

Conservation of temperate North Pacific terns

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Abstract

Twenty-one species of terns, numbering between 1.4 and 2.7 million breeding pairs and originating in tropical and colder temperate regions in a 2:1 ratio, populate the temperate North Pacific. The Asiatic coast supports 14 species, North America nine, and the Pacific Ocean (i.e., the Hawaiian Islands - Wake Island - Johnston Atoll) seven: only Sooty Terns *Sterna fuscata* breed in all three areas. North America and Asia share four species, and Hawaii and Asia three. Even though synoptic counts are lacking for Asia, it is clear that the greatest tern biomass is found in the Hawaii-Wake-Johnston complex, and we estimate Sooty Terns account for ca. 85% of the terns in the temperate North Pacific. Adding Brown Noddies *Anous stolidus* and Gray-backed Terns *S. lunata* raises the total to 95%—underscoring the numerical dominance of Central Pacific terns in the temperate North Pacific. Populations of most species seem to be more or less stable, with the exceptions of the Chinese Crested Tern *S. bernsteini*, which is on the brink of extinction, the Elegant Tern *S. elegans*, now possibly reduced to one major colony with at least 90% of the species' total population, and the apparently tiny population of the Gull-billed Tern subspecies *S. nilotica vanrossemi*. Those three species should immediately be designated Endangered.

Threats to terns run the usual gamut of those facing other seabirds: feral animals, development, human disturbance, eggging, and military activities. Chemical pollution seems to be declining as a problem on the west coast of the United States, and is apparently not significant in Hawaii. Site- or species-specific data from terns of the Asiatic coast are few. Excessive heavy metal and oil pollution is present in the exact area in northeastern China where the Chinese Crested Tern was last reported possibly nesting. Actual or potential commercial fisheries interactions with terns have been investigated in the Hawaiian Islands but are not complete; a northern anchovy *Engraulis mordax* fishery off southern California and Baja might control not only the continued existence of Elegant Tern but an entire suite of endemic seabirds, and should be investigated from that perspective.

Résumé

En tout, 21 espèces de sternes fréquentent les zones tempérées du Pacifique Nord. Ces espèces, qui comptent entre 1,4 million et 2,7 millions de couples reproducteurs, viennent des régions tropicales et tempérées plus fraîches, dans un rapport de 2 à 1. Les côtes de l'Asie, les côtes de l'Amérique du Nord et les îles du Pacifique (Hawaï, Wake, Johnston)

subviennent aux besoins de 14, 9 et 7 espèces de sternes, respectivement. La Sterne fuligineuse *Sterna fuscata* est la seule espèce qui fréquente les trois régions. L'Amérique du Nord et l'Asie se partagent quatre espèces. Les îles Hawaï et l'Asie se partagent trois espèces. Malgré l'absence de données synoptiques pour l'Asie, il ne fait aucun doute que la plus forte biomasse de sternes se trouve dans les îles du Pacifique (Hawaï, Wake et Johnston). Selon les estimations, les Sternes fuligineuses comptent pour 85 % environ des sternes dans les zones tempérées du Pacifique Nord. Si l'on tient compte des Noddies *Anous stolidus* et des Sternes à dos gris *S. lunata*, cette proportion atteint 95 % et donne un net avantage numérique aux sternes des régions centrales du Pacifique. Pour chaque espèce, les populations semblent relativement stables, exception faite de la Sterne huppée *S. bernsteini*, en voie d'extinction, de la Sterne élégante *S. elegans*, dont il ne reste vraisemblablement plus qu'une seule colonie imposante, regroupant au moins 90 % de tous les individus et de la sous-espèce de Sterne hansel *S. nilotica vanrossemi*, dont la population serait très réduite. Il faut immédiatement ajouter ces trois sternes à la liste des espèces menacées de disparition.

Les sternes partagent toute la gamme des menaces auxquelles sont exposés les autres oiseaux marins : animaux féroces, disparition de l'habitat au profit du développement, perturbations par les humains, dénichement et activités militaires. La pollution chimique semble ralentir sur la côte ouest des États-Unis et n'est apparemment pas un problème majeur dans les îles Hawaï. On dispose de peu d'information par emplacement ou par espèce pour les sternes des côtes asiatiques. On signale, cependant, une pollution extrême par les métaux lourds et les hydrocarbures, à l'endroit précis dans le nord-est de la Chine où l'on a relevé pour la dernière fois la nidification de la Sterne huppée. On a étudié les rapports réels et potentiels entre la pêche commerciale et les sternes, dans les îles Hawaï, mais l'information demeure incomplète. Une pêche de l'Anchois du Pacifique *Engraulis mordax*, au large du sud de la Californie et de la Basse-Californie, pourrait mettre en péril la survie de la Sterne élégante et de nombreux autres oiseaux marins endémiques. Il importe d'étudier attentivement les effets de cette pêche.

