 10 March 1991 revealed that huge quantities of oil had stranded on Karan, but the other islands escaped major impact by the oil spills except for some pollution by fresh tar balls, mainly on their northern beaches. However, on Jana, as well as on Karan, the northern rocky parts of the islands were covered by a thick layer of old tar, accumulated during spills that occurred mainly in 1983–4 during the Iran–Iraq War.

Plate 4. The oil clean-up in progress on Karan (Saudi Arabia), May 1991. (*Arnoud B. van den Berg*)

During April and the first half of May 1991, a specialist company cleaned up the oil on the sandy beaches of Karan by burying it in pits along the periphery of the island, and beaches were subsequently re-levelled with sand from the central part of the island. Due to a shortage of time, tar on the rocky parts of the beaches was not removed, as it was necessary for clean-up operations to finish before the beginning of the turtles' and terns' breeding seasons.

Plate 5. Colony of Lesser Crested Terns *Sterna bengalensis*, with two Swift Terns *S. bergii*, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

THE TERNS

Four species of tern were known to breed in large numbers on these islands: Swift Tern *Sterna bergii* (but not annually), Lesser Crested Tern *S. bengalensis*, White-cheeked Tern *S. repressa*, and Bridled Tern *S. anaethetus* (e.g. Gallagher *et al.* 1984; Bundy *et al.* 1989). Population estimates were nevertheless few and mostly rough, being based on data gathered during short visits. Previous to 1991 there existed only one systematic population estimate, made in 1986 (Zwarts 1987), and so it was decided to carry out the 1991 census in a similar way to the 1986 one, in order that results might be compared.

Plate 6. Lesser Crested Terns *Sterna bengalensis* mating, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

In the Arabian Gulf, all four tern species are mainly summer visitors, present in large numbers only from March or April to September or October, although small numbers of Swift Tern and the occasional Lesser Crested and White-cheeked Tern can be observed throughout the winter (e.g. Bundy *et al.* 1989).

It was feared that the tern populations and their breeding activities could be severely impacted by the Gulf War oil spills. Oil pollution can cause damage to seabirds during various stages of their life cycle. Large numbers of adults can be killed by oil-fouling, as so many sad examples have demonstrated. Oiling of eggs by a contaminated incubating bird can also cause serious problems (Freedman 1989), 10–20 μl of fresh oil on a freshly laid larid egg being enough to kill the embryo (White *et al.* 1979; Lewis and Malecki 1984). Furthermore, oil can have a severe impact on flightless chicks forming crèches on beaches near the colonies. In order to assess the direct impact of the Gulf War spills on the breeding populations of terns, careful observations were made on each stage of their life cycle.

Plate 7. Crèche of Lesser Crested Terns *Sterna bengalensis*, Samamik island (eastern Saudi Arabia), June 1984. (*Duncan Brooks*)

Oil spills can also affect seabirds indirectly through the food chain, for toxic hydrocarbons may damage the ecosystems within which the birds' food resources are produced. Disruption of the breeding cycles of certain fish species could cause a drastic decline in seabirds' breeding success.

As there was no previous baseline information available on the breeding and feeding ecology of these tern populations, the present study initiated longer-term monitoring of chick growth rates, daily activity patterns, hunting success, and feeding ecology, with the aim of assessing any indirect impact that might become evident in future years. The methods and results of these studies will be discussed when data from several seasons are available.

METHODS

Censuses

As there exist specific differences in the distribution patterns of terns on their breeding grounds, different methods were used to estimate as accurately as possible the total numbers of nests of each species. Swift and Lesser Crested Terns have a clustered nest distribution and form large, dense, and very localized colonies on bare ground. Bridled Terns are known to have an even distribution, covering the

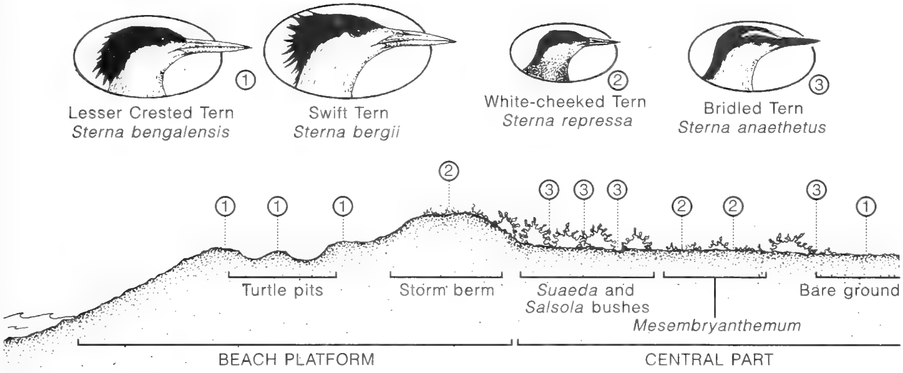

Figure 2. Relationship between relief, vegetation zonation, and nesting habitat of four tern species on coral islands in the northern Arabian Gulf, Saudi Arabia, 1991.

entire well-vegetated surface of the islands in loose colonies, while White-cheeked Terns follow an intermediate pattern, breeding in small colonies spread over the islands in areas with a scattered vegetation of low annual plants (Figures 2–3).

The number of nests of Bridled and White-cheeked Terns was estimated by line transect counts at regular intervals of 50–100 m (see Figure 3). A party of three persons searched for nests within a strip 5 m wide along each transect. These counts were made in the early morning and late afternoon in order to avoid the overheating of eggs in unattended nests during the hottest part of the day. For each nest found, species and clutch size were recorded, as was the total length of the transects (Table 1), and densities calculated from these data were used to estimate total populations for the whole of each island (Table 2).

Plate 8. Harqus island (Saudi Arabia), with colonies of Swift Tern *Sterna bergii* and Lesser Crested Tern *S. bengalensis*, May 1991. (*Mike Evans*)

Table 1. Data for line transects on islands surveyed off north-east Saudi Arabia, 1991.

	Karan	Kurayn	Jana	Jurayd
Number of transects	16	5	17	8
Distance between transects (m)	50	50	50	75
Total length of transects (m)	8,113	833	3,466	1,408
Total area covered (m^2)	40,567	4,166	17,329	7,038

Table 2. Total numbers of breeding pairs of terns *Sterna* on islands in the northern Arabian Gulf, Saudi Arabia. Breeding densities are averaged over the whole surface area of each island. Data for 1991 are from the present study, those for 1986 from Zwarts (1987). Surface areas of islands are from Basson *et al.* (1981).

		Harqus	Karan	Kurayn	Jana	Jurayd	Total
Swift Tern	1986	0	0	0	0	0	0
	1991	1,780	196	1,250	3	0	3,229
Lesser Crested Tern	1986	1,750	8,050	15,610	100	830	26,340
	1991	1,600	10,154	8,710	37	0	30,501
White-cheeked Tern	1986	0	2,070	0	8,730	1,580	12,380
	1991	0	2,310	0	5,690	930	8,930
Bridled Tern	1986	0	4,240	950	2,680	1,260	9,130
	1991	0	11,160	3,180	6,930	12,730	34,000
Total	1986	1,750	14,340	16,560	11,510	3,670	47,830
	1991	3,380	23,820	13,140	12,660	13,660	66,660
Breeding density	1986	875	112	2,123	346	178	250
(nests/ha)	1991	1,690	186	1,680	381	663	348
Dates of survey (1991)		14.5, 1.7	2-6.6, 22.6	12.6	7.6	8-10.6	
Surface area (km²)		0.02	1.279	0.078	0.332	0.206	1.915

In colonies of Swift and Lesser Crested Terns nests were counted individually. If colonies were too extensive to permit complete counts, the area of the colony was determined and the density of nests within the colony was estimated by counting nests within a number of 1×1 m squares placed evenly throughout the colony. Harqus was not visited but was twice overflown by helicopter, in May and July. As there is no vegetation on this island it was possible to count the numbers of breeding terns from aerial photographs (Plate 8).

Plate 9. Lesser Crested Terns *Sterna bengalensis*, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

Plate 10. Lesser Crested Terns *Sterna bengalensis*, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

Impact of oil on terns and their breeding activities

Numbers of oil-fouled adult terns were estimated on Karan by counting the proportion of oiled birds in the large numbers returning to the island just before dusk. The amount of oiling was scored as light (only a small spot of oil visible on the plumage, covering less than 5% of the total body), moderate (several small spots or one bigger spot of oil visible, covering 5–33% of the body), or heavy (more than a third of the total body marked by oil). A total of 16,420 terns was checked while flying within 100 m of the observation point. In addition, 64 adult Bridled Terns were caught by dazzling at night, and they were then examined in the hand for signs of oiling. Numbers of dead oil-fouled terns were recorded during all transect counts.

Eggs were checked for oiling during the transect counts, and on Karan the hatching rate of those marked by oil was monitored. The overall hatching success on Karan was monitored in 586 nests of White-cheeked Tern and 274 nests of Bridled Tern. These nests were individually marked and checked daily until the chicks hatched. For Lesser Crested Tern and Swift Tern hatching success was monitored in three subcolonies containing a total of 540 nests of Lesser Crested Tern and 64 nests of Swift Tern. Egg laying within these species' colonies was highly synchronized, all eggs being laid within a period of three days. The eggs were counted every second day throughout the incubation period until hatching.

A large number of chicks was ringed randomly on Karan, Kurayn, and Jana, and most of these were checked for oil-fouling. Towards the end of the breeding season transect counts were made on Karan to estimate the number of surviving chicks of Bridled Terns. In mid-August, when the majority of the chicks of Lesser Crested Tern, Swift Tern, and White-cheeked Tern had just started attempting to fly and were close to fledging, the total number of these chicks was counted on the beaches of Karan in order to estimate fledging success.

RESULTS

The numbers of each species and the overall breeding densities for each island are summarized in Table 2.

Census of Swift and Lesser Crested Terns

Totals of 20,501 pairs of Lesser Crested Tern and 3,229 pairs of Swift Tern were found. Lesser Crested Terns were breeding in large colonies on Harqus, Karan, and Kurayn, and a much smaller colony was found on Jana. Swift Terns were found in large colonies on Harqus and Kurayn, while smaller numbers bred in association with the colonies of Lesser Crested Tern on Karan, Kurayn, and Jana. The colonies of these two species were all on areas of bare sand (Figure 2). On

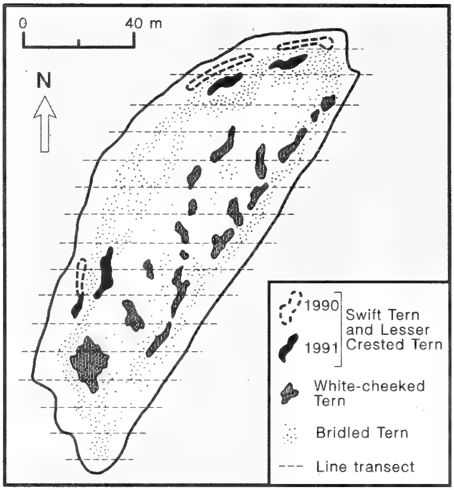

Figure 3. Distribution of breeding colonies of terns on Karan island, Saudi Arabia (in 1991, except as shown).

Plate 11. Lesser Crested Terns *Sterna bengalensis*, Samamik island (eastern Saudi Arabia), June 1984. (*Duncan Brooks*)

Plate 12. Lesser Crested Terns *Sterna bengalensis* nesting among turtle pits, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

Kurayn 28% of the nests of the species were found in long, narrow colonies only 0·6–2 m wide, situated on the narrow ridges between sea turtle pits on the beach platform. The other 72% of nests were in two large, oval-shaped colonies on bare areas in the centre of the island. On Karan less than 2% of nests were on the beach platform between sea turtle pits (Figure 3), the remainder being in large colonies on open, sandy areas 50–100 m inland which had been created during the oil burial operations of the previous month. However, remains of large colonies of the previous year were found on the beach platform (Figure 3). The densities of nests within colonies of Swift and Lesser Crested Terns are shown in Table 3.

Table 3. Nesting densities of Swift Tern *Sterna bergii* and Lesser Crested Tern *S. bengalensis* within (sub)colonies on Karan and Kurayn (Saudi Arabia), June 1991. Sample sizes are numbers of 1 × 1 m squares within which nests were counted.

	Total no. of nests	Average density nests/m² (SD)	Sample size
Swift Tern			
Karan	93	8.3 (1.9)	6
Kurayn			
Subcolony 1	126	7.0 (1.4)	3
Subcolony 2	900	6.7 (1.6)	3
Overall	1,026	6.8 (1.6)	6
Lesser Crested Tern			
Karan			
Subcolony 1	2,082	12.5 (2.5)	15
Subcolony 2	5,990	11.7 (1.8)	7
Overall	8,072	12.3 (2.4)	22
Kurayn			
Subcolony 1	258	10.3 (1.9)	3
Subcolony 2	470	8.5 (2.1)	4
Subcolony 3	1,077	8.0 (2.3)	8
Subcolony 4	2,503	10.3 (1.1)	3
Overall	4,308	8.9 (2.2)	18
Karan+Kurayn	12,380	10.8 (2.9)	40

Plate 13. White-cheeked Tern *Sterna repressa*, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

Census of White-cheeked and Bridled Terns

White-cheeked Terns totalled 8,930 pairs. They were in small colonies spread over the islands of Karan, Jana, and Jurayd, on small sandy patches sparsely vegetated with low annuals (Figure 2). Averaged over the entire surface of the islands, they occurred in densities ranging from 11 to 171 nests/ha. Working on a basis of transects divided into 8-m-long units of 40 m² each (here called 'surface units', and equivalent to the Step Count Units of Zwarts 1987), the proportion of each island that was actually used for breeding by this species was found to range from 1·5% on Karan to 12·4% on Jana, and nest densities within the colonies ranged from 1,428 nests/ha on Jana to 765 nest/ha on Jurayd (Table 4). The highest density of nests recorded in a surface unit on the different islands ranged from 8 to 23 nests, or from 1 nest per 8 m² to 1 nest per 1·74 m².

Plate 14. White-cheeked Tern *Sterna repressa*, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

A total of 34,000 pairs of Bridled Terns were breeding on the islands in 1991. No Bridled Terns were breeding on

Table 4. Nesting densities of White-cheeked Terns *Sterna repressa* and Bridled Terns *S. anaethetus* on islands off north-east Saudi Arabia, June 1991 (SU = surface unit of 40 m²; see text).

	Karan	Kurayn	Jana	Jurayd
White-cheeked Tern				
Density over total island surface (nests/ha)	11	0	171	45
Percentage of SUs occupied	1.5	0	12.4	5.4
Maximum no. of nests per SU	8	0	23	11
Average no. of nests per occupied SU	3.1	0	5.7	3.6
Overall density on occupied SUs (nests/ha)	765	0	1,428	890
Bridled Tern				
Density over total island surface (nests/ha)	87	408	209	818
Percentage of SUs occupied	16	51	45	53
Maximum no. of nests per SU	10	9	13	14
Average no. of nests per occupied SU	2.3	3.3	1.9	4.9
Overall density on occupied SUs (nests/ha)	570	833	480	1,223
Total no. of SUs sampled	974	100	418	168

Harqus. They occurred in densities of 87–618 nests/ha on the other islands, when the entire surface of these islands was considered, or from 480 nests/ha on Jana to 1,223 nests/ha on Jurayd if only the actual surface occupied is considered (Table 4). The highest density of nests recorded in a 'surface unit' ranged from 9 to 14 nests, or from 1 nest per 4·5 m² to 1 nest per 2·9 m², on the different islands.

Oiling and breeding success

Table 5 gives an overview of the extent of oiling of adult terns on Karan, based on field observations. Of 64 adult Bridled Terns closely examined in the hand, none was moderately or heavily oiled, though 29 (45%) showed minor oil spots, mostly consisting of a single tiny spot on the underparts. Only four oil-fouled adults were found dead during the transects on Karan, Kurayn, Jana, and Jurayd, and extrapolation from this number suggests a total of 110 carcasses of oil-fouled adult terns over the whole area of these islands (0·09% of the live terns present).

Clutch sizes for the different species and the dates of first hatching on Karan are shown in Table 6. In total only two White-cheeked Tern eggs (out of 1,226) and

Table 5. Percentages of adult terns *Sterna* on Karan (Saudi Arabia) with oil fouling in 1991 (see text), based on inspection in the field of birds flying within 100 m of an observation point.

	Degree of oil fouling				
	Light	Moderate	Heavy	Total	Sample size
Swift Tern	5.0	0.8	0.8	6.7	120
Lesser Crested Tern	1.2	0.2	0.2	1.6	5,300
White-cheeked Tern	5.4	0.3	0.3	6.0	3,800
Bridled Tern	4.8	0.4	0.5	5.6	7,200
Total	3.8	0.3	0.3	4.4	16,420

Table 6. Clutch sizes and hatching dates for terns *Sterna* on Karan (Saudi Arabia), 1991.

	Clutch size (%) 1 egg	2 eggs	3 eggs	Date of first hatching	Sample size (nests)
Swift Tern	99.7	0.3	-	26 June	445
Lesser Crested Tern	99.8	0.2	-	28 June	2,890
White-cheeked Tern	56.5	43.3	0.2	19 June	853
Bridled Tern	99.7	0.3	-	27 June	1,294

Plate 15. Nest of White-cheeked Tern *Sterna repressa* with oiled egg, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

one Swift Tern egg (out of 447) were found with visible spots of oil. Both the White-cheeked Tern eggs hatched, while the Swift Tern egg was found destroyed before hatching. Of 274 marked nests of Bridled Terns, all containing a single egg, 257 chicks hatched, giving a hatching success of 93·8%; 15 eggs proved to be infertile and the two other nests were destroyed before hatching. From the 586 nests of White-cheeked Terns, containing 837 eggs, 781 eggs hatched (93·3%), the others remaining unhatched in the nests. Of the 540 eggs of Lesser Crested Tern and the 64 eggs of Swift Tern, 19 and 8 respectively were lost during the incubation period; 513 Lesser Crested and 49 Swift Tern chicks hatched, resulting in hatching successes of 94·8% and 76·5% respectively (Table 7).

During the first half of July, 3,234 tern chicks were ringed on Karan, Jana, and Jurayd and all were closely examined for oil-fouling from the tar mats on the rocky parts of the beaches (Table 8). During a count of dead Lesser Crested Tern chicks on Karan at the beginning of August, 22 ringed birds were found from a total of 254 dead chicks, these numbers representing respectively 2·55% of the total number of ringed chicks and 2·63% of the total number of chicks of this species that hatched on the island. Thus the ringing activities were seen to have had negligible impact on chick mortality.

On 14 August the total number of surviving chicks of Lesser Crested Tern on Karan was estimated at 8,340 (this may include a small number of Swift Tern chicks,

Table 7. Breeding success of terns *Sterna* on Karan (Saudi Arabia) in 1991. (Hatching success: percentage of eggs hatching. Fledging success: percentage hatching eggs which eventually produced fledged young. Overall success: percentage of eggs resulting in fledged young.)

	No. of eggs	Hatching success	No. of chicks	No. of chicks fledging	Fledging success	Overall success
Swift Tern	196	76.5%	150	?	?	?
Lesser Crested Tern	10,174	94.8%	9,645	8,340	86.5%	82%
White-cheeked Tern	3,319	93.3%	3,097	2,390	77.2%	72%
Bridled Tern	11,194	93.8%	10,500	10,150	96.7%	91%

Table 8. Percentages of tern *Sterna* chicks with oil fouling on islands off north-east Saudi Arabia, 1991 (sample sizes in brackets).

	Karan	Jana	Jurayd	Total
Swift Tern	11 (9)	—	—	11 (9)
Lesser Crested Tern	9 (861)	—	—	9 (861)
White-cheeked Tern	16 (231)	31 (460)	0 (7)	24 (761)
Bridled Tern	0 (781)	0 (822)	—	0 (1,603)

the latter being difficult to locate in the huge crèche flocks of young Lesser Crested Terns); for White-cheeked Tern the figure was 2,390 (Table 7). Most young at this stage were very close to fledging. Transects on Karan between 10 and 13 August showed that an estimated 10,150 Bridled Tern chicks were surviving at a point close to fledging.

DISCUSSION

Censuses

The total number of breeding terns on the islands increased by 39% from 47,830 pairs in 1986 (Zwarts 1987) to 66,660 pairs in 1991 (Table 2). This increase is partly due to the breeding of more than 3,000 pairs of Swift Terns in 1991, a species which was completely absent in 1986. Bundy *et al.* (1989) also mentioned that Swift Terns do not breed annually at all of their sites in the Gulf region. The fact that the first breeding of this species in the Saudi Arabian part of the Gulf was established as late as 1979 (Bundy *et al.* 1989), and that the numbers found in 1991 are the

Plate 16. Swift Terns *Sterna bergii*, with some Lesser Crested Terns *S. bengalensis*, Abu Ali (Saudi Arabia), April 1991. (*Arnoud B. van den Berg*)

largest ever recorded for this region (Gallagher *et al.* 1984), may indicate that the species is expanding its range in this area.

The breeding population of Bridled Terns made a spectacular increase of more than 270% from 9,130 pairs in 1986 to 34,000 pairs by 1991. Whereas in 1986 it was the least numerous tern on the islands, in 1991 it had become the most abundant. In 1986, Zwarts (1987) found only 12·4% of the surface of Karan occupied by breeding Bridled Terns with an average colony density of 1·26 nests per 40 m^2 and a maximum density of 5 nests per 40 m^2. In 1991, 16% of Karan was used, while the average density had increased to 2·3 nests per 40 m^2 and the maximum to 10 nests per 40 m^2 (Table 4). A similar increase took place on the other islands. At present it is not clear why the numbers of Bridled Terns increased so dramatically between 1986 and 1991, but as they depend on well-developed vegetation for breeding it is assumed that changes in the plant cover may be part of the explanation. According to local fishermen, the general condition of the islands' vegetation was better than average in 1991. The amount of rainfall during the previous months was said to be quite high, while the smoke clouds resulting from the oil well fires in Kuwait reduced the strength of the summer sun, thereby reducing summer temperatures and allowing the plants an extended period of growth.

According to Cramp (1985), summarizing studies on breeding Bridled Terns, the highest nesting density recorded for this species is 1 nest per 6 m^2, but in 1991 the maximum density on the different islands in our study area ranged from 1 nest per 4·5 m^2 to 1 nest per 2·9 m^2 (Table 4). These high densities might indicate that this species is close to the maximum that the islands can sustain, though on the other hand the very high breeding success of 91% in 1991 (Table 7) suggests that

Plate 17. Nesting Swift Terns *Sterna bergii*, with some Lesser Crested Terns *S. bengalensis* behind, Karan (Saudi Arabia), June 1991. (*Arnoud B. van den Berg*)

a maximum density has not been reached. At present, the Saudi Arabian Gulf islands are among the world's most important breeding sites for this species (see Croxall *et al.* 1984, Croxall 1991).

The White-cheeked Tern populations decreased by 28% from 12,380 pairs in 1986 to 8,930 pairs in 1991 (Table 2). Both the area occupied by the colonies and the average density in the colonies decreased. The highest density of nests recorded in 1986 was 23 nests per 40 m^2 on Jana (Table 4) and in 1991 the highest density was also recorded on Jana, but had decreased slightly to 23. Although the numbers of White-cheeked Terns that breed on the islands are not very high compared to other locations such as Sheedvar island in Iran, where 300,000 pairs were breeding in 1972 (Gallagher *et al.* 1984), the Saudi Arabian Gulf breeding population of this species is still of considerable importance as the White-cheeked Tern has only a very limited world distribution, being confined to the seas surrounding the Arabian peninsula.

The total numbers of Lesser Crested Terns also declined by 22% from 26,340 pairs in 1986 to 20,500 in 1991 (Table 2). At 10·8 nests/m^2 (Table 3) the average density of nests within the colonies was very high compared with densities reported from Australia (2·8 nests/m^2) and elsewhere (4·1 nests/m^2) (Cramp 1985). Large colonies of 8,700 and 10,000 pairs of Lesser Crested Terns, as found on Kurayn and Karan in 1991 and previously (Gallagher *et al.* 1984; Zwarts 1987), have never been described from other areas in the world (Croxall *et al.* 1984; Cramp 1985; Croxall 1991), so the islands in the Saudi Arabian part of the Gulf must hold a substantial part of the world population.

Table 2 shows that, averaging over the whole surface of each island, the density of tern nests declined steeply as the total surface of the island increased. Harqus and Kurayn, the two smallest islands, had the highest densities with 1,690 and 1,685 nests/ha respectively. The density of nests on Kurayn declined by 20% between 1986 and 1991, and Kurayn is the only island where the total numbers of terns declined over that period. Karan, the largest island, had the largest numbers of breeding terns, although nesting density averaged over the whole surface of the island was only 11% of the densities on the smaller islands.

Oiling and breeding success

Less than 1% of the total adult population of terns was moderately or heavily oiled, and this low level, plus the very small number of dead oiled adults found on the islands, suggests that mortality in adults caused by oil-fouling was negligible, even though so many of the Bridled Tern adults examined in the hand showed minor spots of oiling. These spots were so small that in most cases they were not noticeable in observations of flying birds, as was illustrated by the lower numbers of lightly oiled birds recorded in the field (Table 5). Because of the location of these oil spots (many were found as isolated spots on the underwings and upperparts) and because of their tiny size, it is assumed that they resulted from contact with the huge quantities of tar balls floating in the upper part of the water column rather than with liquid oil on the surface. Contact with these tar balls could easily occur during plunge-diving. The low numbers of seriously oiled adults can be explained by the fact that most of the floating, liquid oil had been wind-driven from the open sea into embayments along the Saudi mainland well before the terns returned to the northern Gulf from their southern wintering areas.

Although only a very few eggs with visible oil spots were recorded, these numbers could possibly have been underestimated because of the eggs' cryptic patterning. However, the small proportion of seriously oil-fouled adults does indicate that the number of oiled eggs was genuinely low. That the oiled eggs of White-cheeked Tern eventually hatched shows that the oil around the island at this stage had presumably lost its toxicity due to evaporation and weathering. The high hatching success rates (Table 7) also indicate no significant effect of oil pollution on the eggs.

The only serious impact from oil-fouling was observed on the chicks of Lesser Crested and White-cheeked Terns on Karan and Jana (Table 8). These chicks leave the nest within a few days of hatching and spend most of their time on and near the beach. Oiling arose from contact with the thick tar mat that covered the beach rock on these two islands and became fluid under the midday sun. On very hot days, the tar melted to such an extent that it was running off onto the sea, forming a sheen on the surrounding water and on the pools between the rocks, in which many young terns bathed to keep cool. Some young chicks were seen to get stuck and die in the sticky oil on the beaches, but nevertheless very few dead oiled chicks were found in comparison with the total numbers of oiled chicks, and the high fledging success for both species (Table 7) indicates that the impact of this oiling did not seriously affect the chicks' overall survival. As Bridled Tern chicks stayed in the cover of vegetation on the central parts of the islands until able to fly they were not subject to this oil-fouling problem (Table 8).

Most of the Bridled and White-cheeked Tern chicks on all islands were heavily soiled by the huge amount of soot (from the Kuwaiti oil well fires) that covered the vegetation. Again, however, the high fledging success of both species on Karan indicated that this did not interfere seriously with the chicks' survival. In fact, the moderating effects of these smoke clouds on the high summer temperatures may have been beneficial to the breeding terns in general, as heat stress was greatly reduced.

The overall high breeding success on Karan indicates too that in 1991 the breeding activities of the terns did not suffer either through direct poisoning or through a reduction of their food supplies.

CONCLUSIONS

The data obtained in 1991 demonstrated that the offshore coral islands of Saudi Arabia in the northern Arabian Gulf are of international importance not only for Lesser Crested Tern and White-cheeked Tern, as previously known (Gallagher *et al.* 1984; Zwarts 1987), but also for Bridled Tern. At present these islands not only harbour the largest known Lesser Crested Tern colonies in the world, but are also among the world's five most important breeding sites for Bridled Terns (see Croxall *et al.* 1984).

Comparison with population estimates made in a similar way in 1986 (Zwarts 1987) shows a decline in numbers of Lesser Crested and White-cheeked Terns and an enormous increase in numbers of Bridled Tern, while Swift Tern may be expanding its range in the region. Continued monitoring will be necessary to confirm these population trends and to understand their background.

Having returned to their breeding grounds after the major oil slicks had disappeared from their open-sea feeding grounds, the terns and their breeding activities in 1991 were not seriously affected by the spills that occurred earlier in the year. However, an impact on the terns' food supply might become noticeable only over a long period, and it is very important that the monitoring of breeding success is continued over several seasons.

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Impact of Gulf War oil spills on wintering seabird populations along the northern Arabian Gulf coast of Saudi Arabia, 1991

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Summary Counts of dead birds along the northern Arabian Gulf coast of Saudi Arabia indicated that more than 30,000 wintering seabirds, mainly grebes and cormorants, were killed by the Gulf War oil spills in January–April 1991. The significance of this mortality on the regional population level of Great Crested Grebe *Podiceps cristatus,* Black-necked Grebe *P. nigricollis,* Great Cormorant *Phalacrocorax carbo,* and Socotra Cormorant *P. nigrogularis* is discussed, based on results of population counts of grebes and cormorants along the Saudi Gulf coast during the period October 1991 to January 1993. Although the estimated mortality for these species ranged from 17% to more than 50% of the regional populations, it is concluded that the spills did not reduce any species to a level from which recovery is impossible, and the recent high proportion of juvenile Great Cormorants in the population indicates that this is occurring. A short overview of the activities of the Jubail Wildlife Rescue Center is included.

THE INTERNATIONAL importance of the Arabian Gulf for migrating and wintering waders and breeding seabirds is widely recognized (e.g. Gallagher *et al.* 1984; Zwarts *et al.* 1991), but much less is known about the area's value to wintering seabirds such as grebes and cormorants.

Plate 1. Socotra Cormorant *Phalacrocorax nigrogularis,* killed by oiling during the Gulf War, north of Jubail (Saudi Arabia), April 1991. (*Arnoud B. van den Berg*)

During the Iraq–Kuwait conflict in 1991 (the Gulf War), a total of 6–8 million barrels of oil was released from different sources in the northern Gulf, covering some 1,550 km^2 of sea (WCMC 1991; USGTF undated), and impacting some 560 km of the Saudi Arabian coastline between al-Khafji and Abu Ali, the southernmost shore oiled in the Gulf (Anon. 1991). It became clear very soon after the initial releases that cormorants and grebes were the first and most obvious victims of the largest marine oil spill in history.

Researchers from the National Commission for Wildlife Conservation and Development of Saudi Arabia (NCWCD) made an assessment of the damage that was done to these seabird populations through counts of dead birds washed ashore along the northern Gulf coast in Saudi Arabia from February to April 1991. This paper discusses the results of these counts and also presents a short overview of the activities and results of the Wildlife Rescue Center that was established by the NCWCD and the Royal Commission for Jubail and Yanbu following the spill.

METHODS AND RESULTS

Dead birds were counted at 82 sites with oiled beaches, covering 197 km of the *c.* 560 km of oiled coastline. Counts were done while walking along the tideline on the beaches in search of surviving birds which were to be brought to the Jubail Wildlife Rescue Center. However, access to many beaches was restricted due to military activities which, in many cases, made both repeat visits and a more complete coverage impossible. As the number of dead birds at each site varied with the exposure of the site to the sea, and as the different species were not equally

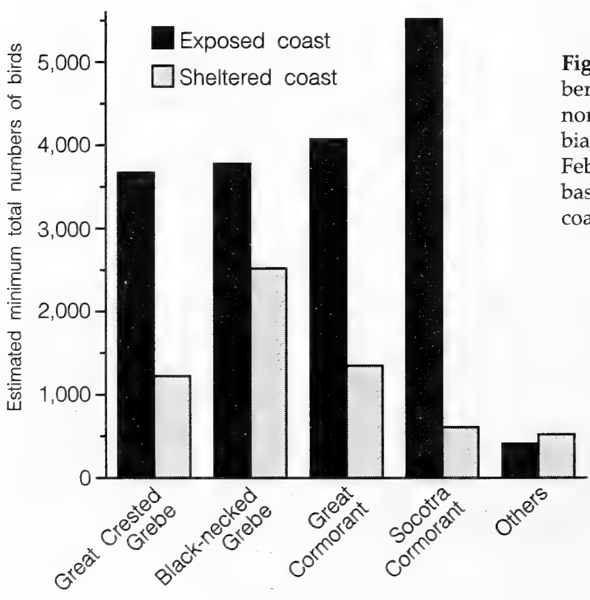

Figure 1. Estimated minimum numbers of birds washed ashore on the northern Gulf coast of Saudi Arabia, killed by the Gulf War oil spills, February–April 1991. Estimates are based on sample counts along oiled coast (see text and Table 1).

Table 1. Minimum numbers of birds washed ashore along the northern Gulf coast of Saudi Arabia, killed by the Gulf War oil spills, February–April 1991. Figures in brackets are actual counts along oiled coast; other figures are estimated totals for all oiled coast in Saudi Arabia (see text).

	Exposed coast		Sheltered coast		Total
Great Crested Grebe	(1,820)	3,673	(317)	1,225	4,898
Black-necked Grebe	(1,872)	3,778	(652)	2,519	6,297
Great Cormorant	(2,006)	4,069	(349)	1,348	5,397
Socotra Cormorant	(2,730)	5,510	(158)	610	6,120
Others	(204)	412	(135)	522	934
Total	(8,632)	17,422	(1,611)	6,224	23,644
Number of sites surveyed	45		37		82
Total length covered (km)	109		88		197
Estimated total length of oiled coast (km)	220		340		560

represented at all locations, the sites were divided into two categories, exposed and sheltered, in order to estimate the total numbers of dead birds of each species (Table 1, Figure 1). The average number of dead birds per kilometre of coastline was 79 (range 9–186) in exposed areas, 18 (0–41) in sheltered areas.

Regular counts along a 2-km stretch of exposed beach at Ras Tanajib showed that the highest count of dead birds occurred within the first ten days after the oil reached the beach. After that, a significant number of dead birds disappeared, being washed away by the sea, buried by new sediment, or carried away by scavengers such as red fox *Vulpes vulpes* and golden jackal *Canis aureus*. It was therefore decided to take only the count made during the first visit to each site for calculation of total numbers. Most sites were visited one to three weeks after first receiving oil.

A total of 10,243 dead birds was counted at the various sites surveyed (Table 1), almost all (97%) of these belonging to four species: Great Crested Grebe *Podiceps cristatus* (21%), Black-necked Grebe *Podiceps nigricollis* (25%), Great Cormorant *Phalacrocorax carbo* (23%), and Socotra Cormorant *Phalacrocorax nigrogularis* (28%). Carcasses of another 21 species—including (in order of decreasing abundance) gulls, waders, ducks, terns, and herons—were encountered in much smaller numbers.

DISCUSSION

The number of dead birds on the length of surveyed beach suggests a total of about 23,600 washed ashore along the whole length of the oiled northern Gulf coast of Saudi Arabia during the first three months following the Gulf War oil spills (Table 1). Grebes and cormorants comprised 96% of these. However, the number can be only a fraction of the total killed, for many birds that died at sea will not have been washed ashore, and in the absence of detailed studies on the currents in this area no accurate estimate can be made of what this fraction might be. Furthermore, a significant number of oiled cormorants which reached the shore alive wandered as far as 1 km inland before they died and could have been overlooked during the counts. Assuming that a similar mortality occurred along the Kuwaiti coast, it can be concluded that at least 30,000 seabirds died as a direct consequence of oil-fouling in the northern Gulf between February and April 1991.

It is difficult to define how significant this mortality is at the species level, as no accurate pre-war population estimates for wintering seabirds are available from this region. However, based on the available literature and the results of surveys along the Gulf Coast in Saudi Arabia since 1991, the following can be concluded for the individual species of grebes and cormorants.

Grebes

Both Great Crested and Black-necked Grebes are winter visitors to the Arabian Gulf. Whereas Great Crested Grebe becomes scarce towards the south of the Gulf, the winter distribution of Black-necked Grebe reaches to the Gulf of Oman and the Arabian Sea (e.g. Gallagher and Woodcock 1980; Bundy *et al.* 1989; Richardson 1990), and thus the mortality caused by the oil spills in the northern Gulf most probably consisted not only of birds wintering in the impact zone but also of many birds on migration northwards from their wintering grounds further south. The high number of dead grebes was completely unexpected, as such a large population was not known to winter in the Gulf. During surveys in December 1992 and January 1993 only small numbers of wintering grebes were found along the northern Gulf coast, but more were discovered wintering further south along the coast of the Gulf of Salwah in Saudi Arabia. The total number of wintering grebes along the Gulf coast in Saudi Arabia in 1992–3 was estimated at a minimum of 3,500 Great Crested and 5,000 Black-necked (Symens in prep.). If numbers are stable between years, and if similar densities winter off Qatar and the United Arab Emirates, the total wintering in the Gulf off its western/southern shore can presently be estimated at 7,000 Great Crested and 10,000 Black-necked. An unknown proportion of these birds will be young from the breeding seasons of 1991 and 1992. As such, it is estimated that the oil from the war may have killed more than 50% of the grebes that wintered in this region of the Gulf in 1990–1.

Cormorants

Great Cormorant is also a winter visitor to the Arabian Gulf (e.g. Bundy *et al.* 1989), occurring as far south as Oman (Gallagher and Woodcock 1980; Richardson 1990), though in smaller numbers there than in Saudi Arabia. The wintering population along the Saudi Gulf coast was estimated at more than 15,000 birds in 1991–2 and 12,000 in 1992–3, with two large concentrations occurring around Abu Ali and in Tarut Bay, the higher number in 1991–2 being probably due to the extremely cold weather during that particular winter in the Middle East, which forced many birds to winter further south than usual (Symens in prep.). Assuming that the Saudi population represents about half of the total wintering off the Arabian side of the Gulf, then that total can be estimated at *c.* 20,000–30,000 birds. As such the Gulf War oil spills may have killed a minimum of 18–27% of Great Cormorants wintering in this region. During the winter of 1991–2 the proportion of juveniles in the wintering flocks of Great Cormorants in Abu Ali was 58%, and in 1992–3 52%

(pers. obs.), demonstrating that, despite the heavy losses in 1991, this species is capable of a quick recovery.

Socotra Cormorant is endemic to the Arabian region, and it is believed that two separate populations exist, of which the largest is restricted to the Arabian Gulf and a much smaller one to the Arabian Sea and the Gulf of Aden (e.g. Gallagher *et al.* 1984). Most of the breeding colonies of this species are situated in the southern part of the Gulf, from the Gulf of Salwah in the west to the Strait of Hormuz in the east. In recent times in the northern Gulf only one small breeding colony has survived, on Kurayn island in Saudi Arabia (e.g. Bundy *et al.* 1989). Breeding takes place in winter, and after the breeding season dispersive movements occur, though their extent is poorly understood. Large flocks can be seen in the northern Gulf from mid-January onwards (Symens *et al.* in press). At present, the total population in the Arabian Gulf is estimated to consist of 450,000–950,000 birds (Symens *et al.* in press), so the Gulf War mortality would represent a minimum of only 0·6–1·4% of that population. However, the birds in the northern Gulf belong most likely to the breeding population of Saudi Arabia which consists of some 30,000–35,000 birds (Symens *et al.* in press), of which this mortality would represent a minimum of 17–20%.

It can be concluded that, although the estimated mortality of grebes and cormorants was very high, the Gulf War oil spills did not diminish any of these populations to a level from which full recovery is impossible. The high proportion of juveniles in the Great Cormorants along the northern Gulf coast of Saudi Arabia indicates a recovery in this species, and it is hoped that continued monitoring in the coming years will reveal similar trends in the other three species.

REHABILITATION OF GREBES AND CORMORANTS AT JUBAIL WILDLIFE RESCUE CENTER

In February 1991, the NCWCD and the Royal Commission for Jubail and Yanbu set up a Wildlife Rescue Center in Jubail as a first response to the large number of oiled birds that were dying on the beaches. Manned by highly dedicated volunteers, efficiently trained by a team from the Royal Society for the Prevention of Cruelty to Animals (UK), the Center treated more than 1,500 birds, mainly cormorants and grebes, both of which are known to be difficult groups to rehabilitate (Williams 1986).

An average survival rate of 38% for the different species was obtained, ranging from 60% for Socotra Cormorant and 45% for Great Cormorant to less than 10% for grebes. The latter were extremely difficult to rehabilitate as most of them suffered from a fatal gizzard impaction: a dense, hard ball, consisting of feathers mixed with oil and sand was found in the gizzard in 60% of the Great Crested Grebes (n=103) and in 35% of the Black-necked Grebes (n=86) on which a post-mortem examination was done. Furthermore, they were very sensitive to ingestion of oil, leading to inflammation of the gut. A complete overview of the pathological effects of the oil on these four species of seabirds is given by Greth *et al.* (in press). The Center also collected new information on the biology and migration patterns of the little-studied Socotra Cormorant (Keijl and Symens 1993; Symens *et al.* in press).

All birds treated in the Center were ringed before release, and during the winters of 1991–2 and 1992–3 several such Great Cormorants were resighted at Ras Tanajib and Abu Ali at exactly the same places where the majority of the oiled cormorants were washed ashore in 1991.

The survival rates obtained in the Rescue Center may appear low, but one must also consider, besides its ecological and scientific value, the ethical and educational value of this work. It played a major role in generating global public concern about the loss of wildlife in the Gulf and in publicizing, throughout Saudi Arabia and abroad, the high biological and ecological value of the rich marine resources of the Gulf.

ACKNOWLEDGEMENTS

The authors wish to thank Prof. Dr A. H. Abuzinada, Secretary General of the NCWCD, and Mr Youssef Al Wetaid, Director of the NCWCD Research and Monitoring Department and Manager of the Jubail Wildlife Rescue Center, for their continuous support. The counts along the beaches would not have been possible without the assistance of many NCWCD researchers, Dr Khushal Habibi and Mr Mohammed Shobrak in particular. Special thanks go to all volunteers of the Jubail Wildlife Rescue Center for their interest, dedication, and support. The assistance of a BirdLife International survey team, coordinated by James Wolstencroft and mainly funded by the Royal Society for the Protection of Birds (UK), in the waterfowl counts along the Saudi Arabian Gulf coast during the winter of 1991–2 was greatly appreciated. The waterfowl counts along the Saudi Arabian Gulf coast in the winter of 1992–3 were conducted as part of the study carried out under CEC contract B7–5040/92 with financial support from the Commission of the European Communities and the NCWCD.

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Biometrics and moult of Socotra Cormorant *Phalacrocorax nigrogularis*

GUIDO O. KEIJL and PETER SYMENS

Summary Socotra Cormorants *Phalacrocorax nigrogularis* which died between February and April 1991 following oil spills along the northern Saudi Arabian Gulf coast were classified into three age groups on the basis of plumage characteristics. Most adult and subadult birds were actively moulting primaries, secondaries, tail feathers, and body feathers. Only a few juveniles had started to moult (inner) primaries and tail feathers, and about half the juveniles were in light body moult. Socotra Cormorants have a stepwise moult of both primaries and secondaries, and the moult pattern seems to resemble that of congeners in this and in other respects, though a complete moult of primaries may take rather less time than in other species, perhaps due to environmental factors. In adults and subadults, males were significantly larger than females in most body measurements, but in juveniles only lengths of head+bill, tarsus, and wing differed significantly between the sexes. A gonadal index was calculated for each sex and plotted against a *bursa Fabricii*-index, which revealed that the difference in maturity between adult and subadult was somewhat larger in females than in males. This could be because the birds were found just after the breeding season, when their gonads would already have shrunk, or because males reach sexual maturity at an earlier age than females. Observations in a breeding colony seemed to confirm the latter possibility.

THE SOCOTRA CORMORANT *Phalacrocorax nigrogularis* is an endemic species of the Arabian Gulf, the Arabian Sea, and the Gulf of Aden. The largest numbers are found in the southern Arabian Gulf, from the Gulf of Salwa (between Saudi Arabia, Bahrain, and Qatar) in the west, to the United Arab Emirates in the south, and to the Straits of Hormuz in the east. The species breeds on marine islands in the Gulf from September to March (*contra* Meinertzhagen 1954) and disperses after the breeding period. Throughout spring, summer, and autumn, flocks numbering from a few individuals up to several thousand can be seen from northern Saudi Arabian shores (pers. obs.), but movements outside the breeding season remain mysterious, and data on wintering areas, food, social structure, and breeding numbers are scarce or completely lacking (Meinertzhagen 1954; Bailey 1966, 1971; Cramp and Simmons 1977), probably due mainly to the relative inaccessibility of the region.

Because of its surface-diving feeding behaviour the species is very vulnerable to surface pollution, such as oil spills. From January 1991 onwards, during the last stage of the Iraq–Kuwait conflict (the Gulf War), massive oil spills occurred offshore from Kuwait, and oil drifted southwards in the Arabian Gulf and stranded on the northern Saudi Arabian shore from February onwards. Large numbers of oil-fouled seabirds came ashore with the oil slicks. One of the most numerous victims was the Socotra Cormorant (Symens and Suhaibani 1993), of which over 650 heavily oiled birds were brought to the Jubail Wildlife Rescue Center. Approximately 250 birds died and were kept frozen for later research. Since little is known about the moult and measurements of the Socotra Cormorant, 73 individuals were measured and dissected and moult was recorded.

METHODS

The oiled Socotra Cormorants were captured alive between February and April, mainly along the northern Gulf coast of the Kingdom, between Abu Ali and Ras Tanajib. For scoring moult of flight-feathers, only birds which had been cleaned in the Center were used; for measurements and sexing both oiled and unoiled birds were taken. Differences in body length were noted, but we did not select birds on size. We tried to take approximately equal proportions of adults, subadults, and juveniles, 73 birds in all.

Moult of flight-feathers was recorded following the system of Ginn and Melville (1983): an old feather is given a moult score 0 and a new, fully grown feather is scored 5, while a growing feather is given a score between 1 and 4; a bird with ten old primaries thus has a moult score of 0, and one with ten new primaries is scored 50. However, this system is not suitable for stepwise moulting species such as cormorants because in these birds there are feathers which would require an 'intermediate' score (slightly worn, but newer than an old feather), and this makes calculating a true moult score impossible. These intermediate feathers were recorded during the data collection, and for calculation purposes were given a value of 5 to permit comparison of moult scores of different age groups. It should be borne in mind that this results in a higher moult score than is actually the case.

Moult of breast and flank feathers was assessed internally on dissected birds, which were recorded either as not moulting or as having moult light (less than 25% of shafts visible), moderate (25–50% of shafts visible), or heavy (over 50% of shafts visible). Ages were determined on the basis of feather characteristics, birds in fully juvenile plumage being classed as 'juvenile', those with mixed juvenile and adult-type feathers as 'subadult', and birds without juvenile feathers 'adult'. In some heavily oiled birds, however, mistakes may have been made in ageing birds on the basis of these characters. Birds were sexed by gonadal inspection.