1. Introduction

The temperate North Pacific (TNP) has been arbitrarily defined to be the North Pacific Basin north to the Bering Strait (ca. 66°N), south along the North American coast past the tip of Baja California to the 19th parallel, thence westwards across the Pacific to ca. 122°E, thence north to intersect the China coast at

Figure 1
Present temperate North Pacific distribution for breeding Aleutian, Sooty, Gray-backed, and Gull-billed terns

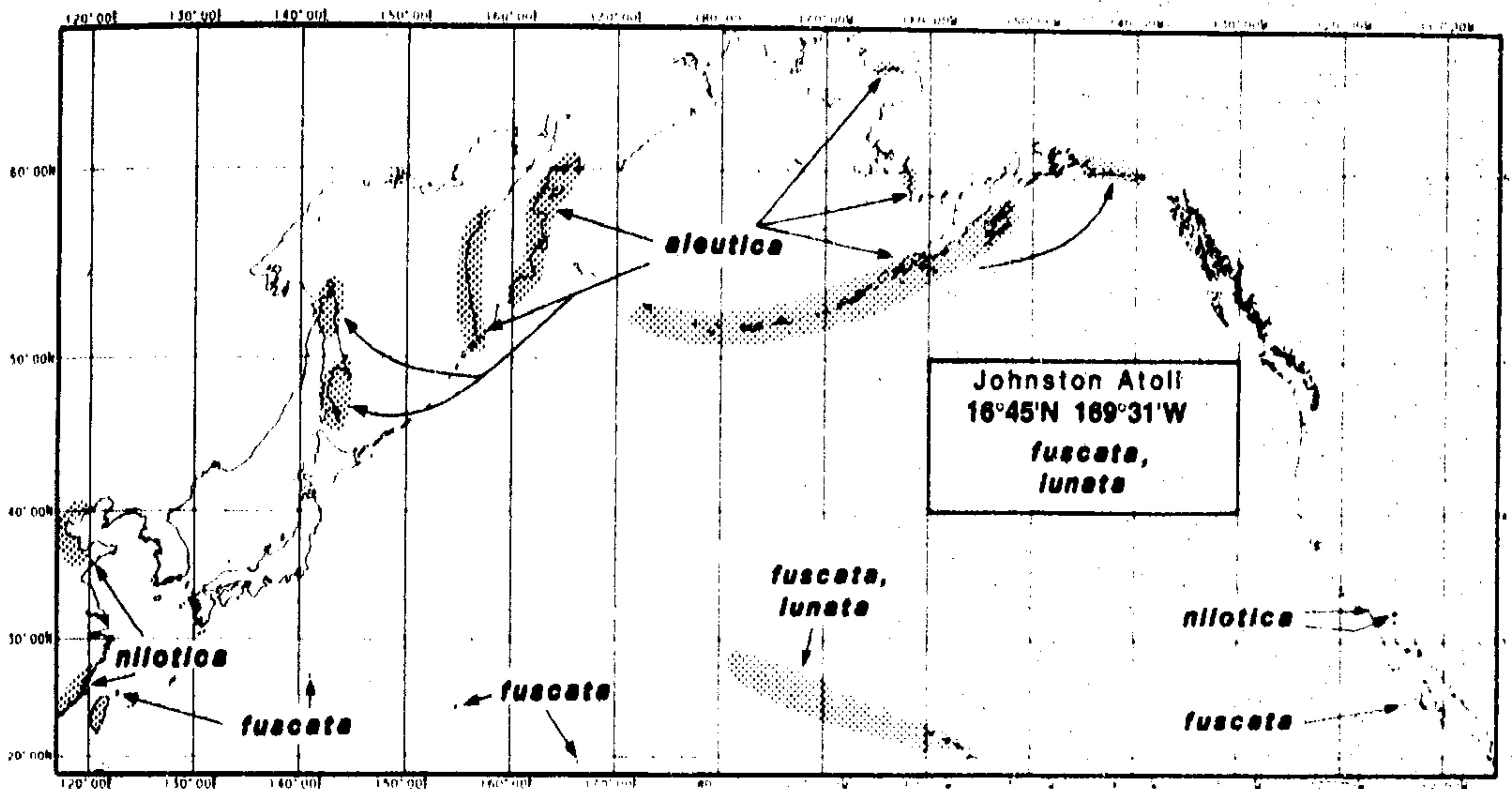
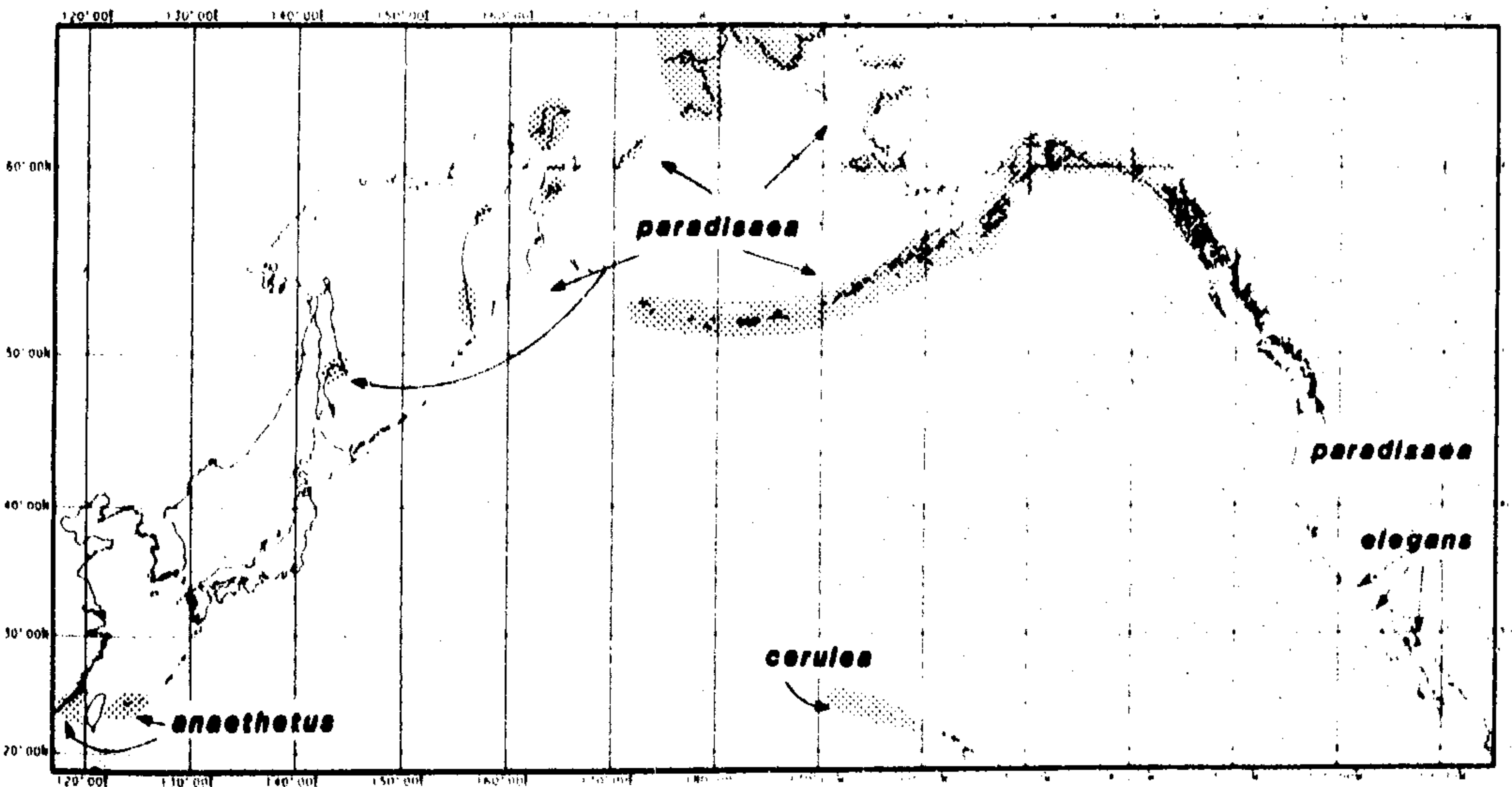


Figure 2
Present distributions for breeding Arctic, Elegant, and Bridled terns and Blue-gray Noddy



ca. 23°N, thence northwards along the Asiatic coast to the Bering Strait (see Figs. 1-5). We have included all Asiatic and North American shores, islands, sounds, lagoons, gulfs, seas, bays, and estuaries, but not inland or disjunct freshwater bodies. We have also included Johnston Atoll (16°45'N, 169°31'E) because its tern populations interact with those on Wake Island and on the Hawaiian Islands. Because they are tropical extensions into the TNP, we have excluded the Tres Marias,

and Revillagigedo Islands south of Baja, and the northern Mariana and the northernmost Philippine islands.