The following measurements were taken for all birds (Figure 1): length of head plus bill (from tip of bill to distal part of skull), bill length (from tip of bill to feathering on central part of culmen),

Plate 1. Juvenile Socotra Cormorant *Phalacrocorax nigrogularis*, Abu Ali (Saudi Arabia), April 1991. (*Arnoud B. van den Berg*)

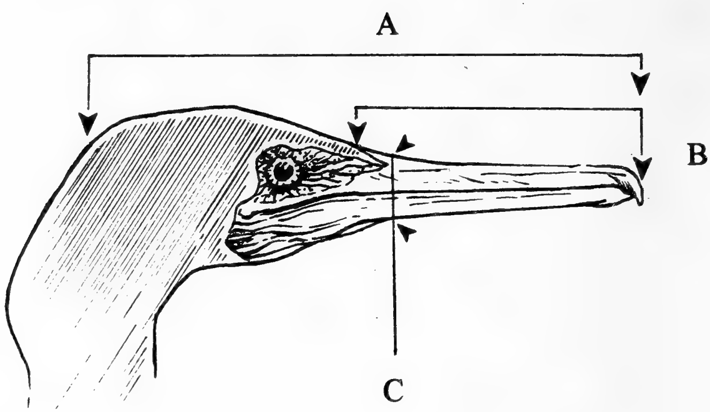

Figure 1. Measurements taken on Socotra Cormorants *Phalacrocorax nigrogularis*. A: head+bill length. B: bill length. C: bill depth.

bill depth (at distal point of feathering on culmen), tarsus length, total body length (from tip of bill to tip of longest tail feather in loosely stretched body), wing length (flattened and straightened, following Svensson 1992), tail length from base of tail feathers (tail-1), and tail length by 'tail folded towards back' technique (tail-2; see Svensson 1992). We recorded sternum length (excluding cartilage), largest follicle (in females), and length and width of left testis (in males) on dissected birds. The *bursa Fabricii* (hereafter called bursa, an organ within the cloaca which can be used to assess maturity: present in juveniles, absent in adults) was noted as being present or absent, and length and width were measured. In females the shape of the oviduct was recorded as straight and thin (scored 1), intermediate (2), swollen and twisted (3), or as very swollen and twisted (4). From the measurements of these internal organs were calculated the follicle-oviduct index (f-o index: product of the oviduct score and the diameter of the largest follicle) and the testis and bursa indices (product of length and width) (cf. van Franeker 1983).

For various reasons it was not possible to take all measurements on every bird, or to score moult in every bird, so sample sizes for different measurements within a given age/sex-class are not always constant. None of the birds was weighed because some had previously been dissected, some were heavily oil-fouled, and some had been in captivity for as much as several weeks. Stomach contents were not sampled, as most birds had been force-fed.

RESULTS

Sex ratio

The sample was found to contain 40 males and 33 females, a distribution differing from a 50:50 ratio no more than would be expected by chance (χ^2-test, χ^2=0·49, P>0·05). The numbers of males and females in each age group are presented in Table 1.

Moult

Most birds were in active moult (Figure 2), with the lowest proportion of moulting individuals among juveniles and the highest in subadults. Almost all (93%) of 45 adults and subadults were actively moulting flight-feathers. Of 24 juveniles investigated, six had started moult of wing or tail. In Figure 3 the numbers of growing flight-feathers are given for primaries, secondaries, and tail feathers separately.

Flight-feathers

In adult and subadult birds only three out of 45 individuals were recorded as having two adjacent primaries growing. From Figure 3 it can be concluded that several 'moult waves' occur in each wing (see, e.g., Ginn and Melville 1983), with two waves present in 38% of adults and subadults combined, and three or four waves in 11%. As is normal for almost all Phalacrocoracidae (Stresemann and Stresemann 1966), none of the birds had a primary moult score of 50. Four juvenile females

Table 1. Measurements of Socotra Cormorants *Phalacrocorax nigrogularis* which died in early spring in the northern Arabian Gulf. sample size, and range are given. See Figure 1 and text for details of measurements taken. Body length is given in cm; all other measurements are in mm. SD = standard deviation.

	Bill length	Bill depth	Head+bill	Tarsus	Wing	Tail-1	Tail-2	Body	Sternum
Male, adult									
Mean	71.4	15.8	139.9	75.5	298.3	94.9	138.6	72.4	111.9
SD	3.35	1.05	4.59	2.58	4.75	3.17	8.88	2.40	5.62
Sample	18	18	17	18	18	14	12	18	16
Range	64.2–76.5	14.2–17.6	131.4–146.4	71.5–80.0	285–305	90–102	126–155	66–76	101–119
Male, subadult									
Mean	71.5	15.7	141.3	76.0	297.2	89.6	132.9	72.6	110.9
SD	3.38	0.79	2.86	1.99	4.53	4.60	11.29	1.96	4.27
Sample	10	11	10	11	11	10	10	11	9
Range	64.3–76.4	14.4–17.0	137.0–144.9	71.8–78.4	290–306	81–97	116–150	69–75	108–121
Male, juvenile									
Mean	72.5	15.0	139.2	74.7	293.5	90.8	130.9	72.9	108.9
SD	4.13	1.29	5.77	2.57	9.37	9.77	11.93	4.22	5.75
Sample	11	11	11	10	11	10	11	8	10
Range	66.0–77.7	13.5–17.1	130.3–145.3	70.2–79.0	274–304	72–103	103–149	66–78	101–117
Female, adult									
Mean	66.9	13.6	132.1	71.4	281.9	86.7	124.3	69.5	107.0
SD	1.39	0.74	2.96	2.42	5.36	3.35	8.12	1.31	7.14
Sample	10	10	10	10	10	7	7	8	9
Range	64.2–69.0	12.7–14.7	126.8–135.8	67.7–75.4	273–289	82–92	115–135	67–71	97.6–117.4
Female, subadult									
Mean	65.9	12.9	129.2	71.0	280.0	86.5	120.8	67.3	102.7
SD	4.06	2.00	3.45	1.28	4.64	5.05	5.63	1.25	4.25
Sample	10	10	10	10	10	6	5	10	9
Range	55.8–70.4	8.6–15.1	121.0–132.7	69.0–72.8	275–287	81–95	115–130	65–69	95.6–108.9
Female, juvenile									
Mean	69.9	13.2	132.7	72.7	279.2	86.9	125.9	69.6	103.7
SD	2.98	2.50	3.37	1.65	6.54	5.25	4.41	2.07	5.32
Sample	13	13	12	12	11	8	7	9	10
Range	63.8–75.3	7.7–16.2	127.4–146.1	69.9–75.6	270–297	80–95	121–133	66–73	94.5–112.2

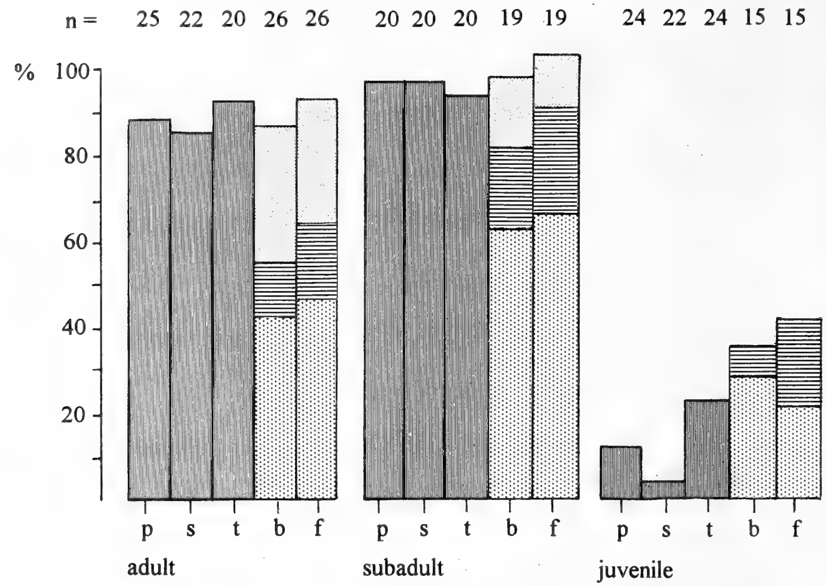

Figure 2. Percentages of Socotra Cormorants *Phalacrocorax nigrogularis*, February–April, with moult of primaries (p), secondaries (s), tail (t), breast (b), and flanks (f). For breast and flanks, dotting = light moult, horizontal hatching = moderate moult, grey = heavy moult (see text). Sample sizes are given at the top of the figure.

had just started primary moult (but not yet secondary moult). Their respective moult scores were (right/left wing) 12/10, 1/2, 4/4, and 1/2. The other birds still had juvenile primaries and secondaries.

In 52% of the 42 adult and subadult birds investigated, two or three out of the 20 secondaries on each wing were growing at a time (Figure 3). None of the juveniles had started secondary moult.

Although moult in most birds was not symmetrical (i.e. it differed between left and right wings) there was no significant difference in median moult scores between left and right wings for both sexes and for all age groups (Mann–Whitney *U*-test, P>0·1 for all groups tested). In only two adults (*n*=25) and three subadults (*n*=20) was wing moult symmetrical, though in 11 adults and 11 subadults this was almost so, with the same feather having a different moult score in left and right wings.

In adults and subadults the tail appeared to moult in an irregular sequence, but with a similar number of feathers moulting on left and right sides in most cases. In 52% of 45 adult and subadult birds there were on average two or three moulting feathers (in the whole tail) at a time (Figure 3). The median tail moult score was 16 in adults, 18 in subadults, and 0 in juveniles.

Six juveniles were in tail moult: this started with t1 (central pair of feathers), after which t4 was shed when t1 had a score of approximately 3; t1 and t4 were the first to be fully grown and t5 was the last to be moulted. If the growth rate of all tail feathers is equal (cf. Dorward 1962; Ginn and Melville 1983), the moult sequence in juveniles is t1–t4–t2–t3–t7–t6–t5, though t2 and t3 may change order.

Body feathers

Body moult (breast and flanks) was present in 90% of the 26 adults, in 97% of the 19 subadults, and in 40% of the 15 juveniles (Figure 2). Most birds had light moult,

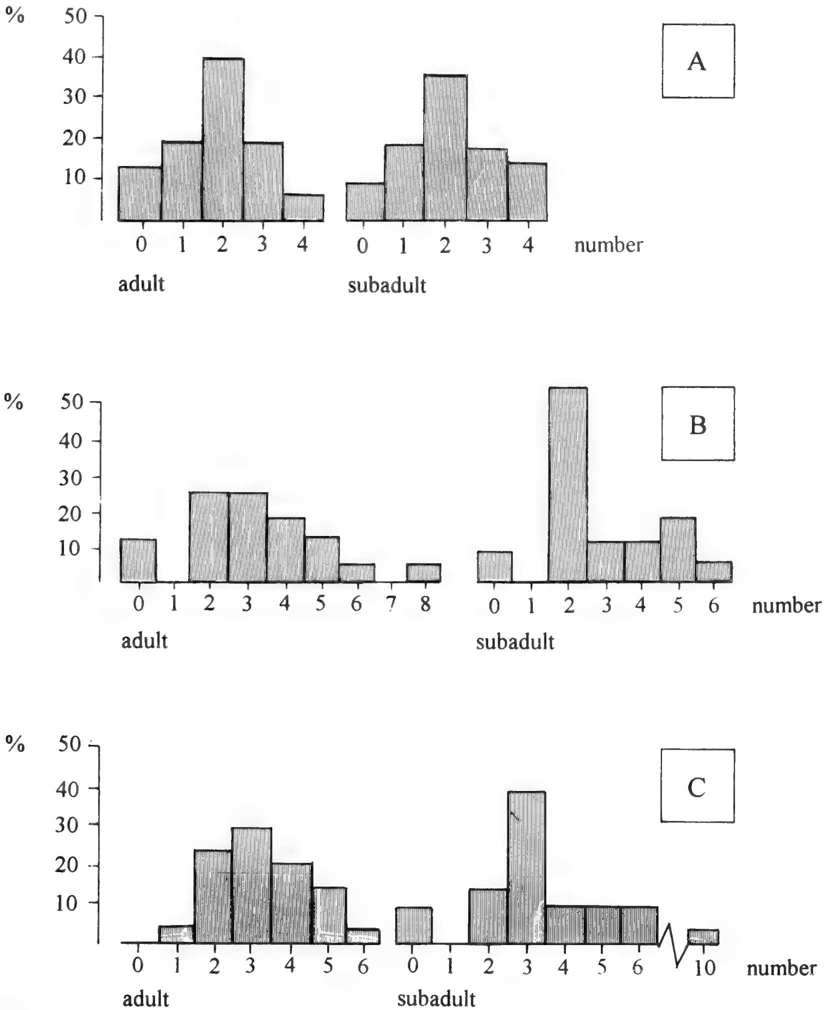

Figure 3. Moult of Socotra Cormorant *Phalacrocorax nigrogularis*, February–April: frequency distributions for number of growing primaries (A: adult n=25 birds, subadult n=20), secondaries (B: adult n=22, subadult n=20), and tail feathers (C: adult n=20, subadult n=20), expressed as a percentage of the number of birds in each age group. Numbers of primaries and secondaries are for one wing; numbers of tail feathers are for whole tail.

and only in subadults and (especially) adults was heavy moult recorded.

One juvenile had started to replace the light brown juvenile body plumage with dark adult-type feathers. In this bird the proportion of new feathers was estimated (externally) as 0% on head and foreneck, 40% on hindneck, 50% on mantle and back, 5% on scapulars, 10% on median and lesser upperwing coverts, 0% on greater upperwing coverts, and less than 5% on all underwing coverts. Primary coverts 1 and 2 (the two innermost) were new (as were primaries p1 and p2, while p3 was growing). This bird was also actively moulting its tail, but not yet the secondaries.

Biometrics

The measurements for different ages and sexes are presented in Table 1, and it is obvious that males are on average larger than females in all body dimensions. Most measurements are highly significantly different between the sexes within any one age group (Table 2), though in juveniles only head+bill, tarsus, and wing are significantly different. No differences were found between adults and subadults, except for tail-1 in males (*t*-test, t=3·19, $P<0{\cdot}05$, n=22). Although males and females within each age group differ in their averages for length of wing, head+bill, and body (Table 2), there is some overlap in measurements between the sexes (Table 1, Figure 4).

Table 2. Significance of differences (*t*-test) between measurements of male and female Socotra Cormorants *Phalacrocorax nigrogularis* within different age groups. Differences are significant at $P<0{\cdot}05$ (*) or $P<0{\cdot}01$ (**); others are not significant ($P>0{\cdot}5$). See text for details.

	Adult		Subadult		Juvenile	
	t	*n*	*t*	*n*	*t*	*n*
Bill length	3.91**	28	3.18**	20	1.71	24
Bill depth	5.65**	28	4.08**	21	2.07	24
Head+bill	4.64**	27	8.10**	20	3.18**	23
Tarsus	3.97**	28	6.44**	21	2.10*	22
Wing	8.05**	28	8.17**	21	3.96**	22
Tail-1	5.21**	21	1.18	16	0.96	18
Tail-2	3.30**	19	2.10	15	1.00	18
Body	3.09**	26	6.95**	21	1.95	17
Sternum	1.82	25	3.85**	18	1.99	20

In females there is a clear difference between birds with a high f-o index and a low bursa index and birds with a low f-o index and a high bursa index, with subadults (aged on basis of feather characteristics) being intermediate (Figure 5, Table 3). In males there is a similar picture, with adults having a high testis index and a low bursa index and juveniles having the converse, but subadults apparently do not differ much from adults.

DISCUSSION

The stepwise descendant moult of the primaries and the stepwise ascendant moult of the secondaries, as well as the moulting asynchrony between the wings and the

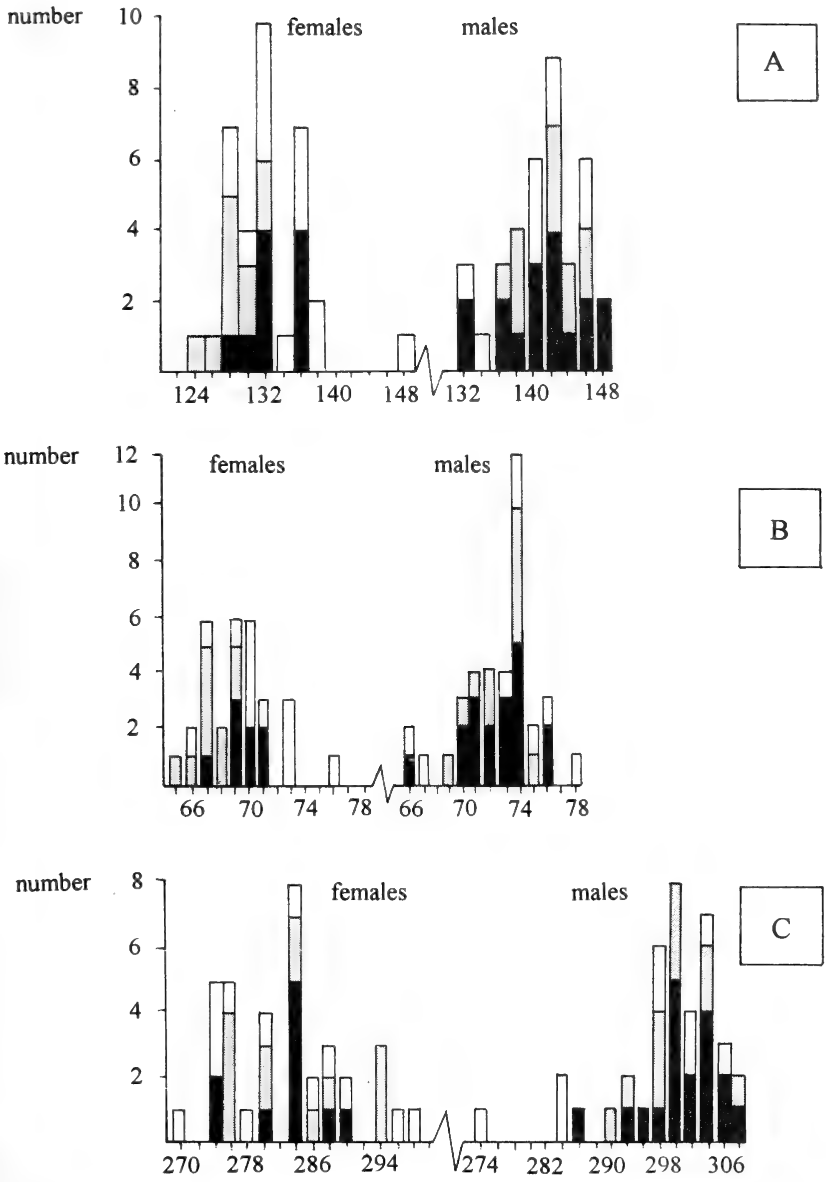

Figure 4. Frequency distributions for head+bill length (A, in mm), body length (B, in cm), and wing length (C, in mm) of Socotra Cormorants *Phalacrocorax nigrogularis* of different sex- and age-classes.

Table 3. The presence of a *bursa Fabricii* in different sex- and age-classes of Socotra Cormorants *Phalacrocorax nigrogularis*, February–April, northern Arabian Gulf.

		Present	Absent	Sample size
Male	Adult	1	15	16
	Subadult	5	5	10
	Juvenile	8	0	8
Female	Adult	0	9	9
	Subadult	8	1	9
	Juvenile	13	0	13

long moulting time are known from most Phalacrocoracidae and other Pelecaniformes (Stresemann and Stresemann 1966; Cramp and Simmons 1977; de Korte and de Vries 1978; Nelson 1978; Rasmussen 1987, 1988). The number of moult waves that occur in flight-feathers differs between species, with one or two (or even none) in small species like Pygmy Cormorant *P. pygmeus*, and up to four in larger ones such as Imperial Shag *P. atriceps* (Cramp and Simmons 1977; Roselaar 1977; Rasmussen 1988).

Adult Shags *P. aristotelis* and Great Cormorants *P. carbo* start their primary moult after the breeding season, and the Shag continues after a pause in winter (Potts 1971; Roselaar 1977), but in these species, as well as in others (e.g. Rasmussen 1987, 1988), birds have been found moulting during the breeding season as well, and the state of moult in the Socotra Cormorants studied suggests that that species does not differ greatly from other cormorants in this respect. Our results suggest that the first post-juvenile (body) moult commences soon after fledging and the onset of the first primary moult is at an age of about six months, which is somewhat earlier than found in some studies of other cormorants (Potts 1971; Roselaar 1977; Rasmussen 1987, 1988) but comparable to the results of Winkler (1987).

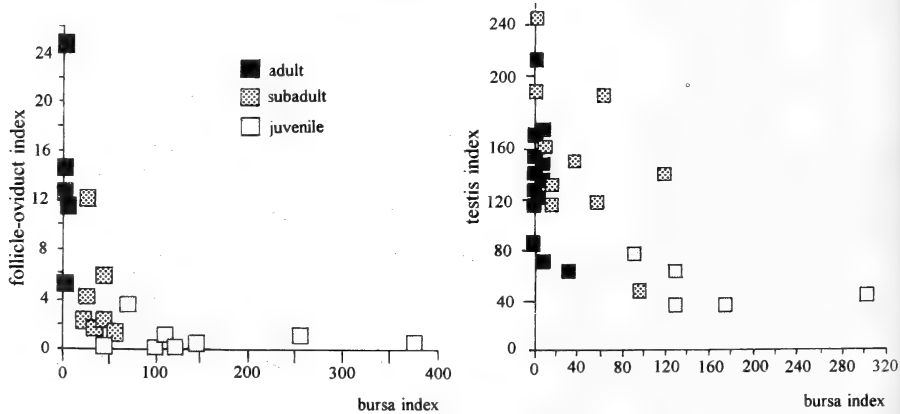

Figure 5. Follicle-oviduct index (females) and testis index (males) plotted against bursa index for three age-classes of Socotra Cormorant *Phalacrocorax nigrogularis* from the northern Arabian Gulf, February–April. See text for definitions of indices.

The results also suggest that, unlike other cormorant species, a complete primary moult takes slightly less than one year, since in our sample only one subadult was found with retained juvenile primaries (p9 and p10). This somewhat faster moult could be an adaptation to the high summer temperatures and the very high salinity of the water in the Gulf, which would presumably cause feathers to wear more quickly than in more temperate or less saline areas.

Sexual dimorphism occurs in cormorants (Roselaar 1977; Cooper 1985), although sometimes only marginally (Hustler 1989). No plumage characters are known to be dimorphic, but the size differences in some species are often enough to allow at least tentative sexing of individuals by measurement alone (M. Platteeuw pers. comm.). In Socotra Cormorants the sexes differ in several body measurements, and, despite the overlap, this should be visible in the field, at least in breeding colonies. Weight would probably also help in sexing birds (Roselaar 1977; Hustler 1989).

A slight difference in plumage between subadults and adults was found, with subadults being greyer on the upper- and underparts, and having narrow, light-coloured fringes on feathers of the upperparts, and often worn brownish feathers on the underparts. Socotra Cormorants apparently gain an adult-type plumage during their third calendar year. The results of the dissections suggest that a few birds would be incorrectly aged on internal organ measurements alone (Figure 5). This applies particularly to males, of which a few subadults with a high testis index and a low bursa index (together suggesting adulthood) were found (note that only one subadult female with a high f-o index and a low bursa index was found). Van Franeker (1983) has argued that birds with a low testis index or a low f-o index could well be adults outside their breeding season, and indeed the Socotra Cormorants died at the end of, or just after, the breeding season. Probably the difference between subadults and adults in Figure 5 would have been more obvious earlier in the season. Winkler (1987) states that in Great Cormorants investigated in Switzerland the bursa was an unreliable feature for recognizing immatures. The fact however that we found mainly males to be incorrectly aged on the basis of the bursa index, together with our own observation of subadult males (but not subadult females) displaying at a breeding colony, suggests that males can become sexually mature at an earlier age than females. This also clarifies the finding that subadult males (with a bursa) had a higher than expected testis index. It is not uncommon for immature seabirds to be present at breeding colonies (e.g. Nelson 1978). Other researches have revealed that a small proportion of subadults of a seabird species can still have a bursa (de Wijs 1983; Anker-Nilssen *et al.* 1988; Camphuijsen 1990; Camphuijsen and Keijl 1991). Most Socotra Cormorants probably lose the bursa in the course of their third calendar year (at about two years old).

Living amidst the most important oil-transportation routes in the world, it can be expected that continuous oil-related mortality of seabirds will take place in the Arabian Gulf. Other threats are the commercial fishery which continues to expand in the region, and the increasing rate of human disturbance at the breeding colonies. Effective action has therefore to be taken to protect the highly vulnerable Socotra Cormorant.

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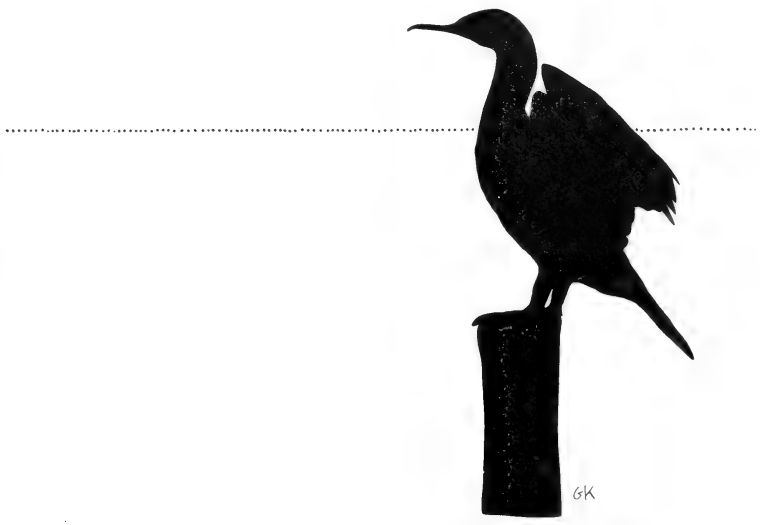

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Spring migration of coastal waders through the Saudi Arabian Gulf in 1991

M. I. EVANS and G. O. KEIJL

Summary Following the massive oil pollution of the northern half of the Saudi Arabian Gulf coastline during the Gulf War, the migration of waders (Charadrii) through this area was investigated during April–May 1991 in an attempt to produce a baseline picture for future reference. The results indicated that the coast probably supported at least 75,000 waders in spring, including significant proportions of the flyway populations of 11 species. The coast is particularly important as a refuelling site for Lesser Sand Plover *Charadrius mongolus* and Terek Sandpiper *Xenus cinereus*. The most important area was found to be Tarut Bay, and the embayment comprising Dawhat al Musallimiyah and Dawhat ad Dafi was probably also very important before it was severely oiled in February–March 1991. The numbers of migrating waders peaked in the last week of April and first two weeks of May. Migration patterns for individual species are described, and conservation of migrant waders is discussed.

THERE ARE at least 59 wader species (Charadrii) reliably recorded from Saudi Arabia, of which 55 are known from its Eastern Province (Jennings 1981a; Hollom *et al.* 1988; Bundy *et al.* 1989; this study). Of these 55 species, 22 occur in appreciable numbers in marine or intertidal habitats or show a preference for them, at least when in the Arabian Gulf (Table 1). Most species are Palearctic migrants which breed in summer at high latitudes in Europe and western Siberia, especially in the Arctic tundra and sub-Arctic taiga zones, and which migrate south to spend the winter in the Middle East and eastern and southern Africa. The various migration routes used by waders flying between these breeding and non-breeding regions collectively form a fairly distinct pathway, referred to here as the West Asian Flyway (see Summers *et al.* 1987), but also known as the East African Flyway (e.g. Smit and Piersma 1989).

Summers *et al.* (1987) showed that all waders wintering in eastern Africa and the majority of those in southern Africa pass through the Middle East on migration. They concluded from the limited evidence that the intertidal zone of the Arabian Gulf coast was probably one of the most important stop-over or 'refuelling' areas for migrant waders in the whole West Asian Flyway region, and that the Gulf coast was one of five major areas of concentration of wintering waders in western Asia and in the eastern half of Africa.

Until recently, however, little was known about the distribution and numbers of waders using the Arabian Gulf. National checklists summarized the bare details of seasonal status and relative abundance (Jennings 1981a, 1981b; Stuart and Pilcher 1983; Hill and Nightingale 1984; Bundy *et al.* 1989; Richardson 1990; Nightingale and Hill 1993). A few more in-depth but small-scale studies were carried out on particular species or sites in the Gulf (Etheridge 1971; Smart *et al.* 1983; Tucker 1985; Palfery 1988), but it was only in the last seven years that any major systematic surveys of waders were carried out on the Arabian side of the Gulf and the results published: in January–February 1986 in Saudi Arabia (Zwarts *et al.* 1991) and in the autumns of 1986 and 1987 in Dubai (Uttley *et al.* 1988). Increasingly since 1987 systematic mid-winter counts of coastal waterbirds (including waders) have also been carried out in several Gulf countries for the Asian Waterfowl Census, but the results have not yet been fully analysed (Scott and Rose 1989; Perennou *et al.* 1990; Perennou and Mundkur 1991; Perennou and Mundkhur 1992).

Zwarts *et al.* (1991) tentatively estimated that 260,000 waders winter on the Saudi Arabian Gulf coast and up to four million in the whole Arabian Gulf, and on this basis judged the the intertidal zone of the Gulf coast to be one of the world's five major wintering areas for waders, along with north-west Africa, Australia, north-west Europe, and the northern coast of South America. In addition, Zwarts *et al.* (1991) suggested that the number of migrant waders stopping off to refuel in the Gulf during migration in spring and autumn could be of the same magnitude as the number present in winter.

Despite this previous work, no quantitative information had been collected systematically and published on the spring wader migration anywhere in the Gulf. It was important to rectify this lack of knowledge for the following reasons.

- When the gigantic Gulf War oil spills devastated 560 km of the northern Saudi Arabian Gulf intertidal zone during February and March 1991 (Evans and Keijl 1993), it was not known with confidence when and where any important concentrations of migrant waders (or other waterbirds) occurred along the coast in spring, or what the overall magnitude and importance of the migration was. Given that physical protection of coastal sites from oil pollution is time-consuming and expensive, it pays to know where the highest priority sites are. It was difficult to respond to the spills, and to predict or measure their impact, due to this lack of baseline information.
- Coastal development, especially land-claim, has resulted in permanent destruction of much intertidal habitat along the Saudi Arabian Gulf coast (IUCN 1987; Coles and McCain 1989), to the detriment of waterbird populations generally (Evans and Keijl 1993). There is an urgent need to identify the most important remaining sites for waterbirds along the coast, so that these can be protected from further damage.
- The effective management and conservation of waders and other waterbirds in the protected areas which are being proposed for the Saudi Arabian Gulf coast (Child and Grainger 1990) will depend, among other factors, on identifying which are the most significant species in conservation terms, on locating the most important sites for these within the protected areas, and on gaining an understanding of why these sites are favoured.
- Saudi Arabia, as a Party to the Bonn Convention on Migratory Species, is encouraged to conclude agreements between range states covering the conservation and management of migratory waders, amongst other groups (Boere 1991). Clarification of Saudi Arabia's role in conserving migratory waders necessitates the identification of those species for which Saudi Arabia is most important, followed by identification of these species' breeding grounds, of their

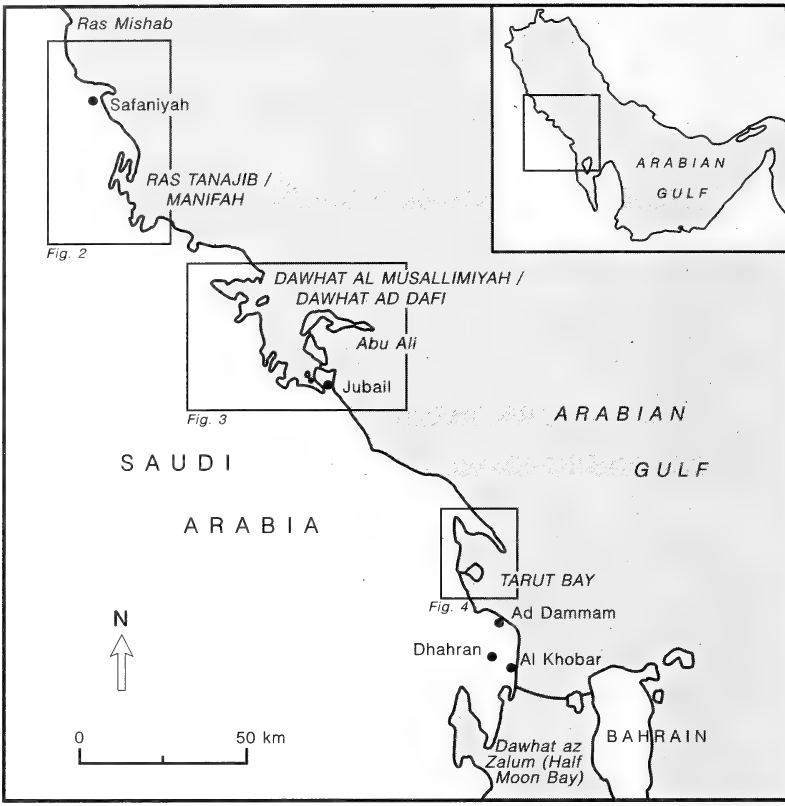

Figure 1. The Gulf coastline of Saudi Arabia, showing the three major embayments of the study area: Ras Tanajib/Manifah, Dawhat al Musallimiyah/Dawhat ad Dafi, and Tarut Bay.

important migration staging posts, and of their main wintering areas, both within Saudi Arabia and abroad, in order to detect which are the relevant range states.

Following the Gulf War, therefore, the National Commission for Wildlife Conservation and Development (NCWCD) invited a team from BirdLife International (formerly the International Council for Bird Preservation, ICBP) to work with it on the Gulf coast of Saudi Arabia during April and May 1991, gathering baseline data on species diversity, numbers, distribution, origins, and movements of waders, focusing on those species dependent on coastal habitats and thus most at risk from oil pollution and coastal land-claim and most relevant to the proposed coastal protected areas. Other coastal non-wader waterbird species were also investigated to a lesser extent, but the data on these species will be summarized elsewhere (Evans *et al.* in prep.).

THE SAUDI ARABIAN GULF INTERTIDAL ZONE

Over 50% of the linear extent of the intertidal zone of the Saudi Arabian Gulf consists of a narrow beach exposed to the open Gulf, but this forms only about 5% of the area of the intertidal zone, which is almost wholely intertidal flats (IUCN 1987). These latter lie mostly within three major embayments that indent the Saudi Arabian Gulf coastline: from north to south these are Ras Tanajib–Manifah, Dawhat al Musallimiyah–Dawhat ad Dafi, and Tarut Bay (Figure 1). As a result of the low relief of the Saudi Arabian Gulf coast (average slope 35 cm/km) (IUCN 1987) and a maximum tidal amplitude of *c.* 2·4 m (at Tarut Bay), a width of 1 km or more of intertidal flats is often exposed at low tide in the embayments (pers. obs.).

Other habitats of importance for waders are saltmarshes, sabkhas (natural salt pans), and mangroves. Well-developed saltmarshes provide cover and, indirectly, food for waders, and are found mainly within the four major embayments. Sabkhas are used for roosting (and for feeding when flooded with rainwater in winter), and are scattered all along the coast above the high tide line. Mangroves also provide shelter and a rich food supply for waders, but are of very limited occurrence in the Saudi Arabian Gulf, apparently due mainly to the harsh temperature/salinity regime. Nevertheless a large proportion has been destroyed by land-claim in recent years (Coles and McCain 1989).

THE STUDY AREAS

Within the logistical constraints of accommodation and transport, three main study areas were chosen so as to cover as much as possible of the three major embayments (presumed to be the richest areas for waders), including oiled and unoiled sites (Figures 2–4). Tidal amplitudes at the study areas during April and May varied from 1·9 to 2·4 m.

Ras Tanajib area

There were limited areas of intertidal sandflat (Figure 2); patches of well-developed saltmarsh occured in the more sheltered northern half of the embayment, sabkha was frequent (especially to the south), but there was no mangrove. Virtually the whole intertidal zone was already heavily oiled by April–May 1991 (see Evans and Keijl 1993).

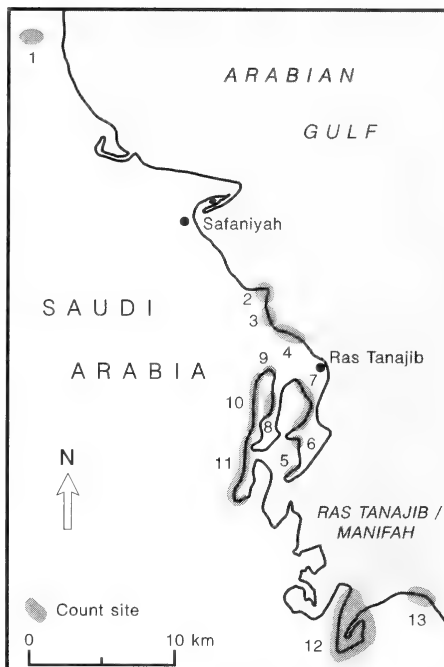

Figure 2. The Ras Tanajib study area, showing wader count sites.

Jubail area

Intertidal flats on the Abu Ali headland extended up to 1 km offshore, mainly on the sheltered southern and eastern sides, but were mostly less than 500 m wide, with the narrowest beach areas along the exposed northern and western shores (Figure 3). In the Dawhat al Musallimiya–Dawhat ad Dafi embayment, intertidal

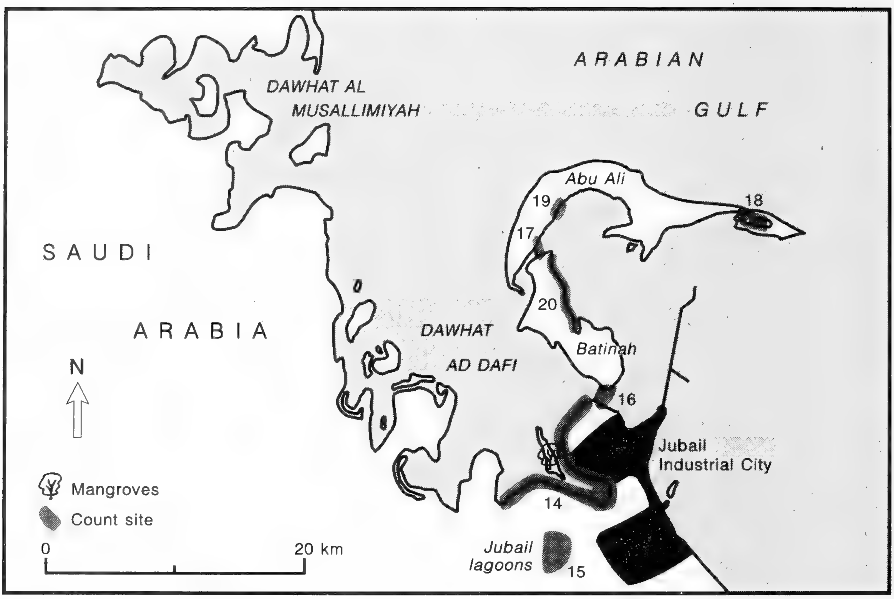

Figure 3. The Jubail study area, showing wader count sites.

flats were very extensive (at least 1 km wide), with a greater extent of pure mud sediment compared to most flats along the Saudi Arabian Gulf coast, and saltmarshes were well-developed and extensive here as well. About 10 ha of mangrove were present in Dawhat ad Dafi. Sabkhas were particularly extensive in the south-west of Dawhat ad Dafi and on the mainland south of Abu Ali. There were extensive, brackish, man-made lagoons north-west of Jubail Industrial City at an area called Sabkhat al Fasl on maps, and here referred to as the Jubail lagoons. The northernmost point on Abu Ali marked the limit of the heavily oiled intertidal zone; points to the east were not affected by the 1991 spill.

Tarut Bay area

The intertidal mud- and sandflats within Tarut Bay may be the most extensive in the Saudi Arabian Gulf, with at least 2–3 km often exposed offshore at low tide (e.g. east of Tarut Island), and are rich in food for waders (Figure 4). The predominant substrate appeared to be mixed sand/mud, but there were also scattered smaller areas of purer muddy sediment mostly associated with mangroves and/or the most sheltered areas. The largest remaining areas of mangrove in the Saudi Arabian Gulf are found within the Bay at eight sites, totalling less than 1 km²; the largest expanses were at Anuk and on the southern shore of Tarut Island, but the tallest trees were found in a small patch on the north-west shore of Tarut Island. There were three large areas of saltmarsh: north-west of Rahimah (the largest and the most nearly pristine saltmarsh/mangrove community left in the Saudi Arabian Gulf), east of Safwah, and on the southern shore of Tarut Island; all three areas were associated with mangroves.

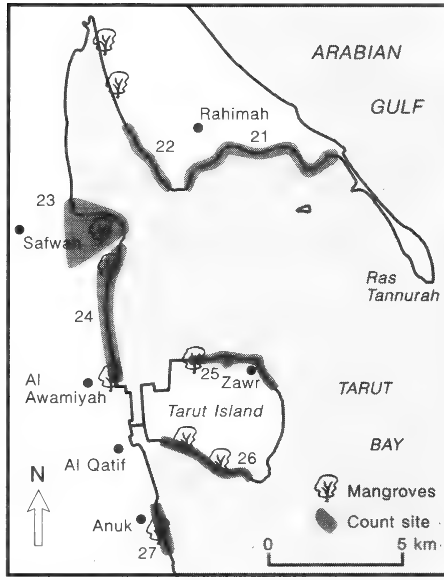

Figure 4. The Tarut Bay study area, showing wader count sites.

METHODS

Counts

Waders were counted at selected sites at high and low tides (as described in, e.g., Howes and Bakewell 1989). A two-man team worked at Ras Tanajib from 14 April to 28 May and covered 13 main count sites (Figure 2), mostly in the Ras Tanajib/Manifah embayment. Two two-man teams worked at Jubail between 12 April and 28 May, and counted waders at seven main sites covering the Abu Ali headland, the Jubail lagoons, and the southern and south-west part of the large and complex Dawhat al Musallimiyah/Dawhat ad Dafi embayment (Figure 3). In the Tarut Bay area, a two-man team worked between 14 April and 28 May, covering seven main count sites, all within the bay (Figure 4). We defined high tide and low tide periods as being two hours on either side of the peak. Intertidal substrate types (mudflat, mud/sand flat, sandflat) were estimated qualitatively by walking on the substrate and feeling samples of it.

In estimating the total number of migrating waders passing through the study areas, turnover was allowed for by multiplying the peak counts of each species at each site by a conservative factor of two. Studies on turnover have produced multiplication factors varying from 1·0 to 4·5 (Howes and Bakewell 1989; Keijl *et al.* 1992; M. Tasker *in litt.*), but no study has been carried out with 100% success.

Ringing

The biometrics of migrating waders can give indications of their origins and present migratory state. Birds were therefore mist-netted at the Jubail lagoons, ringed, weighed, and measured, and notes were taken on plumage stages (e.g. moult).

Potential flight ranges of fattened-up migrants are estimated in the Results section (below}, according to the formula of Davidson (1984), for selected species of which some individuals had weights well above winter weight (latter based on: Etheridge 1971; Curry *et al.* 1980; Pomeroy 1980; Cramp and Simmons 1983; DSP 1987; Uttley *et al.* 1988; Zwarts *et al.* 1990; Hirschfeld *et al.* 1992; J. Uttley *in litt.*; ICBP/Kuwait Environment Protection Council unpubl. data). In using this formula, flight speed for all species was taken as 65 km/hr (probably an underestimate: see Zwarts *et al.* 1990), fat load estimates were calculated using the formula of Piersma and van Brederode (1990), and lean weights are based on winter weights. Zwarts *et al.* (1990) argue that although Davidson's is one of the most 'moderate' flight range equations, it is still likely to underestimate the true potential flight ranges of migrants.

Visible migration

Data on departing flocks of waders were gathered *ad hoc* throughout the period. On six days (8, 12–14, 16, 20 May), systematic watches were carried out at the Jubail lagoons, from approximately 16.30 hrs until dark (*c.* 18.30 hrs). On all occasions, data were collected on species composition, departure time, flock size, weather at departure, direction taken, and behaviour. Direction angles were estimated, or measured using a compass.

DIVERSITY AND RELATIVE ABUNDANCE OF SPECIES

Thirty-eight species of wader were recorded along the Saudi Arabian Gulf coastal zone during this survey, and results are given for 22 which occur in appreciable numbers in the coastal zone and/or which are coastal-dependent (Table 1). The remaining 16 species are not dealt with further.

Table 1 lists the single, highest count for each species at each count site, irrespective of tidal state. Zwarts *et al.* (1991) showed that the relative abundance of wader species indicated by high tide counts of waders strongly reflected their relative abundance as indicated by the more accurate low tide (or 'feeding density') counts. Because of this, and because too few low tide counts were carried out during the present survey to enable an accurate estimate of overall relative abundance of species, peak counts (whether at high or low tide) at the 27 count sites have simply been added together to give a rough idea of overall relative abundance of each species along the Saudi Gulf coast (Table 1).

Including all the study sites, the five most numerous wader species were (in order of decreasing abundance) Bar-tailed Godwit*, Lesser Sand Plover, Little Stint, Terek Sandpiper, and Curlew Sandpiper, all migratory Palearctic breeders. However, the two brackish water sites surveyed—the Jubail lagoons and near Ras Mishab (Ras Tanajib area; naturally rain-flooded sabkha)—are not strictly part of the intertidal ecosystem, not being connected to the sea, although coastal waders used these areas because they were so close to the shore. These brackish sites attracted large numbers of certain species such as Little Stint and Curlew Sandpiper which were

* Scientific names of wader species are given in Table 1.

otherwise less numerous on the intertidal zone according to our data (possibly due to a preference for less saline conditions than the hypersaline Gulf water), and so their abundance in the oil-pollution-vulnerable intertidal zone is over-emphasized. If one excludes these brackish sites, the five most numerous species are (in order) Bar-tailed Godwit, Lesser Sand Plover, Terek Sandpiper, Grey Plover, and Turnstone (Table 1).

Lesser Sand Plover and Grey Plover are also amongst the top five commonest species in winter, but Bar-tailed Godwit, Terek Sandpiper, and Turnstone are less predominant then (Zwarts *et al.* 1991).

OVERALL MAGNITUDE AND TIMING OF MIGRATION

About 75,000 waders may have migrated through the 27 count sites during spring, after accounting for turnover (Table 1). Although the sites covered, or drew roosting waders from, less than 50% of the total area of the Saudi Gulf intertidal zone, they did cover most of the wader-rich parts of the coast. The wader carrying capacity of the severely oil-polluted northern half of the Saudi Arabian Gulf coast appeared to have been reduced by about 97% during 1991 (Evans and Keijl 1993), and the unpolluted coastline south of Tarut Bay in the Gulf of Salwah that was not covered by this study is also reported to support very low densities of waders due to the hypersaline seawater and/or the unsuitably rocky substrate (Zwarts *et al.* 1991). Thus it seems unlikely that the coast supported more than 100,000 waders in spring 1991.

Bearing in mind that the overall carrying capacity of the whole Saudi Gulf coastline seemed to have been approximately halved by the oil pollution in 1991 (Evans and Keijl 1993), *c.* 150,000 or more waders may have been using the Saudi Arabian Gulf coastline during spring migrations immediately before 1991. This is in line with Zwarts *et al.*'s (1991) prediction that numbers of waders in spring might be of equal magnitude to numbers in winter in the Saudi Arabian Gulf (260,000).

Peak counts for the majority of species occurred in the last week of April and the first two weeks of May (see Table 1 and below). In addition, the finding of Piersma *et al.* (1990) that the maximum size of a visibly migrating wader flock of a particular species is generally recorded during the peak migration period suggests that, for most species in the Gulf, the peak migration occurred in the last week of April or first two weeks of May (see Table 2).

SPECIES ACCOUNTS

The information collected on biometrics, moult, weights, and visible migration is presented and discussed on a species-by-species basis, since migratory strategies and breeding/wintering grounds vary widely between species. The magnitude of peak counts (Table 1) is discussed in relation to numbers recorded in January–February 1986 (Zwarts *et al.* 1991), in March 1991 (Dennis 1991), and in November–December 1991 (Harbard and Wolstencroft 1992), to give some idea of the fluctuations in abundance of each species over changing seasons. The biometrics

Table 1. Peak wader counts in the coastal zone of the Saudi Arabian Gulf, 14 April to 27 May 1991. Dates of counts (in italics) are given where the count exceeds 100. See footnotes.

	Ras Tanajib area												
Site number:	1	2	3	5	6	7	9	10	11	12	Total	14	1
Oystercatcher		7		3	20	4	4	20	3	3	64		
Haematopus ostralegus													
Avocet													2
Recurvirostra avosetta													
Crab Plover		7			1						8		
Dromas ardeola													
Ringed Plover				2	2	3	1			1	9	2	12
Charadrius hiaticula													*24/*
Kentish Plover	5	11	3	1	114	5	6	13	12	58	228	18	67
C. alexandrinus					*15/5*								*9/*
Lesser Sand Plover	6	8	2	42	442	28	24	4	1	136	693	95	1,08
C. mongolus					*6/5*					*6/5*			*2*
Greater Sand Plover				4	11					1	16	12	
C. leschenaultii													
Grey Plover	4	14	3	15	33	17	1	1	3	5	96	35	6
Pluvialis squatarola													
Great Knot													
Calidris tenuirostris													
Sanderling	8	8			30	13	1			7	67	2	43
C. alba													*13*
Little Stint	12	16	3	1	51	12	2			21	118	1	3,56
C. minuta													*13*
Curlew Sandpiper	3	14	1		37	43	3		3	23	127	2	1,28
C. ferruginea													*13*
Dunlin	1,070		1		266	13				3	1,353		65
C. alpina	*17/4*				*16/4*								*2*
Broad-billed Sandpiper					5						5		24
Limicola falcinellus													*2*
Bar-tailed Godwit		6		5	458	20				2	491	33	(
Limosa lapponica					*23/4*								
Whimbrel		1			3	1					5	3	
Numenius phaeopus													
Curlew		6		2	15	5	4	10	5	14	61	18	
N. arquata													
Redshank					11	6			1		18	6	1
Tringa totanus													*14*
Greenshank	1				14						15	1	
T. nebularia													
Terek Sandpiper		1		8	29	21	11	5	1	1	77	9	
Xenus cinereus													
Turnstone		27	3	4	31	2	2		2	65	136	39	
Arenaria interpres													
Red-necked Phalarope													
Phalaropus lobatus													
Peak counts of other wader species (summed)		4	3	2	6			5	2	6	28	1	4
Total of all peaks	1,109	130	19	89	1,579	193	59	58	33	346	3,615	277	8,9
Total no. of wader species recorded	8	16	8	13	22	15	11	7	10	16	25	16	

Notes:

1. Site numbers correspond to those on maps (Figures 2–4). 2. Peak counts are given without regard to tidal state. 3. Data are

Jubail area						Tarut Bay area								Grand
16	17	18	19	20	Total	21	22	23	24	25	26	27	Total	Total
11	4	8	3	1	27	70	45	29	17	32	5	36	234	325
					22					1			1	23
1	3			5	9	5							5	22
2	5		1	1	132	1	51	12		84	4	32	184	325
20	70	5	41	34	862	47	100	49	68	230	36	113	643	1,733
							29/4			*2/5*		*17/5*		
370	410	4	29	81	2,076	123	103	109	169	1,750	30	296	2,580	5,349
0/4	*2/5*					*6/5*	*1/5*	*21/4*	*17/4*	*2/5*		*30/4*		
1	7		4	16	43	1	3	3	2	2		1	12	71
76	60	6	21	54	315	380	119	122	191	178	209	270	1,469	1,880
						1/5	*8/5*	*15/5*	*5/5*	*25/4*	*25/4*	*25/4*		
							1		107				108	108
									14/4					
50	120	12	4	9	636	132	101	40	34	125	10	66	508	1,211
	2/5					*6/5*	*8/5*			*12/5*				
50	77		9	3	3,707	2	34	7	11	119		76	249	4,074
										17/4				
100	71	15	13	33	1,519	29	141	44	213	520	200	166	1,313	2,959
0/4							*1/5*		*5/5*	*2/5*	*25/4*	*6/5*		
260	70	5		7	994	18	53	25	16	150	85	47	394	2,741
0/4										*2/5*				
	1				246	1		9	6	250		15	281	532
										25/4				
434	164	17	22	121	855	280	251	1,600	179	1,860	700	266	5,136	6,482
7/4	*23/4*			*23/4*		*24/4*	*29/4*	*13/4*	*17/4*	*25/4*	*25/4*	*18/4*		
2	1		1	2	11	23	38	22	32	20	26	27	188	204
43	12	4	11	21	114	106	52	167	28	81	66	69	569	744
						15/5		*21/5*						
21	57	5	15	14	286	51	33	220	11	108	62	6	491	795
								15/5		*20/5*				
2	5	20	1	4	51	21	5	10	1	13	1	1	52	118
93	305	4	24	82	540	310	268	696	344	668	173	436	2,895	3,512
	2/5					*1/5*	*29/4*	*16/5*	*5/5*	*18/5*	*28/4*	*25/4*		
20	33	10	14	16	209	207	209	55	106	464	31	433	1,505	1,850
						1/5	*5/5*		*5/5*	*12/5*		*25/4*		
					22									22
	4	4	1		451	3	14	10	3	91	21	39	181	660
556	1,479	119	214	504	13,127	1,810	1,621	3,229	1,538	6,746	1,659	2,395	18,998	35,740
18	23	14	17	18	31	22	21	21	21	27	17	24	32	38

systematic counts only, and exclude all opportunistic observations. 4. No waders were recorded at sites 4, 8, and 13.

are discussed in relation to previous studies in the West Asian Flyway, especially those in the Gulf and nearby: Kuwait, November (BirdLife International, Kuwait Environment Protection Council unpubl. data); Bahrain, September–October (Hirschfeld *et al.* 1992); Dubai (United Arab Emirates), August–October (DSP 1987; Uttley *et al.* 1988; J. Uttley *in litt.*); Sharjah (UAE), winter (Etheridge 1971); Masirah island (Oman), autumn (Curry *et al.* 1980; Pomeroy 1980).

During ringing, a total of 197 waders of 16 species was caught. No previously ringed birds were controlled. The biometrics of all birds caught are displayed in Table 3, including the weights of all unoiled, fully-grown birds. Previous ringing recoveries from the Gulf are detailed in the species accounts following, but an exhaustive search for these was not made.

Table 2. Data on departure of waders along the Saudi Arabian Gulf coast, April–May 1991.

	Date range	Flock size			Total no. of birds seen departing	Mean departure direction of flocks	Mean departure time of flocks (min. before sunset, *c.* 18.30 hrs)
		Mean	*n*	Range			
Avocet	16/5	1	1	–	1	337°	1
Ringed Plover	12/5	10	1	–	10	360°	120
Lesser Sand Plover	16–20/5	10	3	5–18	30	353°	33
Grey Plover	5–12/5	10	3	2–15	30	358°	98
Sanderling	6–12/5	40	2	8–72	80	360°	45
Little Stint	7–24/5	21	15	4–40	315	005°	12
Curlew Sandpiper	2–20/5	49	13	2–165	637	022°	28
Dunlin	6–21/5	18	5	1–50	90	009°	39
Broad-billed Sandpiper	2–16/5	16	4	6–25	64	360°	23
Bar-tailed Godwit	23/4–25/5	50	5	4–120	250	009°	84
Curlew	28–29/4	6	3	1–9	18	360°	–
Redshank	9/4–21/5	20	6	6–49	120	030°	69
Greenshank	6/5	2	1	–	2	360°	35
Terek Sandpiper	1–27/5	54	9	5–140	486	351°	63
Turnstone	6–20/5	37	11	2–160	407	001°	42

Observations of visible migration comprised records of 82 flocks, involving 15 out of the 22 species under study (Table 2). Specific details are discussed below. A detailed study by Piersma *et al.* (1990) of spring wader migration at the Banc d'Arguin in Mauritania on the East Atlantic Flyway, at a similar latitude to the Gulf, allows a general comparison. Our much more limited data do not contradict their findings, as follows.

- Most flocks consisted of 10–60 individuals.
- The vast majority of departures occurred between late afternoon and dusk, although our more systematic observations were biased towards this period.
- The majority of departing flocks vocalized intensely.
- A small minority of flocks contained more than one species: 4% of flocks in Mauritania, 11% in the Gulf (11 out of 96 flocks).

Oystercatcher

At most sites there appeared to be a peak in numbers in the last week of April and/or first week of May, but numbers are smaller than during November–March by about half, thus the peak possibly represents an influx of oversummering young birds. Birds in the Gulf are of the race *H. o. longipes* (Cramp and Simmons 1983).

Avocet

There was a strong peak in numbers at the Jubail lagoons in the first week of May, over and above the few pairs that had already settled to breed; elsewhere, the species was much less common. Many more (daily max. 136) have been recorded in November–December at the Jubail lagoons. At most Mediterranean study sites (where the main spring peak is earlier than May), there is a second migratory peak at the beginning or middle of May, similar to the one recorded here (GOK pers. obs.).

Crab Plover

Small groups of up to seven were seen on eight occasions from 16 May onwards. A few breeding sites are known in the Gulf, where this species is otherwise more widespread as a winter visitor and passage migrant (Cowan 1990). No breeding sites are known in the Saudi Arabian sector of the Gulf; the nearest colony appears to be Ummal Karam island across the Gulf in Iran, where an estimated 1,500 pairs were breeding in the 1970s (D. Scott unpubl. data).

Ringed Plover

Peak numbers were seen in the third week of April, with a decline thereafter. Overall, the magnitude of the spring passage seems relatively insignificant, which in itself is surprising given the numbers that must winter south of the Gulf along African shores. However, since Ringed Plovers often roost amidst other wader species, they may have been overlooked in large gatherings. Although the sample size is very small, the short wing and bill (Table 3) point to a rather easterly breeding origin (Smit and Wymenga 1989). One bird, captured on 15 May, had a very low weight of 46 g (Table 3), indicating that it had either just arrived from a long journey or that it had been driven away from its oiled feeding grounds.

Kentish Plover

Numbers in most places remained roughly stable throughout the period (apart from the addition of chicks to the population through breeding). At the Jubail lagoons, however, numbers of fully grown birds increased steadily throughout May to levels roughly ten times those of April; this was thought to be due to an influx of failed breeders and of the earliest fledged juveniles of the year into this productive feeding environment. Counts in November–December are three to four times larger, but those from January to March are apparently much lower than in spring (although this is suspected to be an observer artefact).

The breeding population is presumably augmented in winter by birds which breed further north in the former USSR, the Balkans, and Turkey, these birds most

Table 3. Biometrics (g, mm) of waders during April–May 1991 at Jubail lagoons (Saudi Arabia). Averages, ranges, and sample sizes are given, as well as standard deviations (in brackets) if $n > 5$. Only weights of unoiled, full-grown, live birds are given; data include wing lengths from intact birds found freshly dead.

	Weight	Wing	Tarsus	Tarsus–toe	Bill	Head+bill
Ringed Plover	–	128.7	25.2	45.7	14.1	41.0
	46.0	128–129	24.6–26.0	45–46	13.8–14.2	40.8–41.3
	1	3	3	3	3	3
Kentish Plover	39.3 (5.1)	110.7 (2.8)	28.3 (1.3)	47.5 (1.8)	15.4 (0.9)	41.7 (1.1)
	34–53	104–118	25.4–31.3	44–52	13.2–17.1	38.7–44.0
	14	43	47	48	48	47
Lesser Sand Plover	70.0	133.0 (4.3)	34.1 (1.4)	57.1 (2.6)	16.9 (0.9)	46.9 (1.0)
	60–80	120–141	31.0–37.3	47–63	15.3–19.0	44.4–49.4
	2	44	44	44	44	44
Greater Sand Plover	–	140.5	37.9	63.0	24.6	56.7
		139–142	37.4–38.5	62–64	24.1–25.0	55.7–57.7
		2	2	2	2	2
Grey Plover	211	204.5	48.7	86.5	29.6	67.6
	200–222	204–205	44.3–53.0	81–92	29.1–30.1	66.2–68.9
	2	2	2	2	2	2
Sanderling	68.0	126.2 (3.3)	24.5	46.0	24.0	49.6
	66–70	122–131	24.3–24.7	44–48	23.5–24.5	48.9–50.3
	2	6	2	2	2	2
Little Stint	25.0 (3.1)	99.3 (2.7)	21.9 (0.9)	40.5 (1.2)	18.0 (0.9)	38.6 (1.2)
	19.5–31.0	94–107	20.3–25.5	38–43	16.1–21.0	36.6–42.0
	48	54	61	61	62	62
Curlew Sandpiper	–	132.5	–	–	–	–
	62	132–133	29.0	51	37.7	62.0
	1	2	1	1	1	1
Dunlin	58.6 (5.8)	120.7 (2.3)	26.3 (1.1)	49.1 (1.4)	34.5 (1.3)	59.2 (1.3)
	48–66	117–125	24.7–28.0	47–52	32.5–36.7	57.4–61.3
	8	14	10	10	10	9
Broad-billed Sandpiper	–	105	–	–	–	–
	41	104–106	22.3	42	30.3	52.4
	1	2	1	1	1	1
Bar-tailed Godwit	–	207.5	51.4	89.0	77.7	113.9
		202–213	51.2–51.6	88–90	77.6–77.8	112.0–115.8
		2	2	2	2	2
Redshank	–	165.8	–	–	–	–
	132	162–170	51.8	89	46.0	78.5
	1	4	1	1	1	1
Terek Sandpiper	67.3	137.5 (3.6)	29.3 (2.5)	54.4 (1.8)	47.5 (2.1)	74.1 (1.9)
	62–72	131–143	27.0–34.7	52–57	43.5–52.3	70.7–78.0
	3	15	11	11	11	11
Turnstone	–	156.8	–	–	–	–
	79	152–163	25.3	53	20.7	49.7
	1	5	1	1	1	1
Red-necked Phalarope	–	–	–	–	–	–
	–	113	20.7	42	21.0	42.7
	–	1	1	1	1	1

likely leaving the Gulf region from the beginning of March onwards (Cramp and Simmons 1983). The Kentish Plovers trapped in spring have a very similar mean weight to birds caught in Dubai in autumn/winter (Table 3), suggesting that fattening-up migrants were not present.

Lesser Sand Plover

Numbers peaked in the last week of April and first week of May. Counts are much larger than those from January–March, by factors of up to five. The largest numbers in spring were at the Zawr saltmarsh roost (Tarut Island; a much larger roost than any other found in Tarut Bay for this species) and at the Jubail lagoons. Large numbers of birds at the latter site were oiled and were perhaps attracted to recuperate there.

Cramp and Simmons (1983) indicate that only the race *C. m. pamirensis* winters in the Gulf and southwards, and this is consistent with the biometrics and plumage features recorded by this and previous surveys (Table 3). This race migrates between its breeding grounds high in the central Asian mountains and its Middle Eastern/African coastal wintering area via Iran and Arabia and probably not directly across the Indian Ocean (Cramp and Simmons 1983). Biometrics suggest that birds caught on this survey derive from the north-west extremity of this race's breeding range, in the northern Pamir/Tien Shan mountains (see Cramp and Simmons 1983).

The markedly greater wing length of the spring birds compared to those wintering in the Gulf (Table 3) suggests that spring birds are longer-distance migrants (Alerstam 1990) which have been wintering further south, presumably in East Africa. The sample of Lesser Sand Plovers captured in spring 1991 appear to average about 10–20 g (17–40%) heavier than autumn/winter Gulf birds (Table 3); in order to be this fat the spring migrant population had probably already arrived in the Gulf from their wintering quarters some weeks before the mean date of capture of the sample (5 May); indeed, Cramp and Simmons (1983) state that the main departure from the wintering quarters is in the first half of April.

The scarcity of inland records suggests that autumn migration occurs as a single long-haul flight from the breeding grounds to the shores of the Indian Ocean, and the same strategy is also thought to be taken in spring (Cramp and Simmons 1983). The northern breeding grounds of *C. m. pamirensis* are re-occupied from mid-April to early May (Cramp and Simmons 1983). The Arabian Gulf is the last coastal site encountered by African winterers moving north in spring, and thus it would make sense if these birds used the Gulf as their last refuelling site before flying direct to the breeding grounds, as the peak dates and high weights recorded in spring suggest they do. The heaviest birds in our sample had estimated flight ranges of up to 3,100 km (assuming a lean weight of 52 g), enough to reach the breeding grounds.

Greater Sand Plover

Numbers are much higher in winter than in spring, when only very small numbers of non-breeding second calendar year birds appeared to be present; the emigration of wintering birds thus seemed to be already virtually complete by the second week of April. Birds wintering in the Gulf and in eastern and southern Africa are considered to be of the race *C. l. crassirostris* which breeds in central Asia from Transcaspia east to south-east Kazakhstan, based on study of museum specimens (Cramp and Simmons 1983). The race *columbinus* also occurs in the upper Gulf on autumn passage in August–September, on its way to winter in the Red Sea from breeding sites in Turkey, Jordan, Afghanistan, and Azerbaijan (Cramp and Simmons 1983), although the only information on the return passage in spring is that *columbinus* arrives earlier on its breeding grounds than *crassirostris* (breeding from the end of March onwards). Too few were captured during this survey to allow identification of race(s).

Given the situation above, it would appear that any spring passage of either race through the region occurs earlier than April–May, and it seems likely that most of the wintering *crassirostris* would have left by the end of March, leaving much smaller numbers of summering birds in April–May, probably of both races.

Grey Plover

Most peak counts were in the last week of April and first week of May, although large numbers continued to be recorded up to 15 May. Even larger numbers appear to occur in winter than in spring, in Tarut Bay at least. Highest counts in spring were at Tarut Bay (most sites), with the Ahueza roost being largest.

Birds wintering in eastern and southern Africa and passing through the Gulf in spring are presumably heading for western Siberia, especially between the Yamal and Taimyr peninsulas (Cramp and Simmons 1983). When fully fattened before migration, this species has a potential for continuous flight estimated at 6,500 km (Cramp and Simmons 1983), enough to reach the breeding grounds directly from the Gulf. However, the earliness of the observed spring passage, compared to the timing on the East Atlantic flyway (Zwarts *et al.* 1990), suggests that a further refuelling stop occurs north of the Gulf (i.e. at the Black or Caspian Seas), and recoveries of South-African-ringed birds indicate that at least these birds use the Black Sea (Cramp and Simmons 1983).

Great Knot

A rare visitor to the Gulf region, presumably wintering in low numbers, which breeds in the subarctic zone of north-east Siberia, wintering from the Makran/Sind coast of Pakistan east to southern China and south to Australia (Cramp and Simmons 1983). In recent years there have been a number of records from Arabia, including the first record from Saudi Arabia and the Gulf: two immatures at Al Khobar from 28 May to 9 June 1984 (Bundy *et al.* 1989). One was seen at the Jubail lagoons in early April 1991 (P. Symens pers. comm.), just before this survey commenced, the second Saudi Arabian record. Thus our further two records are of interest:

- A flock of 107 in full breeding plumage at Al Awamiyah (site 24) on 9 April, accompanied by a Knot *Calidris canutus*. They could not be refound on 14–15 April or on frequent visits thereafter, suggesting that they had migrated out of the area.

- A second calendar year bird on 11 May at Rahimah (site 22), Ras Tannurah, echoing the first record for Saudi Arabia (also of immature birds in late spring).

The species is now known to winter in moderate numbers on the Arabian Sea coast of Oman (1,193 in winter 1989–90: Green *et al.* 1992), although the main wintering population is found in Australasia. The flock of breeding plumaged birds in Tarut Bay would be facing a journey of at least 8,500 km to their known breeding grounds, with no obvious wetland refuelling areas along the way. Such a long migratory route, skewed so far east of north, seems odd for a species so dependent on coastal habitat for migratory refuelling, and perhaps there are undiscovered breeding grounds far to the west of those now known.

Sanderling

The highest counts occurred in the second week of May, although numbers were also high in the two preceding weeks. Numbers in January–March are much smaller, suggesting that the Saudi Arabian Gulf coast is more important as a refuelling area for this species. Largest counts in spring came from the Jubail lagoons.

No subspecies can be distinguished and biometrics are of little value in distinguishing different breeding populations (Cramp and Simmons 1983). Recoveries of South-African-ringed birds indicate the possible existence of a loop migration: autumn recoveries come from the Black and Caspian Seas, while spring recoveries indicate a route up the West African coast to the Gulf of Guinea before crossing the Sahara to the central Mediterranean. The only known ringing recovery from the Gulf supports this hypothesis: one ringed in Italy in May was found in Bahrain in September (Cramp and Simmons 1983). On the basis of the breeding distribution and ringing recoveries (Cramp and Simmons 1983) the Sanderlings in the Gulf are likely to come from the Siberian breeding population, centred on the Taimyr peninsula. The heaviest bird in our sample had an estimated flight range of 3,200

Plate 1. Sanderling *Calidris alba,* Jubail (Saudi Arabia), May 1991. Note oiled undertail coverts. (*Arnoud B. van den Berg*)

km (assuming a lean weight of 44 g), enough to reach any potential refuelling areas in the Black Sea, Caspian Sea, or lakes in Kazakhstan.

Little Stint

There was a major peak in numbers during the second week of May at the Jubail lagoons, but (much smaller) peak counts were also recorded at other sites along the coast during the previous two weeks. In general, coastal counts seemed the same as or lower than those recorded in winter.

Biometrics are of little use in determining breeding ground origins of this species (Cramp and Simmons 1983). Vandewalle (1988) maps numerous recoveries of birds ringed in South African which indicate that eastern African birds and some of the southern African wintering population migrate through the general area of the Arabian Gulf. There appear to be no ringing recoveries from the Gulf, although a bird that was colour-dyed in autumn in Dubai was apparently seen next spring on Crete (Uttley *et al.* 1988). The mean weight of spring Little Stints in this survey is about 3 g (14%) higher than mean winter weight in Africa, but still about 1–2 g lighter than adult autumn migrants in Iran and Masirah (Lessells 1976; Urban *et al.* 1986; Table 3), suggesting that birds in our sample were actively refuelling and not yet near departure weight. This accords with the fact that the mean date of weighing of the sample (29 April) is two weeks before the peak count (13 May). The heaviest birds in our sample had an estimated flight range of about 1,500 km (assuming a lean weight of 21 g), enough to reach the southern shores of the Caspian Sea.

Plate 2. Little Stint *Calidris alba*, Jubail (Saudi Arabia), May 1991. Note oiled undertail coverts. (*Arnoud B. van den Berg*)

Curlew Sandpiper

Peak counts from most sites were in the first three weeks of May, with special emphasis on the second week of May, e.g. at the Jubail lagoons, where the largest numbers were recorded. Peak counts were generally much higher than those recorded in winter. Ringing evidence suggests that Curlew Sandpipers migrate between their Russian breeding grounds (central and eastern arctic Siberia) and their wintering grounds in eastern and southern Africa along Great Circle routes via the Black Sea, Caspian Sea, and Middle East, including the Arabian Gulf (Vandewalle 1988), although there is only one ringing recovery from the Gulf: a bird ringed in South Africa in February 1985 and controlled in Dubai in September 1987 (Uttley *et al.* 1988; Martin *et al.* 1993).

Dunlin

Numbers in the second week of April were very much lower than those recorded during January–March, indicating that the vast majority of the winter population had already emigrated northwards by April–May. However, numbers built up rapidly during the last two weeks of April to give peak counts at the most favoured sites (e.g. Jubail lagoons) in the first few days of May. Numbers involved were still much lower than in winter, however. The pattern suggested the arrival for refuelling of a separate population from further south, unrelated to the Gulf's winter population.

According to Cramp and Simmons (1983) Dunlins wintering in the Gulf are of the subspecies *C. a. alpina* which breeds in northern Scandinavia and north-west Russia. Evidence for this comes from the single ringing recovery from the Gulf: a Swedish autumn migrant (*C. a. alpina*) found two years later on Bahrain. However the biometrics (Table 3) and, especially, plumage features of the spring migrants seen and caught in the present survey strongly suggest that most or all of the individuals belonged to the slightly larger subspecies *C. a. sakhalina* (Cramp and Simmons 1983) which breeds in north-east Siberia, wintering mainly in Japan and China though recorded as far west as the Bay of Bengal (Cramp and Simmons 1983).

Bill length is the best indicator of geographical population (Greenwood 1986), averaging 32·0 mm for *C. a. alpina* and 33·6 mm for *sakhalina* (Cramp and Simmons 1983), compared to 34·5 mm in our sample (Table 3). Although there is much overlap between subspecies, and females have bigger bills than males, this seems good

Plate 3. Curlew Sandpiper *Calidris ferruginea* in fresh breeding plumage, Jubail (Saudi Arabia), May 1991. (*Arnoud B. van den Berg*)

evidence for the occurrence of *sakhalina*. Uttley *et al.* (1988) also concluded that the majority of Dunlins in Dubai in October–November were *sakhalina*, and birds showing characters of *sakhalina* have been recorded even further west, e.g. in Tunisia (van Dijk *et al.* 1986; Meltofte 1991). The Dunlins trapped in spring in the Saudi Arabian Gulf (Table 3) averaged *c.* 15–30% heavier than autumn/winter Gulf birds, a substantial difference, implying that refuelling activity was widespread and also well advanced in the population during the trapping period (mean trapping date 26 April). The heaviest birds in our sample had estimated flight ranges of up to 1,400 km.

Broad-billed Sandpiper

Plate 4. Broad-billed Sandpiper *Limicola falcinellus*, Jubail (Saudi Arabia), April 1991. (*Arnoud B. van den Berg*)

Peak numbers occurred in the last week of April and the first week of May. The species seems to have been more widely recorded than in winter, but numbers are roughly similar. The highest counts in spring came from the Zawr saltmarsh roost in Tarut Bay and from the Jubail lagoons, as with Lesser Sand Plover. The species was recorded from only six other sites (four of them in Tarut Bay), but in relatively insignificant numbers, stressing the importance of the main two sites and their nearby intertidal flats (the count sites themselves being roosts only). In the Saudi Arabian Gulf, the species appears to feed almost exclusively on the muddiest intertidal flats (Zwarts *et al.* 1991), which are highly localized and which so far have been found to occur mainly in Tarut Bay (near mangroves) and Dawhat ad Dafi, although patches are likely to occur in the other less explored embayments. These latter areas (and Dawhat ad Dafi) have now been temporarily destroyed by oil pollution, whilst those in Tarut Bay are being permanently destroyed by land-claim.

There are two subspecies, very weakly differentiated; only the nominate occurs in the Gulf. It has a relatively small breeding range in northern Europe, especially Fenno-Scandia, east probably to about the Yenisey River, and winters on coasts in the Gulf south to the Red Sea and eastern Africa, and east to western India (Cramp and Simmons 1983). Quite apart from birds wintering south of the Gulf in the Middle East and Africa, those in Pakistan and India may well also migrate through, and refuel at, the Gulf in spring (IUCN 1987).

Only one bird was ringed, a second calendar year individual in full breeding plumage on 30 April with a high weight given its size, indicating that it was probably refuelling for migration. In fact 13 days later, this bird (colour-dyed) was watched leaving the Jubail lagoons at dusk on its flight northwards with 22 conspecifics. Substantial passage has been recorded at the Black and Caspian Seas (Cramp and Simmons 1983), both probably being favoured destinations for north-bound spring migrants from the Gulf.

Bar-tailed Godwit

Numbers at most sites peaked in the last week of April, with a minority of sites peaking a week earlier, and a few a week later. The total numbers recorded at our scattered count sites were larger than the whole winter population estimated for the entire Saudi Arabian Gulf coast (6,000: Zwarts *et al.* 1991), suggesting that the area is particularly important for refuelling spring migrants. The highest counts in spring came from the high tide roosts at Safwah and at Zawr saltmarsh, both in Tarut Bay.

Birds in the Gulf are most likely of the race *L. l. lapponica* (Uttley *et al.* 1988). Given the longitudinal segregation of breeding and wintering areas shown by most migrant Arctic wader species that have been well studied, the birds in the Gulf, on the eastern edge of the wintering range of *L. l. lapponica*, most probably derive from the eastern edge of the subspecies' breeding range, i.e. from the Taimyr peninsula itself (Cramp and Simmons 1983) or from further east, although the majority of the Taimyr population winter in West Africa (Wymenga *et al.* 1990). There is little evidence for the use of refuelling sites on the flyway north of the Gulf (Cramp and Simmons 1983), but, given the late April departure date of most of the Gulf birds compared to the migration schedule of conspecifics on the East Atlantic Flyway (Piersma and Jukema 1990), it seems certain that such a site must exist. The Caspian Sea is used to some extent (Cramp and Simmons 1983) and is the most likely destination. However, a flock of 120 birds watched rapidly gaining height northwards from Tarut Bay as late as 25 May in classic V-formation at dusk were most likely starting a direct flight to the breeding grounds.

Whimbrel

The nominate race breeds from central Siberia to Iceland and winters on coasts of the Afrotropical region and western Indian Ocean islands. Both the Siberian population of this race and also the south Russian race *N. p. alboaxillaris* occur in the Gulf (Cramp and Simmons 1983). The species winters only sparingly in the Gulf, and spring passage is said to be small, with a peak in April (Cramp and Simmons 1983; Bundy *et al.* 1989). Our data show very small numbers over most of the coast, but with a small peak in Tarut Bay in May, likely to be northern breeding birds rather than summering non-breeders.

Curlew

Counts were generally low in April, much lower than in January–March, indicating that the wintering population had mostly left, but numbers increased in the latter half of May, presumably due to an influx of summering second calendar year birds. The occurrence on Saudi Arabian Gulf coasts of the pale, long-billed subspecies *N. a. orientalis* (from western Asia) was noted by us, as also previously by IUCN (1987), Uttley *et al.* (1988), and Bundy *et al.* (1989).

Redshank

Counts in April–May were much lower than in winter, peak numbers at most sites being at the start of the survey in April, although a few sites in Tarut Bay peaked in late May, presumably due to an influx of summering birds. According to Cramp and Simmons (1983) most of the wintering birds in the Gulf are likely to be of the race *T. t. ussuriensis*, which breeds across Siberia west to the Urals. There are old records of *T. t. eurhinus* (which breeds in northern India, Tibet, and Pamir) from Iraq and Arabia (Cramp and Simmons 1983), although doubted by Vaurie (1965); however, this somewhat larger race is also suspected to occur on Masirah island, Oman, on the basis of biometrics (Pomeroy 1980), and so may well occur in the Gulf. There are apparently no ringing recoveries from the Gulf (contra IUCN 1987). The flight range of the bird caught on 15 April was estimated to be just over 1,300 km.

Greenshank

Most peak counts were in mid- to late April; numbers seemed to be higher than those recorded in winter. Most birds occurring in the Gulf in spring and autumn are likely to be migrating on the Great Circle route between eastern/southern Africa and west/north-central Russia (Cramp and Simmons 1983).

Terek Sandpiper

This species was unusual in that peak counts were spread out between the third week of April and the third week of May, depending on the site, and in general high numbers were sustained throughout this period. The largest counts came especially from Tarut Bay (all sites) and from the roost near the causeway between Abu Ali and Batinah 'islands'. Numbers recorded in spring in Saudi Arabia were very much higher than counts in winter, in places by a factor of five, suggesting that the Saudi Arabian Gulf is a very important refuelling site in spring for the population that winters in eastern and southern Africa, and which perhaps initially moves north via the East African Rift Valley lakes (Vandewalle 1988). In spring, the species is also abundant in coastal Iraq (Moore and Boswell 1956–7) and particularly common in Somalia (Ash and Miskell 1983). However, large numbers are not recorded at the Caspian Sea in spring, although they are in autumn (D. Scott unpubl. data).

The birds in spring 1991 (Table 3) were longer winged than wintering Gulf birds, as might be expected for migrants wintering further south in Africa (cf. Lesser Sand Plover), and this, together with the recorded tarsus and bill lengths, suggests that they were heading for the north of the species' wide latitudinal span of breeding range (see Cramp and Simmons 1983). Biometrics are of no use in determining the longitudinal location of the breeding range of Gulf birds, however.

The sampled birds are also remarkably light compared to autumn/winter birds in the Gulf (Table 3). Indeed the range of weights found at Jubail in spring falls almost wholly below the means for both autumn/winter Gulf birds and wintering east/south African birds (Urban *et al.* 1986). This might indicate that birds were trapped at Jubail on average very soon after they had arrived from a long flight and had not yet had time to fatten up; the mean trapping date was 24 April which gave such birds up to a further month for refuelling given the high numbers observed even as late as the third week of May. The very low mean weight suggests as well that the previous flight may have been remarkably long. South African birds in April (about to start migration) are more than 50% heavier than Jubail birds on average (Urban *et al.* 1986), and have an estimated mean flight potential of 4,000 km (Summers and Waltner 1979) compared to 1,500 km for the heaviest birds in our sample (assuming a lean weight of 60 g). Given a month's more refuelling in the Gulf to achieve a potential flight range comparable to the South African birds (4,000 km would take them to the breeding grounds), it may well be that at least some spring migrants in the Gulf are fattening up for a direct flight to the breeding grounds—as evinced by the lateness of departure of large numbers of them. Breeding areas are re-occupied at the earliest from 10–15 May (Finland) to the first week of June (Russia) (Cramp and Simmons 1983).

An alternative (but not necessarily exclusive) explanation for the low weights in our sample, and for the large numbers observed over a prolonged period at the count sites, is that many may have been driven south from oiled intertidal flats to suboptimal feeding grounds, with consequent overcrowding, starvation, and reduced likelihood of attaining a high enough weight to attempt migration (Evans and Keijl 1993).

Turnstone

Peak counts for most sites were in the first week of May, otherwise in the week before and week after this period. Numbers were certainly higher than in January–March, suggesting the importance of the area as a spring refuelling site. The highest counts came from roosts at Zawr saltmarsh and at Anuk, both in Tarut Bay.

Birds wintering in the Gulf are assumed to be from the population which breeds in the Arctic tundra between the White Sea and central Siberia (eastern limits unclear), and which also winters on the coasts of the Indian Ocean, Red Sea, and eastern Mediterranean, but this remains the least studied population in the species' range (Cramp and Simmons 1983).

There is good evidence from ringing that South African birds use a Great Circle route over inland Africa to the Middle East when migrating north, and do not necessarily hug the coast (Vandewalle 1988; Summers *et al.* 1989). It is likely that spring migrants in the Gulf are heading for the Black and Caspian Seas and lakes in Kazakhstan (Cramp and Simmons 1983), or even making a non-stop flight direct to the breeding grounds. The single bird trapped in this survey (on 5 May) was an unoiled individual in full breeding plumage and with an incredibly low weight (Table 3; lean weight is given as just over 100 g by Summers *et al.* 1989), which suggests that it had just completed a very long flight and was going to refuel before continuing. Alternatively (perhaps less likely due to the quality of its plumage), it may have been driven south from traditional feeding grounds by the oil pollution in February–March to suboptimal feeding grounds, with attendant loss of weight (cf. Lesser Sand Plover and Terek Sandpiper).

Red-necked Phalarope

Most birds in the Gulf are likely to be *en route* from the main wintering area in the Arabian Sea to the breeding grounds in Fenno-Scandia and western Siberia. However, the main refuelling sites on this route appear to be the Black and Caspian Seas and lakes in Kazakhstan, judging by the huge numbers recorded during migration periods (Cramp and Simmons 1983), although there are a few reports of large numbers moving into the southern Gulf in late winter and spring when the abundant food in the Arabian Sea decreases, e.g. about 10,000 at the mouth of Tarut Bay ('25 miles [40 km] north-west of Bahrain') on 27 March 1978 (Hallam 1980; see also Basson *et al.* 1981).

DISCUSSION

Important species for conservation

In conservation terms, the wader species for which Saudi Arabia has the greatest international responsibility are those which have the highest proportions of their world populations occurring within the country. Due to their mobility, however, the world populations of many migratory Palearctic wader species are spread widely through many different countries at any one time, although significant concentrations do occur. However, isolated or highly separated breeding populations of a species tend to winter in discrete or different areas in a predictable manner, and to use different flyways to migrate between these areas. Where such biogeographical discreteness of populations leads also to some degree of genetic isolation (e.g subspecies), one can regard such populations as deserving to be conserved in themselves. It is often difficult or impossible to distinguish biogeographically distinct populations amongst the more globally dispersing wader species, in which cases populations can be defined for the purposes of conservation according to traditional flyway boundaries, in the belief that gene flow is greater within flyways than between them.

A widely accepted threshold for determining whether a species occurs in significant numbers at a site is 1% of the relevant population (subspecies, biogeographi-

	1% level	Number recorded	Minimum % of population using the coast
Lesser Sand Plover	250	5,349	21
Terek Sandpiper	440	3,512	8
Great Knot	15	108	7
Bar-tailed Godwit	1,000	6,482	6
Grey Plover	440	1,880	4
Turnstone	500	1,850	4
Little Stint	1,200	4,074	3
Dunlin	1,500	2,741	2
Broad-billed Sandpiper	220	532	2
Oystercatcher	250	325	1
Sanderling	1,200	1,211	1

Table 4. Wader species for which more than 1% of their regional population used the Saudi Arabian Gulf coast during April–May 1991. Number recorded is sum of peak counts at all sites (see Table 1). 1% levels are from Rose and Scott (1993)—except for Broad-billed Sandpiper which is based on Uttley *et al.* (1988), since Rose and Scott provide only a range (100–1,000).

cal, flyway, etc.) of that species. For instance, up to 18% of the Fenno-Scandian population of Broad-billed Sandpiper may migrate through just one site in Dubai in autumn (Uttley *et al.* 1988), making that site internationally important for the species, as well as making that species very important to Dubai in terms of its conservation responsibilities. Table 4 lists those species whose total numbers exceeded the relevant 1% level in Saudi Arabia during spring. It can be seen that the Saudi Arabian coast supports internationally significant numbers of half of the 22 predominantly coastal wader species which regularly occur on spring migration. In particular, the coast supports a very high proportion of the subspecies *C. m. pamirensis* of Lesser Sand Plover, and also high proportions of the flyway populations of Terek Sandpiper, Great Knot, and Bar-tailed Godwit. These proportions are absolute minima since population turnover has not been accounted for.

Important sites for conservation

There are two main criteria whereby internationally important waterbird sites are selected: (1) whether the site holds an average annual maximum of 20,000 or more waterbirds, or (2) whether the site regularly holds 1% or more of the relevant population at some time in the year. It can be seen from Table 1 that none of the 27 count sites had a peak total of waders alone exceeding 20,000, even if one accounts for turnover (nor would the sites qualify if totals for non-wader waterbirds were added). The top five count sites, simply in terms of numbers of waders, were: Jubail lagoons (8,978), Zawr saltmarsh (6,746), Safwah (3,229), Anuk (2,395), and Ahueza (1,810). Excluding the non-marine environment of the Jubail lagoons, the other four sites are all in Tarut Bay.

Since the NCWCD is proposing to create a single protected area within Tarut Bay, covering the whole shoreline (Child and Grainger 1990), all peak wader counts for the whole of Tarut Bay can be amalgamated (18,998), and added to those for non-wader waterbirds (3,492), thus exceeding the '20,000 waterbirds' criterion. So Tarut Bay as a whole qualifies as an internationally important wetland on numbers of waterbirds alone.

The importance of Tarut Bay was confirmed also by the peak counts of individual species, which exceeded 1% levels for six species at eight sites (Table 5), not accounting for turnover. The majority (eight out of 14) of these counts came from four sites in Tarut Bay, the remainder from three sites in the Jubail area, and from one in the Ras Tanajib area (despite the oiling of the coast there, or perhaps because of it, waders appeared to be concentrated very heavily at the one or two remaining small 'islands' of unoiled intertidal habitat: Evans and Keijl 1993). Zawr saltmarsh (site 25) within Tarut Bay, and the Jubail lagoons (site 15), stand out as particularly important sites; Zawr is a roost site, but the size of the roost indicates the importance of the adjacent intertidal flats as feeding grounds. Tarut Bay is clearly the outstanding mainland waterbird site on the Saudi Arabian Gulf coast, at least pending recovery of the oiled northern half (Evans and Keijl 1993), and perhaps the most important on the country's entire coastline (see Perennou and Mundkhur 1992). All four of the key Tarut Bay count sites in Table 5 have already been reduced in extent by land-claim, illustrating the severe plight of the Tarut

Table 5. Internationally important sites holding more than 1% of wader species' regional populations in April–May 1991, Saudi Arabian Gulf. Site numbers correspond to those used on maps (Figures 2–4). For species' 1% levels, see Table 4.

	Ras Tanajib area	Jubail area			Tarut Bay area				Total no. of sites
Site number:	6	15	16	17	23	24	25	27	
Lesser Sand Plover	•	•	•	•			•	•	6
Broad-billed Sandpiper		•					•		2
Bar-tailed Godwit					•		•		2
Terek Sandpiper					•		•		2
Great Knot						•			1
Little Stint		•							1
Total number of species	1	3	1	1	2	1	4	1	

Bay intertidal flats, saltmarshes, and mangroves, and the waterbirds that depend on them.

Management considerations

It is notable that four of the top five sites listed above are either brackish or have a significant input of fresh or nutrient-rich water, which will have management implications if these sites become part of protected areas. It may be that dilution of the hypersaline Gulf seawater is attractive to waders and other waterbirds, perhaps through reducing the physiological stress of salt excretion (see Klaassen and Ens 1990), or through increasing the density of invertebrate food present. In Tarut Bay at least some of this water arrives as semi-treated sewage or agricultural runoff from (e.g.) date palm plantations, which causes eutrophication and possibly pesticide pollution of the intertidal sediments. The Jubail lagoons are supplied with fully treated 'fresh' water from industry via a pumping station, and there seem here to be good possibilities for creative management of the water supply to benefit waterbirds.

There is evidence from the study of Zwarts *et al.* (1991; L. Zwarts unpubl. data) that Dawhat ad Dafi was an important site for *Calidris* waders, especially Little Stint, before the oiling catastrophe occurred (Evans and Keijl 1993). The markedly muddy nature of the intertidal flats at this site also suggests that the habitat may have been highly suitable for (and therefore important for) Broad-billed Sandpiper as well.

CONCLUSIONS

In spring, the Saudi Arabian Gulf coast probably supports a total of at least 75,000 waders, including significant numbers of 11 species. In particular it appears that the shores of the Gulf may be the main final (and potentially most important) refuelling area in the West Asian Flyway for northward-migrating Lesser Sand Plovers and Terek Sandpipers. The most important area for waders and other coastal waterbirds in spring 1991 was Tarut Bay, on account of its extensive intertidal flats, saltmarshes, and mudflats. Another important site was the Jubail lagoons; although man-made they were supporting a minimum of 8,000 waders.

As yet there are no areas of Saudi Arabian Gulf coastline protected by law for the conservation of wildlife. The protected areas proposed by the NCWCD in the Gulf will form an excellent network for protecting the Kingdom's important populations of coastal waders and other waterbirds, in terms of covering significant sites and species. Although the man-made Jubail lagoons do not feature in the protected areas plan, some protection has now been given by the Royal Commission for Jubail and Yanbu, and their birds are being studied together with the wildlife in the adjacent, oiled Dawhat ad Dafi embayment by the Wildlife Sanctuary for the Gulf Region, a joint venture of the NCWCD, Commission of European Communities, and Senckenberg Research Institute.

The coastal wetlands of Tarut Bay have been severely reduced in area by landclaim over the past 20 years; the establishment of the Tarut Bay protected area, to halt further habitat loss in the most crucial areas, is perhaps the most pressing wildlife conservation priority along the Saudi Arabian Gulf coast. Designation of the other proposed coastal reserves would also be the most effective step that Saudi Arabia could take in meeting its responsibilities as a contracting party to the Bonn Convention to cooperate internationally to conserve and effectively manage migratory species of waders and other waterbirds.

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Impact of Gulf War oil spills on the wader populations of the Saudi Arabian Gulf coast

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Summary The northern half of the Saudi Arabian Gulf coastline (*c.* 560 km) was heavily polluted by the enormous marine oil spills of the Gulf War from February 1991 onwards. This study investigated the effects on coastal wader (Charadrii) populations, and found that the oiled coastline no longer supported significant numbers of waders during the spring migration period of April–May 1991 or in early winter (November–December 1991); the magnitude of the reduction in numbers compared to a single previous baseline survey was estimated as *c.* 97%. It is not known what happened to the 'missing' waders, but it is likely that most were displaced due to die-off of their food supply and due to the noxiousness of the oil itself. The number of waders which died within the impact zone and elsewhere due to oiling and/or starvation is not known, but may be in the order of tens of thousands. Of the relatively few waders remaining in the oiled zone during March–May 1991, at least three-quarters were oiled. Waders with more than 10% of their plumage oiled were found to be significantly lighter in weight than unoiled waders, and such individuals are unlikely to have successfully migrated or bred in 1991. The vulnerability of wader populations to land-claim as well as to oil pollution is highlighted.

THE MARINE oil spills which occurred at the head of the Arabian Gulf in the few days following 19 January 1991 during the Gulf War were the largest ever recorded, with an estimated total volume of 6–8 million barrels (USGTF undated). The slicks covered more than 1,500 km^2 of sea (USGTF undated) and were

Plate 1. Oiled beach at Abu Ali (Saudi Arabia), April 1991. The piles of fresh sand are made by ghost crabs *Ocypode saratan*. (*Arnoud B. van den Berg*)

blown down the Gulf by prevailing north-west winds before being washed ashore in February from the town of al-Khafji south to Abu Ali headland, severely polluting some 560 km out of 1,070 km (*c.* 50%) of the Saudi Arabian coast (IUCN 1987; Anon. 1991). The coast of Kuwait largely escaped oiling, with 95% free of oil in May 1991 (Pilcher and Sexton 1993).

Initial surveys of the damage to coastal bird populations in Saudi Arabia by the National Commission for Wildlife Conservation and Development (NCWCD) together with a team from BirdLife International (formerly the International Council for Bird Preservation) during 2–12 March identified the most urgent and immediate concern to be waterbirds using the freshly oiled intertidal zone. These were facing oiling and mortality which might be significant at the population level (Dennis 1991a; Heneman 1991). Amongst waterbirds which habitually depend on the intertidal zone of the Saudi Arabian Gulf, waders (Charadrii) were of particular conservation concern because:

- the Gulf overall is thought to be one of the five most important areas in the world for wintering waders, harbouring an estimated four million birds during the period of oil impact in January and February (Zwarts *et al.* 1991);
- the number of migrant waders which stop off to re-fuel in the Gulf during March–May was thought to be of the same magnitude as the number present in winter (Zwarts *et al.* 1991).

A second BirdLife International team worked with the NCWCD from 7 April to 28 May 1991 in carrying out surveys of the damage caused to wader populations on the Saudi Arabian Gulf coast (Evans 1992). A third team carried out further coastal waterbird surveys in November–December 1991 (Harbard and Wolstencroft 1992).

The results of the April–May study are reported here, together with relevant information from the March and November–December surveys. For maps of the areas described, including locations of April–May 1991 count sites, see pp. 58–61.

METHODS

There have been very few previous studies of the effects of oil pollution on wader populations (Hooper *et al.* 1987; Richardson 1990), and the following methodology was developed without access to this sparse and often obscure literature.

Estimating distribution, density, and population size of waders after the spill

To assess the effects of the oil pollution on wader populations, it is necessary to compare the situation before and after the oil spill. Quantitative pre-oil spill information consisted solely of a survey along the Saudi Arabian Gulf coast in January–February 1986 (IUCN 1987; Zwarts *et al.* 1991; see Discussion).

In April–May high tide and low tide counts were carried out at defined localities in the oiled and unoiled sectors of the coast to quantify the size, distribution, and feeding density of the populations of waders, following standard practices described in (e.g.) Howes and Bakewell (1989). In order to compare wader feeding densities on intertidal flats before and after the oil spill, everything possible was done to count the same sites as the 1986 survey (site locations and raw data were provided by L. Zwarts *in litt.*). Four aerial surveys of the oiled and unoiled coast were undertaken in an NCWCD light aircraft during April–May.

Assessments of oiling frequency in wader populations

In order to assess the prevalence of oiling, regular counts were made of the numbers of birds oiled. The aim was to identify which species were worst affected by direct oiling and to integrate results with other data so as to estimate how many waders were affected overall. Birds were scored by visual assessment as 'unoiled' (no sign of oil), 'lightly oiled' (10% or less of plumage oiled), or 'heavily oiled' (more than 10% of plumage oiled). This was done by scanning across an intertidal flat with a telescope and sequentially scoring all birds encountered in the field of view, omitting those which were obscured or too distant. Heavily oiled individuals of most species were much more conspicuous at long ranges, and could thus be over-represented in counts, so the maximum scoring distance was taken to be that at which one could no longer discern 'traces' of oiling. Oiling assessment counts were made on at least one day per week, at a selection of sites in each study area.

Effect of direct oiling on individual birds' condition

The effects of direct oiling on birds' health and condition through hypothermia and poisoning are well established (e.g. Bourne 1985; Hooper *et al.* 1987), but there is great uncertainty about what degree of oiling waders can survive, and sublethal effects are also of concern (Heneman 1991). Few dead, oiled waders have been found after previous major oil pollution incidents, and few have been taken to oiled bird rescue centres, despite high rates of oiling being observed (Heneman 1991). For instance only six waders (0·1%) were among the 7,800 identified bird corpses collected after the 1988 *Nestucca* spill in Grays Harbor, Washington, USA, even though there were *c.* 3,500 oiled live waders present (Larsen and Richardson in prep.), and only 49 dead waders (not necessarily oiled) were among the 36,202 bird corpses retrieved after the *Exxon Valdez* spill in Alaska (0·1%) (Piatt *et al.* 1990; Piatt unpubl. data *per* Richardson 1990).

In order to investigate and quantify the effect of oiling on individual birds, waders were netted during April–May at the waste-water lagoons west of Jubail Industrial City. Captured waders were weighed and measured and the extent of plumage oiling was described in detail on data sheets.

OILING IN THE STUDY AREAS

The slicks reached the north coast of Abu Ali headland, their southernmost point of gross shoreline contamination, by 21 February, defining the southern limit of the impact zone. By then, prevailing winds had channelled and trapped much of the floating oil remaining near the coast into embayments such as that of Dawhat al Musallimiyah/Dawhat ad Dafi. By 2 March, the great majority of the intertidal area in the impact zone had been heavily polluted, especially the north-facing shores. By 7 April almost 100% of the tidal flats in the impact zone had been cov-

Plate 2. Oiled saltmarsh at Abu Ali (Saudi Arabia), April 1991. (*Arnoud B. van den Berg*)

ered by oil at one time or another due to continual re-flotation and re-deposition of oil by the tides. Only two small areas had escaped oiling by then: the innermost reaches of a small tidal inlet at Safaniyah, and a small bay in the Ras Tanajib embayment (count site 6, Figure 2, p. 59). However, the latter site was totally oiled on 9–10 May by refloated oil.

The exposed beaches that had been oiled in early February, e.g. at al-Khafji, appeared clean by March, but this was merely because oil had soaked deep into the sediment and storms had washed and floated off the remainder (southwards), after which the beach had been covered with a fresh layer of unpolluted sediment from the shallow subtidal zone.

By April–May the beached oil was most concentrated on the highest part of the intertidal flat, beneath the storm berm; upper to middle reaches of the flats had less free oil standing on them, but had everywhere been soaked and stained by oil to variable depths (usually at least several centimetres), giving the substrate a patchy, black and dark brown appearance. The lowest areas of the flats were stained varying shades of paler brown, indicating less prolonged exposure to beached oil.

No slicks reached as far south as Tarut Bay (although patches of sheen did) but the area has a long history of oil pollution due to the high concentration of oil industry facilities around the Tarut Bay/Dhahran area (e.g. Spooner 1970). For instance a small oil slick was noted on 2 May off Ras Tannurah Coastguard station; two days later it had come ashore as a 50 cm wide band along 3 km of Rahimah beach. Patches of sheen 200 m long were also noted twice in the Bay in April.

RESULTS

Numbers of waders in the impact zone after the spill

Before it ended on 28 February, the Gulf War prevented any investigation of the impact zone. During the first half of March about one third of the Saudi Arabian

Gulf coastline was surveyed by land or air (Heneman 1991), including four days spent exploring 10–50% of the oiled coast. Substantial numbers of wintering waders were still present in unoiled areas south of the impact zone, but only *c.* 400 waders were noted on the oiled intertidal zone explored (Dennis 1991a). However, unoiled areas immediately adjacent to the oiled intertidal zone held large numbers of waders (the majority of which were oiled: see below). For example, of the 12,050 Dunlin counted along the northern, oiled half of the coastline, only 50 (0·4%) were found on the oiled intertidal zone itself, while 3,000 were at an unoiled, temporarily rain-flooded sabkha (saltflat) at Ras Mishab and 9,000 were at the unoiled, man-made Jubail waste-water lagoons, both sites being just inland from the oiled intertidal zone (Dennis 1991a). The March team could not carry out a comprehensive wader census along the whole of the oiled intertidal zone, but, by extrapolation from the 10–50% of coast surveyed, the total of all species present seems likely to have been less than 4,000 (Table 1).

Table 1. Estimates of oiling of waders on the Saudi Arabian Gulf coast, March 1991 (data extracted from Dennis 1991a).

	Sample counts in impact zone		No. of oiled waders in impact zone[1]	Total no. of waders in impact zone[2]	Proportion 'missing' from impact zone[3]
	No. oiled/unoiled	% oiled			
Oystercatcher			100+		
Grey Plover	70/100	70	?1,000	?1,400	?60%
Sanderling	20/50	40			
Little Stint	6/20	30			
Dunlin	7,400/10,000+	74			
Bar-tailed Godwit	94/194	48	200–500	400–1,000	67–87%
Curlew	5/11	45	several hundred	600+	up to 80%
Terek Sandpiper			500–600		

1 'Guestimate' based on field observations, extrapolating for proportion of oiled coastline not surveyed.
2 Estimated by dividing the number in column 4 by the percentage in column 3.
3 Calculated by comparing the estimate of the total number in the impact zone in March (column 5) with the estimate for the total number potentially in the impact zone in January–February just before impact of the spills (see Table 9).

Numbers of waders in the oiled intertidal zone continued to be very low during April and May (Table 2). Aerial and ground surveys covering the entire oiled shoreline between Ras Safaniyah and Jubail during the peak spring migration period of the last week of April and first week of May indicated that less than 1,000 waders were present, excluding birds at the tiny, unoiled refuges at Safaniyah and Tanajib (Evans and Keijl 1993). During 23–26 May a complete aerial survey of the oiled shoreline could only locate 632 waders, and in November–December 1991 a maximum of only 1,318 waders was counted in the impact zone (Harbard and Wolstencroft 1992).

Density of waders feeding in the oiled intertidal zone

Low tide densities of feeding waders are given for the three defined sites which were similarly counted in 1986 (Zwarts *et al.* 1991), and the 1986 and 1991 results are compared in Table 2. One site in Dawhat ad Dafi had 46·2 waders/ha in 1986,

Table 2. Densities of feeding waders at oiled and unoiled sites in the Saudi Arabian Gulf in 1986 and 1991. Figures in brackets are numbers of counts.

Site no. (1991/1986)	% of site oiled	Area (ha)	Overall wader density (birds/ha) Jan–Feb 1986	April 1991	May 1991
14B/12B	100	90	46.2 (1)	0.8 (2)	0.6 (6)
20/8	0	150	3.6 (1)	2.0 (4)	1.2 (6)
23/14G	0	19.5	21.5 (1)	22.9 (4) [April+May]	

the highest density of feeding waders recorded anywhere in the Saudi Arabian Gulf (L. Zwarts *in litt.*), but was comprehensively polluted by the spills in 1991, after which in April–May the wader density was about 0·7 waders/ha, an absolute difference of *c.* 45·5 waders/ha and a reduction of *c.* 98%. In contrast, the two other sites were not oiled, and show much less of an absolute or relative difference between surveys.

Assessments of oiling frequency in wader populations

Overall frequency of oiling

Spot counts at various sites in or near the impact zone in mid-February (P. Symens in Dennis 1991a) and March (Dennis 1991a) indicated that the great majority (at least *c.* 50–75%, depending on the species) of the waders remaining in and near the impact zone were in an oiled state during this period (Table 1). For example *c.* 75% of 12,050 Dunlin* in or adjacent to the impact zone in March were oiled to varying degrees; as described above, only 50 out of these 12,050 were actually on the oiled intertidal zone in March, indicating that the great majority had formerly been using the oiled intertidal zone, but had now sought refuge at the nearest unoiled habitat.

During April–May at least 75% of waders remaining in the impact zone were still oiled. A total of 858 oiling assessment counts was carried out on 30 wader species, involving assessments of oiling of 30,658 birds. The proportion of oiled waders in the population was highest within the oiled impact zone and decreased very rapidly with distance away from the oiled zone (Table 3). About 77% of waders in the totally oiled area of Dawhat ad Dafi were oiled, as compared to *c.* 50% overall in the heav-

Table 3. Percentages of waders (all species) with different degrees of oiling at various sites in the Saudi Arabian Gulf, April–May 1991. See Methods for definitions of 'light' and 'heavy' oiling.

		Oiling None	Light	Heavy	Sample size
Oiled zone					
Ras Tanajib	April	71	20	9	709
	May	15	26	59	2,149
	Total	**29**	**25**	**46**	2,858
Dawhat ad Dafi	April	–	–	–	–
	May	9	13	77	150
	Total	**9**	**13**	**77**	150
0–5 km from oiled zone					
Abu Ali	April	64	11	25	607
	May	69	13	18	1,907
	Total	**68**	**12**	**20**	2,514
5 km from oiled zone					
Jubail lagoons	April	70	11	19	4,162
	May	62	14	24	1,937
	Total	**68**	**12**	**20**	6,099
75 km from oiled zone					
Tarut Bay	April	98	1	1	4,752
	May	97	2	1	14,285
	Total	**97**	**1**	**1**	19,037
Total sample					30,658

* Scientific names of wader species not given in the text are listed in Table 9.

ily impacted Ras Tanajib area where however observations were centred on the tiny, unoiled refuge. Disproportionate numbers of birds were attracted by its intact food supply and clean state, and many therefore escaped oiling, so reducing the oiling rate locally.

When this refuge was finally oiled on 9–10 May, the perceived level of oiling in waders rose dramatically as a consequence (29% in April, rising to *c.* 85% in May), apparently because most of the unoiled birds left the area (Table 3). Study of oiling was biased towards the unoiled patch because elsewhere in the Ras Tanajib/ Manifah embayment region there were so few individual birds present that collecting large samples of data on oiling was difficult. It is thus likely that the overall proportion of oiled birds in the wader populations in the Ras Tanajib region in April–May was around 85%, even higher than the Dawhat ad Dafi statistic.

Away from the impact zone the proportion of oiled birds in the population was much lower. This even applied immediately south of the impact zone at the Jubail lagoons and the east side of Abu Ali headland. In Tarut Bay, 75 km further south, an average of *c.* 97% of individuals of all coastal species were unoiled (Table 3).

Vulnerability of different species to oiling

In March, heavily oiled individuals were judged to be especially frequent in the impact zone populations of Kentish Plover, Lesser Sand Plover, Grey Plover, Bar-tailed Godwit, Curlew, and Terek Sandpiper (Dennis 1991a, 1991b); although 75% of Dunlin seen were oiled, only *c.* 5% were very heavily contaminated (Dennis 1991a). In April–May, the species with the highest proportion of heavily oiled individuals in their populations were Lesser Sand Plover, Grey Plover, Broad-billed Sandpiper, Curlew, and Terek Sandpiper (Tables 4–7). Table 4 gives the observed rate of oiling for all wader species at Ras Tanajib and at Dawhat ad Dafi (data

Table 4. Percentages of waders with different degrees of oiling in the Saudi Arabian Gulf, April–May 1991: oiled zone (Ras Tanajib and Dawhat ad Dafi; data for Lesser Sand Plover, Curlew Sandpiper, and Bar-tailed Godwit are for Ras Tanajib only). See Methods for definitions of 'light' and 'heavy' oiling. Data are divided into April and May figures where sample sizes for both months are greater than 100.

	Oiling			Sample	No. of
	None	Light	Heavy	size	counts
Oystercatcher	9	29	62	96	19
Lesser Sand Plover					
April	62	26	12	331	3
May	5	27	67	429	19
Total	30	27	43	760	26
Kentish Plover	26	30	44	522	26
Grey Plover	15	16	69	130	24
Sanderling	42	35	23	98	15
Curlew Sandpiper					
April	100	–	<1	247	7
May	99	<1	<1	317	10
Total	99	<1	<1	564	18
Bar-tailed Godwit					
April	81	13	6	230	2
May	5	23	72	228	16
Total	43	18	39	458	20
Curlew	–	3	97	62	9
Terek Sandpiper	8	19	73	224	21
Turnstone	22	27	51	180	20

Table 5. Percentages of waders with different degrees of oiling in the Saudi Arabian Gulf, April–May 1991: edge of oiled zone (unoiled side of Abu Ali headland). See Methods for definitions of 'light' and 'heavy' oiling. Data are divided into April and May figures where sample sizes for both months are greater than 100.

	Oiling			Sample	No. of
	None	Light	Heavy	size	counts
Lesser Sand Plover					
April	32	14	55	176	4
May	36	26	38	217	7
Total	34	20	46	393	11
Kentish Plover	69	16	15	150	12
Grey Plover	87	4	9	171	12
Sanderling	78	18	4	55	8
Little Stint	82	8	10	203	7
Curlew Sandpiper	86	5	8	132	9
Broad-billed Sandpiper	36	47	17	72	12
Bar-tailed Godwit					
April	83	7	10	176	5
May	60	14	26	197	11
Total	71	11	18	373	16
Curlew	35	9	56	170	12
Terek Sandpiper					
April	76	7	16	122	4
May	83	8	9	488	9
Total	82	8	10	610	13
Turnstone	79	17	4	106	10

combined), both sites being within the oiled impact zone, and Tables 5–7 give similar information for the two main counting areas at the edge of the impact zone (Abu Ali and Jubail lagoons) and the one main counting area relatively distant from the impact zone (Tarut Bay).

Effect of oiling on individual birds

Oiling of birds' plumage ranged from very light (a few specks, often only visible in the hand) to complete (entire plumage dark brown and soaked), with partial

Table 6. Percentages of waders with different degrees of oiling in the Saudi Arabian Gulf, April–May 1991: edge of oiled zone (Jubail lagoons). See Methods for definitions of 'light' and 'heavy' oiling. Data are divided into April and May figures where sample sizes for both months are greater than 100.

	Oiling			Sample	No. of
	None	Light	Heavy	size	counts
Ringed Plover	96	3	1	267	10
Lesser Sand Plover					
April	6	26	68	869	9
May	2	22	76	297	6
Total	5	25	70	1,166	15
Kentish Plover					
April	55	28	16	215	7
May	44	15	42	357	5
Total	48	20	32	572	12
Grey Plover	83	14	3	169	4
Sanderling	90	9	1	145	8
Little Stint					
April	94	4	2	1,167	9
May	81	11	8	627	5
Total	89	6	4	1,794	14
Curlew Sandpiper					
April	94	4	2	486	7
May	81	14	5	242	6
Total	90	7	3	728	13
Dunlin	94	4	3	346	10
Broad-billed Sandpiper	89	8	3	193	9
Bar-tailed Godwit	–	15	85	26	5
Redshank	69	14	17	137	10
Terek Sandpiper	27	19	54	70	10
Turnstone	63	21	16	108	9

oiling most commonly located on the vent and under tail-coverts (the legs pick up oil and transfer it to feathers when retracted in flight), followed less frequently by additional more extensive oiling to the belly and to the forehead/chin/bill area (through feeding and preening). Explanations for 100% oiling are that naïve birds mistake oil for water and land in it, as was observed in Saudi Arabia and Kuwait (Harbard and Wolstencroft 1992; Pilcher and Sexton 1993), and that birds spread oil through preening (vigorous preening by heavily oiled birds was commonly observed). Netted birds with heavily oiled plumage almost always had severely peeling skin on the legs, presumably a result of chemical burns from the oil.

Analysis of the effect of oiling on health and body condition (as represented by weight) was only possible for Kentish Plover, Lesser Sand Plover, and Little Stint, sample sizes for other species being too small (Table 8). The mean weights of unoiled birds were not significantly higher than those of lightly oiled birds in Kentish Plover (one-tailed t-test, $P<0{\cdot}05$; $t=0{\cdot}067$, d.f.=38) and Little Stint ($t=0{\cdot}709$, d.f.=56), but the sample of unoiled Lesser Sand Plovers was too small to test. Hence it appears that oiling of up to 10% of plumage did not cause any significant weight loss in at least two of the three species. However, heavily oiled Kentish Plovers and Little Stints

Table 7. Percentages of waders with different degrees of oiling in the Saudi Arabian Gulf, April–May 1991: 75 km south of oiled zone (Tarut Bay). See Methods for definitions of 'light' and 'heavy' oiling. Data are divided into April and May figures where sample sizes for both months are greater than 100.

	Oiling			Sample	No. of
	None	Light	Heavy	size	counts
Oystercatcher					
April	95	5	–	137	8
May	96	4	–	252	12
Total	95	5	–	389	20
Lesser Sand Plover					
April	95	1	4	539	11
May	95	3	2	4,200	22
Total	95	3	2	4,739	33
Kentish Plover					
April	97	1	2	443	11
May	97	1	2	439	15
Total	97	1	2	882	26
Grey Plover					
April	95	2	3	232	7
May	98	1	1	638	11
Total	97	1	2	870	18
Sanderling					
April	100	–	–	122	6
May	98	1	1	311	9
Total	99	<1	<1	433	15
Little Stint	98	1	1	229	15
Curlew Sandpiper					
April	100	–	<1	247	7
May	99	<1	<1	317	10
Total	99	<1	<1	564	17
Dunlin					
April	100	–	<1	210	6
May	99	–	1	107	7
Total	99	–	1	317	13
Broad-billed Sandpiper	99	<1	<1	183	9
Bar-tailed Godwit					
April	99	<1	<1	1,448	12
May	98	1	1	2,199	22
Total	98	1	1	3,647	34
Curlew					
April	94	2	4	126	5
May	97	1	2	1,173	17
Total	97	1	2	1,299	22
Terek Sandpiper					
April	99	<1	<1	725	10
May	98	1	1	3,750	21
Total	98	1	1	4,475	31
Turnstone					
April	100	–	–	193	6
May	99	<1	<1	741	13
Total	99	<1	<1	934	19

Table 8. The relationship between oiling and adult birds' weight for three wader species, Saudi Arabia, April–May 1991. See Methods for definitions of 'light' and 'heavy' oiling. Weights are mean values (sample sizes in brackets); weights of oiled birds are not corrected for weight of oil itself.

	Weight (g)						Min. adult weight ever recorded in flyway[1]		Shortfall in reserves[2]
	Unoiled		Light oiling		Heavy oiling				
Lesser Sand Plover	70.0	(2)	72.2	(17)	64.8	(25)	40.0	(207)	17.3%
Kentish Plover	39.3	(14)	39.6	(16)	35.5	(6)	30.5	(100)	43.2%
Little Stint	25.0	(48)	24.2	(10)	22.3	(5)	13.0	(>10,552)	22.5%

[1] From Cramp and Simmons (1983) and Urban *et al.* (1986).

[2] Calculated as: $\frac{\text{(mean weight of unoiled birds)} - \text{(mean weight of heavily oiled birds)} \times 100}{\text{(mean weight of unoiled birds)} - \text{(minimum adult weight ever recorded in flyway)}}$

do have significantly lower weights than unoiled conspecifics (one-tailed *t*-test, P<0·05; respectively, *t*=1·912, d.f.=27, and *t*=1·832, d.f.=51). If (due to the too-small sample of unoiled birds) the samples of unoiled and lightly oiled Lesser Sand Plovers are assumed to have insignificantly different mean weights (as for the other two species) one can pool data for unoiled and lightly oiled birds and compare them against heavily oiled conspecifics; here too then, heavily oiled individuals are significantly lighter on average (one-tailed *t*-test, P<0·05; *t*=2·48, d.f.=42).

The meaning of such a drop in weight can perhaps be crudely clarified in the following way. The minimum (full-grown/adult) weight ever recorded for an individual of these species in the Gulf in autumn/winter/spring (Table 8) is taken to represent the threshold at which any further weight loss would jeopardize a bird's survival (a 'minimum survival weight'). It is assumed that if any further weight loss was easily possible, birds with lower weights would have been recorded when dealing with samples as large as these. The expression given in Table 8 ('percentage shortfall in reserves') is therefore meant to show how far down the road towards this minimum survival weight the bird has been forced to go, due presumably to being oiled. Such a weight reduction may be seen in this case to represent, on average, a reduction of between a fifth and nearly three-fifths of potentially utilizable energy reserves for these species, due presumably to heavy oiling. If one took into account the weight of the oil itself, the birds' energy reserve losses would be even higher.

DISCUSSION

Numbers of waders in the impact zone before and after the spill

The number of waders remaining in the impact zone after the spill in March–May can be compared with an estimate of the number present just before the spills impacted, based on the results of the January–February 1986 survey and the proportion of the coastline affected (Table 9). From this it can be seen that the population of the oiled coast suffered an enormous decline from an estimated 130,000 to *c.* 4,000 or less (*c.* 97%) by one to two months after the oil spills had started impacting.

Table 9. Tentative winter population size estimates for the 18 most common wintering wader species on the Saudi Arabian Gulf coast (Zwarts *et al.* 1991), ranked according to abundance, and estimated populations present in the oil impact zone (*c.* 50% of the whole Saudi Gulf coast), January–February 1991.

	No. wintering on whole Saudi Gulf coast	No. wintering on oiled sector of coast just before spill
Dunlin *Calidris alpina*	116,000	58,000
Little Stint *Calidris minuta*	51,000	25,500
Lesser Sand Plover *Charadrius mongolus*	28,000	14,000
Redshank *Tringa totanus*	9,000	4,500
Ringed Plover *Charadrius hiaticula*	8,000	4,000
Greater Sand Plover *Charadrius leschenaultii*	8,000	4,000
Grey Plover *Pluvialis squatarola*	7,000	3,500
Broad-billed Sandpiper *Limicola falcinellus*	6,000	3,000
Curlew *Numenius arquata*	6,000	3,000
Bar-tailed Godwit *Limosa lapponica*	6,000	3,000
Black-tailed Godwit *Limosa limosa*	5,000	2,500
Curlew Sandpiper *Calidris ferruginea*	4,000	2,000
Terek Sandpiper *Xenus cinereus*	4,000	2,000
Turnstone *Arenaria interpres*	3,000	1,500
Oystercatcher *Haematopus ostralegus*	1,000	500
Kentish Plover *Charadrius alexandrinus*	800	400
Greenshank *Tringa nebularia*	500	250
Sanderling *Calidris alba*	200	100
Total	260,000	130,000

In the winter after the spills, the total Saudi Arabian wintering wader population during November–December 1991 was estimated to be 100,000 birds (Harbard and Wolstencroft 1992), compared with the estimate of 260,000 made in January–February 1986 (Zwarts *et al.* 1991). In addition, at least some of the commonest wintering species were reduced to less than 20% of 1986 population size estimates: for example, 17,121 Dunlin and 3,766 Lesser Sand Plovers were counted in November–December 1991, only 14·7% and 13·5% of Zwarts *et al.*'s (1991) estimates of these species' January–February 1986 population sizes (Harbard and Wolstencroft 1992).

Although the 1986 survey was made at a later stage in the winter cycle than the one in 1991, there is no reason to assume that major changes in number would occur during the November–February period, since waders arrive in their tropical wintering areas in August–October and depart in April–May. The 1986 survey may have been subject to some sampling bias resulting in an overestimate: a similar survey in Guinea-Bissau overestimated the winter wader population by 15% when compared to a subsequent, more accurate survey (Zwarts *et al.* 1991). If the overestimate is of similar magnitude for the Saudi Arabian survey in 1986, then an approximate halving of the total winter wader population is still apparent. A real and major reduction in the wader carrying capacity of the Saudi Arabian intertidal zone appears to have occurred.

What exactly happened to the large number of waders which disappeared from the oiled coast in February is not known. Possible explanations are (1) normal end-of-winter migration northwards, (2) dispersal out of the impact zone due to lack of food or to avoid the noxious oil itself, or (3) death *in situ*. The relative merits of the three explanations are discussed below.

Normal migration northwards

It is very unlikely that large numbers of wintering waders (predominantly Dunlin) could have disappeared for this reason since a fall in numbers of Dunlin would not normally have become apparent until at least the end of March, according to known departure timings of wintering waders in the Saudi Arabian Gulf area (Bundy *et al.* 1989; Nightingale and Hill in press). The large numbers of wintering waders still present on the unoiled coast south of the spill in early March (Dennis 1991a) also suggest that major depletion of the wintering population due to normal migration was not yet occurring.

Dispersal from the impact zone

There are strong reasons for presuming that the disappearance of waders from the impact zone was due to rapid dispersal in February and March in response to both the annihilation of their invertebrate food supply, and also to the noxious aspect of the oil itself.

Unsystematic observations revealed that overt signs of invertebrate life were virtually non-existent in the oiled intertidal zone in April–May, in comparison with unoiled areas, due presumably to very widespread smothering/poisoning by the beached oil (Anon. 1991; Preen 1991; pers. obs.). Nelson-Smith (1972) cites several examples of the sensitivity of intertidal invertebrates to pollution by Kuwait crude oil. A major and widespread die-off of invertebrate populations in the oiled intertidal zone, especially in the upper half, was later confirmed by more detailed surveys from autumn 1991 onwards (Krupp and Khushaim 1991).

Experiments and field observations on the reaction of birds towards oil suggest that the greatest oiling of wader populations would have occurred during the initial impact of the slicks in February–March, when the birds were naïve with respect to oil. Connors and Gelman (1980) demonstrated that although oil is noxious to a wader regardless of the food supply available, avoidance needs to be learned and is not innate (perhaps because oil is a glistening liquid like water, and therefore visually very attractive), whilst Varoujean (1982) concluded that wild-living seabirds previously exposed to oil were more apt to avoid oil in the future.

Dispersal of waders from the impact zone would be much easier to detect if a large proportion was oiled. Indeed, at least 10,000 oiled Dunlin were in areas immediately adjacent to the oiled impact zone in March (Dennis 1991a), but only very limited southward dispersal of oiled birds could be detected in April–May: 2–3% of waders in general, and 1% of Dunlin in particular, were found to be oiled in Tarut Bay (Tables 3 and 7), equivalent to a total of less than 600 oiled waders present in the bay during this period, including only four Dunlin (estimated by multiplying the Bay's observed oiling frequencies by peak April–May counts: Evans and Keijl 1993). This appears to indicate either that little southward dispersion from the impact zone occurred, or, if it did, that the birds were unsuccessful in establishing themselves.

The frequency of oiled waders elsewhere in the Gulf was even lower during March–May, overall less than 1%, i.e. the typical 'background' rate (E. Hirschfeld and S. Mohamed pers. comm., for Bahrain; R. and H. Nation pers. comm., for Qatar). Overall it seems unlikely that large numbers of oiled waders successfully dispersed south of the impact zone. Northwards, there were several ornithologists at several localities in the Black Sea and Kazakhstan area of the former USSR who had been primed to look out for oiled migrant waders during April–May 1991, but none were observed at all (T. van der Have, M. van Roomen, H. Schekkerman pers. comm.).

Death in situ

Wader corpses were not systematically searched for, but were rarely found, despite the large numbers of heavily oiled live waders seen (although corpses were usually oiled when found), as noticed in previous studies of oiling incidents involving waders (Chapman 1984; Larsen and Richardson in prep.). For example, a corpse count along 4 km of exposed beach coastline at Ras Tanajib in the centre of the oiled zone in May found only eight waders out of 207 oiled dead birds (4%), while there were over 2,000 heavily oiled living waders present in the area at the same time.

The apparent general scarcity of wader corpses in the oiled study areas in no way rules out mass death *in situ*, however, since even very heavily oiled waders are capable of flight as long as their energy reserves last (Dennis 1991a; Larsen and Richardson in prep.; pers. obs.), allowing them to disperse widely before death, e.g. by moving inland or in search of feeding grounds. In this way, even a very large number of oiled wader corpses could become scattered thinly over vast areas. In addition, oiled waders suffering from hypothermia tend to seek shelter in unusual habitats (saltmarsh bushes, reedbeds, etc.) where their corpses will not be obvious (behaviour observed frequently during this study and in the USA by Larsen and Richardson in prep.), and corpses in most areas would be rapidly found by red foxes *Vulpes vulpes* and perhaps carried further inland before being disposed of.

A proportion of waders in each of the above three options will have become oiled, and a proportion of these oiled birds will in turn have died due to the oiling. Putting numbers to these proportions has proved very difficult, due to the unavoidable time-lag between the beaching of the spills and the beginning of field research, and due to the extreme mobility of waders and the great distances that they can potentially disperse, amongst other reasons. Exactly how many waders died of direct oiling in and around the impact zone is therefore unknown.

There are theoretical grounds (Evans *et al.* 1991; Sutherland and Goss-Custard 1991) and experimental evidence (Lambeck 1991; Meire 1991) to suggest that many of the waders displaced by the oil pollution will not have been able to establish themselves at equally good, unoiled intertidal sites elsewhere due to these areas already being close to carrying capacity with respect to feeding waders. It is increasingly clear that many if not most individual waders use the same set of migration and wintering areas from year to year: they appear to depend on their knowledge of their traditional feeding grounds in order to migrate and breed successfully. It is thought likely that in attempting to establish themselves in new areas, the increased feeding density of waders would cause increased depletion of food stocks and increased behavioural interference between feeding waders, resulting in lower feeding success for some birds (most likely the interlopers, plus the youngest individuals in the population), leading to unsuccessful migration or breeding that year, or to death.

Thus the actual fate of the displaced population is impossible to state with certainty, but the loss to wader species of such a large area of feeding habitat will have almost certainly led to a net reduction in their flyway population sizes. The drastic reductions recorded in Saudi Arabian Gulf wintering wader populations during November–December 1991, e.g. of Lesser Sand Plover and Dunlin, are evidence in support of this pessimistic view.

Plate 3. Oiled Lesser Sand Plovers *Charadrius mongolus* and a Dunlin *Calidris alpina,* Jubail (Saudi Arabia), April 1991. (*Arnoud B. van den Berg*)

Density of waders feeding in the oiled intertidal zone

It appears from the (non-oiled) control sites that natural seasonal/annual variation in the density of feeding birds is very unlikely to account for such a drastic reduction at the oiled site: it is almost certainly the oiling itself that has caused this massive drop in wader feeding density. The magnitude of this reduction (*c.* 98%) is closely similar to the scale of depopulation of the oiled coast (97%) indicated by the earlier comparison of pre-oil spill and post-oil spill counts, suggesting some independent corroboration.

Assessments of oiling frequency in wader populations

Overall frequency of oiling

The existence of a minority (*c.* 25% or less) of unoiled birds can be explained by the continuous arrival of fresh, inexperienced migrants from further south during

March–May; these birds will quickly have discovered the lack of food in the flats and/or the noxious qualities of the oil, and the majority are likely to have left the area rapidly. Any that stayed (e.g. through illness or exhaustion) would soon have become oiled.

Vulnerability of different species to oiling

Those species which were, to judge by the remnant populations, particularly badly affected by oil nearly all winter in substantial numbers on the Saudi Arabian Gulf coast (only the status of Broad-billed Sandpiper is not clear), whereas those with noticeably low rates of oiling tended to be species that are much commoner in spring than winter (e.g. Curlew Sandpiper, Sanderling). The only wader species which were not observed to be oiled had strictly freshwater or terrestrial habitat preferences (e.g. Black-winged Stilt *Himantopus himantopus*). It thus appears plausible that most oiled waders seen during April–May actually derived from the local wintering population.

Different species of wader have different feeding strategies on intertidal flats which may expose them to different risks of oiling according to the physical distribution of the oil. Bar-tailed Godwits, for instance, tend to feed at the waterline as it moves with the tide, whereas Greater Sand Plovers tend to feed on the higher, drier areas of intertidal flat. However, these differences in vulnerability are partially obscured by other factors which cause generalized mass oiling of all species: all wader species tend to roost together in flocks above the high tide line, often amongst saltmarsh vegetation, a zone that was especially heavily oiled in this incident, and virtually all wader species on the Saudi Arabian Gulf coast occur at greatest densities on the muddier, more sheltered areas of flats (Zwarts *et al.* 1991), i.e. the kind of areas that were most intensely exposed to floating, liquid oil during this incident. Thus statements about the differing vulnerability of different wader species to oiling cannot be made with confidence.

Effect of oiling on individual birds

The implications of a reduction in energy reserves of the magnitude described in the Results section are serious for migrants. Much evidence suggests that waders only attempt migration if they reach a very high threshold weight (e.g. almost doubling their normal winter weight) within a certain time-window (Zwarts *et al.* 1990). The weight reductions suffered by heavily oiled Lesser Sand Plovers and Little Stints mean that they would not be able to reach their breeding grounds according to the very strict time schedule that migratory wader species such as these face, and they would have failed to reproduce in 1991. Heavily oiled individuals of all other migratory wader species (and other waterbirds) are likely to have suffered in a similar way. Among the three species studied, Kentish Plovers (breeding locally and not preparing for migration) suffered a proportionately much greater drop in weight due to heavy oiling, perhaps because they had less time available to feed themselves while looking after chicks.

The potential disruption caused by oiling to the time-schedule of migrating waders is well illustrated by the only two re-traps of migratory species recorded in the study. An unoiled Lesser Sand Plover of well-above-average weight gained 2 g over 5 days (80 to 82 g, an increase of 0·4 g/day). If it could match this unoiled bird's rate of weight gain despite the extra constraints which faced it, a heavily oiled individual would need on average at least 13 extra days of feeding to reach the weight of a contemporary unoiled bird (see Table 8), and at least 60 further days of feeding to reach the peak weight recorded for this species during this study (94 g, presumably close to departure weight: see Evans and Keijl 1993).

The second re-trapped bird, a Common Sandpiper *Actitis hypoleucos*, gained 2 g over 3 days (a daily weight increase of 0·7 g/day), despite being thinly oiled all over the underparts, i.e. 'heavily oiled'; it went from 40 g to 42 g, however, and as such was well below the mean weight of unoiled birds during the same period (50·2 g; n=3), and at this rate would only have recovered the 'normal' weight of unoiled contemporaries if allowed 12 extra days of feeding.

Unfortunately, little information was gained during this study on the rate of weight change presumed to follow upon oiling in waders, since it is not known exactly when the birds in our samples first became oiled. The lack of these data makes it difficult to predict mortality rates for oiled waders. It seems clear that light oiling, as defined in this study, had little effect on a bird's weight (and hence, one assumes, body condition and health) during the warm weather of April–May. However, it can be anticipated that heavily oiled waders and other waterbirds are likely to have suffered from hypothermia to a greater extent during February, the coldest month in the Gulf (normal mean monthly minimum at Dhahran is 11°C, and inshore sea temperatures drop as low as 10°C: Price 1991), since air temperatures were even lower than normal (by 5–10°C) due to the vast cloud of smoke hanging over the oiled coast from burning Kuwaiti oil wells (USGTF undated), and winds were strong and stormy throughout most of the month (Pledge 1991).

Larsen and Richardson (in prep.) noted that oiled waders in north-west USA in January often appeared isolated or segregated from unoiled birds, which they hypothesized as being due to oiled birds' preference for sheltered areas to stem their much increased rate of heat loss; such behaviour was not so obvious in the Gulf in April–May, perhaps confirming this hypothesis since ambient temperatures were much higher in this case.

Prospects for recovery

Previous incidents involving oiling of the intertidal zone, in the Arabian Gulf and elsewhere, can give some idea of the prospects for recovery. A 113,000 barrel spill of light crude oil in April 1970 in Tarut Bay extended 'from shore to shore' of the bay and left large tar mats on the beaches (Spooner 1970; NOAA 1991). Like the 1991 spill, the oil was carried south down the coast by prevailing winds, accumulating against causeways and other artificial headlands, just as it was trapped by Abu Ali headland (and in various bays further north) during 1991. After heavy slicks had passed in and out with the tide over these areas for more than five days, the intertidal invertebrate fauna was largely killed off. Crabs and bivalves appeared in this incident to be more sensitive than *Cerithium* snails and tube worms, while in 1991 all such organisms were severely affected; the reduction in browsing caused

Plate 4. Oiled Bar-tailed Godwit *Limosa lapponica,* Jubail (Saudi Arabia), April 1991. (*Arnoud B. van den Berg*)

by die-off of *Cerithium* allowed algae to flourish unchecked on the sediment surface, as was very noticeable in 1991.

Surveys of beached oil ten years later showed that Tarut Bay was still more contaminated than the average Saudi Arabian shoreline (NOAA 1991). However, the areas of the bay most heavily impacted by the 1970 slick were, by 1986, particularly rich in waders (Zwarts *et al.* 1991; L. Zwarts *in litt.*), indicating the potential for recovery that exists given sufficient time. Elsewhere, more than 100,000 barrels of diesel crude polluted *c.* 3,250 ha of intertidal flats and saltmarsh at the Medway estuary in England in 1966, and wader numbers dropped significantly due to destruction of the food supply, but both waders and their food were recovering very well 15 months after the incident (Harrison and Harrison 1967; Harrison and Buck 1967, 1968). In this incident the oil was very quickly dispersed with chemicals rather than being allowed to pollute the mudflats indefinitely. A similar die-off and rapid recovery of intertidal invertebrate food supply was reported by Chapman (1984): after sandy barrier-beaches were impacted by oil from the Ixtoc 1 blowout in the Gulf of Mexico in 1979, invertebrate populations in the sediments suffered a 70% reduction in total numbers and waders avoided the polluted areas. One to two years later, however, the habitat had apparently recovered, since wader numbers were back to normal on the affected sections of beach.

Any optimism engendered by these accounts should be tempered however by the realization that the 1991 pollution incident was very much larger and more comprehensive than any previous intertidal oiling incident, and took place early in the year under much cooler conditions than the 1970 Tarut Bay spill, perhaps resulting in much less oxidation or evaporation of toxic compounds within the oil before its burial by ongoing sedimentation. The resulting toxicity may thus be stored in the intertidal sediments, to be released slowly over the years by diffusion and storm-disturbance events, to the continuing detriment of the environment.

Impact of land-claim on wader populations

The habitat loss and associated (probable) net reduction of flyway populations of waders caused by the oil spills needs to be put into the context of another man-induced impact. Between 1973 and 1989 at least 100 km² of intertidal and shallow subtidal habitat is said to have been destroyed by land-claim and associated suction-dredging in the region from Jubail, Abu Ali, and Tarut Bay to the south of Dammam (IUCN 1987; Coles and McCain 1989), which translates to an average annual rate of at least 625 ha/year. A much larger area of surrounding habitat has been affected by associated changes in water quality and shifting substrates. Mangroves, intertidal flats, saltmarshes, seagrass beds, and other important biotopes have been destroyed and lost forever to the marine ecosystem (Coles and McCain 1989).

These habitats play a crucial role in generating and sustaining much of the animal life in the Gulf, since the shallow subtidal benthic environment (most especially seagrass beds) is thought to provide virtually all the net primary productivity of the Saudi Arabian Gulf ecosystem (Basson *et al.* 1981), and mangroves and seagrass beds provide major spawning and nursery areas for economically valuable shrimp and fish, whilst intertidal flats and subtidal shallows are essential feeding and resting areas for internationally important numbers of waterbird species. Overall, waterbird populations must have been reduced, due to the sheer scale of the land-claim.

This habitat destruction and degradation is more serious in the long term than that wreaked by the Gulf War oil spills, because it is permanent; the oiled and polluted coastline between al-Khafji and Abu Ali will recover some or most of its former value as a natural, life-sustaining resource, given enough time, but no amount of time will ever bring back land-filled habitat.

CONCLUSIONS

Past experience of smaller-scale oil spills in the Saudi Arabian Gulf and elsewhere suggests that the oiled coastal habitat and bird populations will recover to some extent, although not fully, within 5–20 years. However, the unprecedented scale and thoroughness of pollution may hinder natural recolonization of oiled areas from unoiled areas by plants and animals.

Baseline data on the Gulf's marine wildlife resources were shown to be important and necessary if any meaningful response to such environmental disasters is to be mounted and their effects understood. A more comprehensive baseline picture will be needed in future, since damage assessment has proved very difficult, e.g. for certain important groups such as waders whose populations are naturally subject to great fluctuations in time and space, where the only previous data were from a single survey in winter 1986.

Because of the permanence of its destructive effect, land-claim is an even worse threat to Saudi Arabia's marine resources than oil pollution. The coastal habitats generate and sustain multi-million-dollar fish and shrimp industries which are economically and socially important. The hardest-hit area is Tarut Bay, which also appears to be the most resource-rich and ecologically important area in the Saudi Arabian Gulf.

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First record of Rock Bunting *Emberiza cia* in Saudi Arabia

SHERIF BAHA EL DIN

WHILE conducting coastal survey work on 25 May 1991 at Ras Abu Murikha (just north of Ras Tannurah, eastern Saudi Arabia), as part of the NCWCD/ BirdLife International wader study in the Arabian Gulf, a medium-sized bunting was noted foraging secretively amongst the coastal dune grasses. The bird was identified as a male Rock Bunting *Emberiza cia*.

Figure 1. Rock Bunting *Emberiza cia*, Ras Abu Murikha (Saudi Arabia), 25 May 1991; drawn from field sketches. (*S. Baha El Din*)

The most striking feature of the bird was a greyish-white- and black-striped head. Closer views showed that it had an all-grey bill; throat, sides of neck, and upper breast were grey with no trace of streaks or speckles; rest of underparts, as well as the rump, rufous. Upperparts contrasted with the underparts because of heavy dark streaking, which extended onto the centre of the crown. The tail was brown, with distinct white outer feathers. Legs were flesh coloured, and the only call heard was a short, sharp 'tssp', delivered in flight. In particular, the colour of bill, throat, and outer tail feathers allowed separation from the Middle Eastern race of House Bunting *E. striolata striolata*.

The bird, which was relatively tame and fed actively, was observed for about 45 minutes at the same location. It was not found there again during a visit on the following day.

The only records of Rock Bunting from Arabia that I am aware of are two from Kuwait, of single birds on 24–26 March 1966 and 1 March 1967 (Bundy and Warr 1980), while none have been reported previously from the Kingdom of Saudi Arabia. The species breeds not far from Saudi Arabia, in south-west Iran to the north of the Arabian Gulf.

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BUNDY, G. AND WARR, E. (1980) A check-list of the birds of the Arabian Gulf states. *Sandgrouse* 1: 4–49.

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The Editorial Committee of *Sandgrouse* will consider for publication original papers which contribute to the body of knowledge on the birds of the Middle East—their distribution, breeding biology, behaviour, identification, conservation, etc. The Middle East for this purpose includes Turkey, Cyprus, and Libya in the west to Afghanistan and the Palearctic fringe of Pakistan in the east, the southern shores of the Black and Caspian Seas in the north, and the Arabian peninsula and the Palearctic limits in Sudan and Ethiopia in the south. Submissions are considered on the understanding that the work has not been previously published and is not being offered for publication elsewhere.

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Figures should be drawn *without any lettering* in black ink on good-quality white or translucent paper. The *original* artwork must be supplied, plus one copy with rough lettering in place; the text of lettering should also be supplied on a separate sheet of paper (and on disk if possible; see below). In preparing figures authors should have regard to the page size and format of *Sandgrouse*. Figures will ideally be drawn about 50 per cent larger than final size; if they are much larger than this care should be taken to avoid use of fine detail that will be lost in reduction. Areas of fine Letraset tint should be avoided and uniform half tones (e.g. pencil shading) are not usually acceptable.

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