Twenty-one species breed in the TNP, consisting of Asiatic endemics, several holarctic species, one cold-water North Pacific endemic, numerous widespread North American species (several of which are North American endemics), one Sea of Cortez endemic, two widespread neotropical species,

Figure 3
Present temperate North Pacific distributions for breeding Royal, Crested, Chinese Crested, and Common terns and Black Noddy

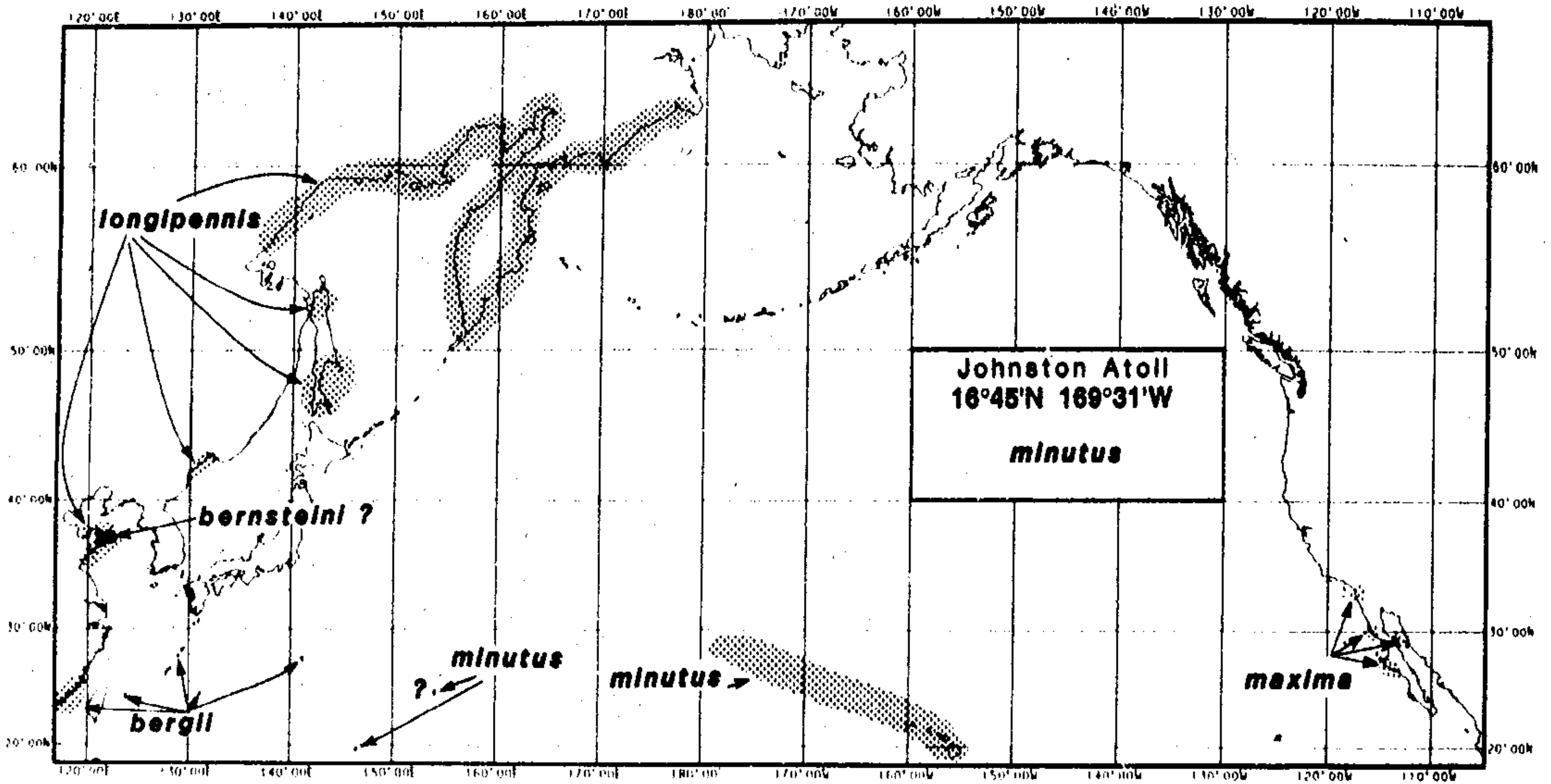
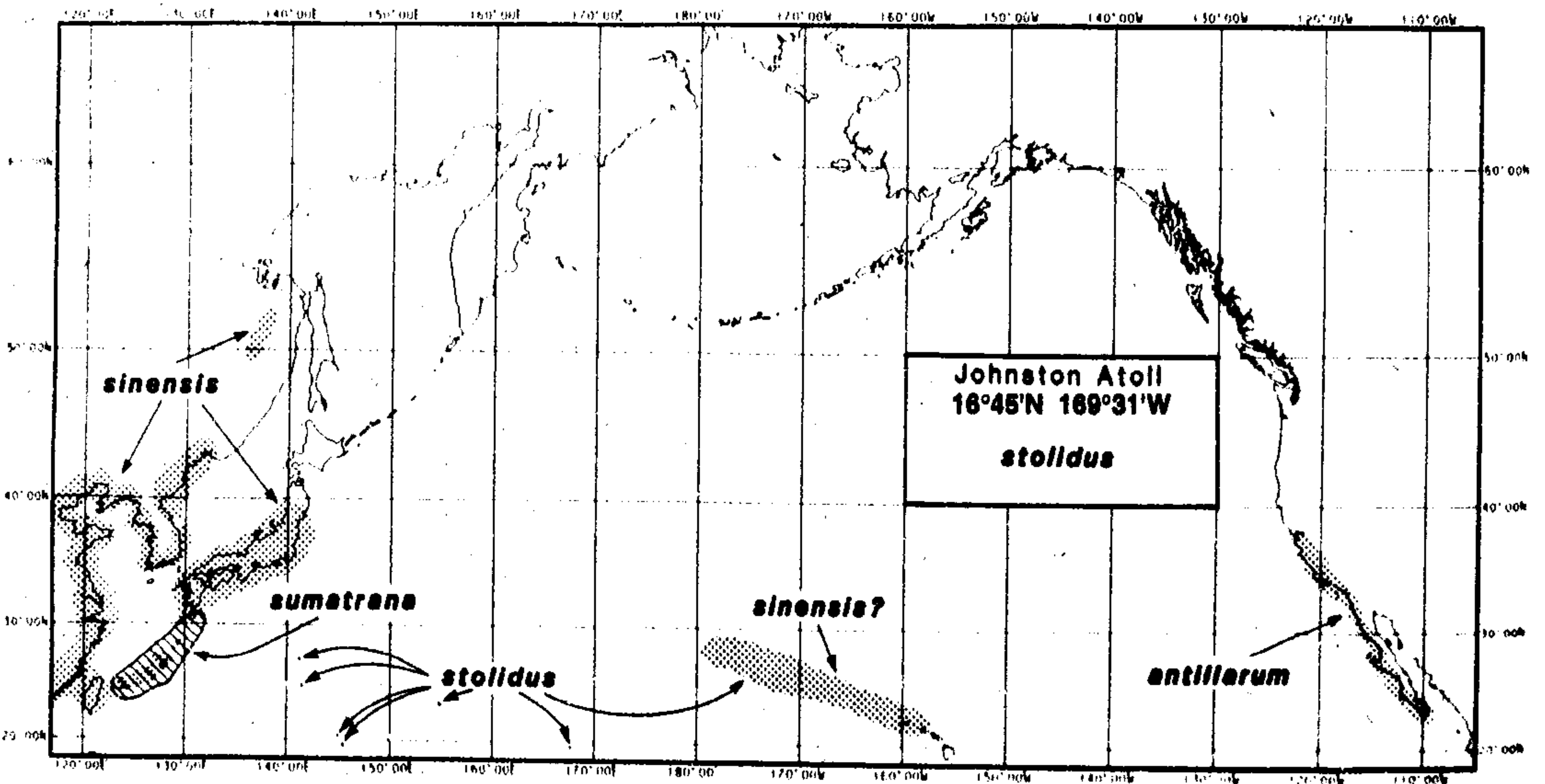


Figure 4
Present temperate North Pacific distributions for breeding Least, Little, and Black-naped terns and Brown Noddy

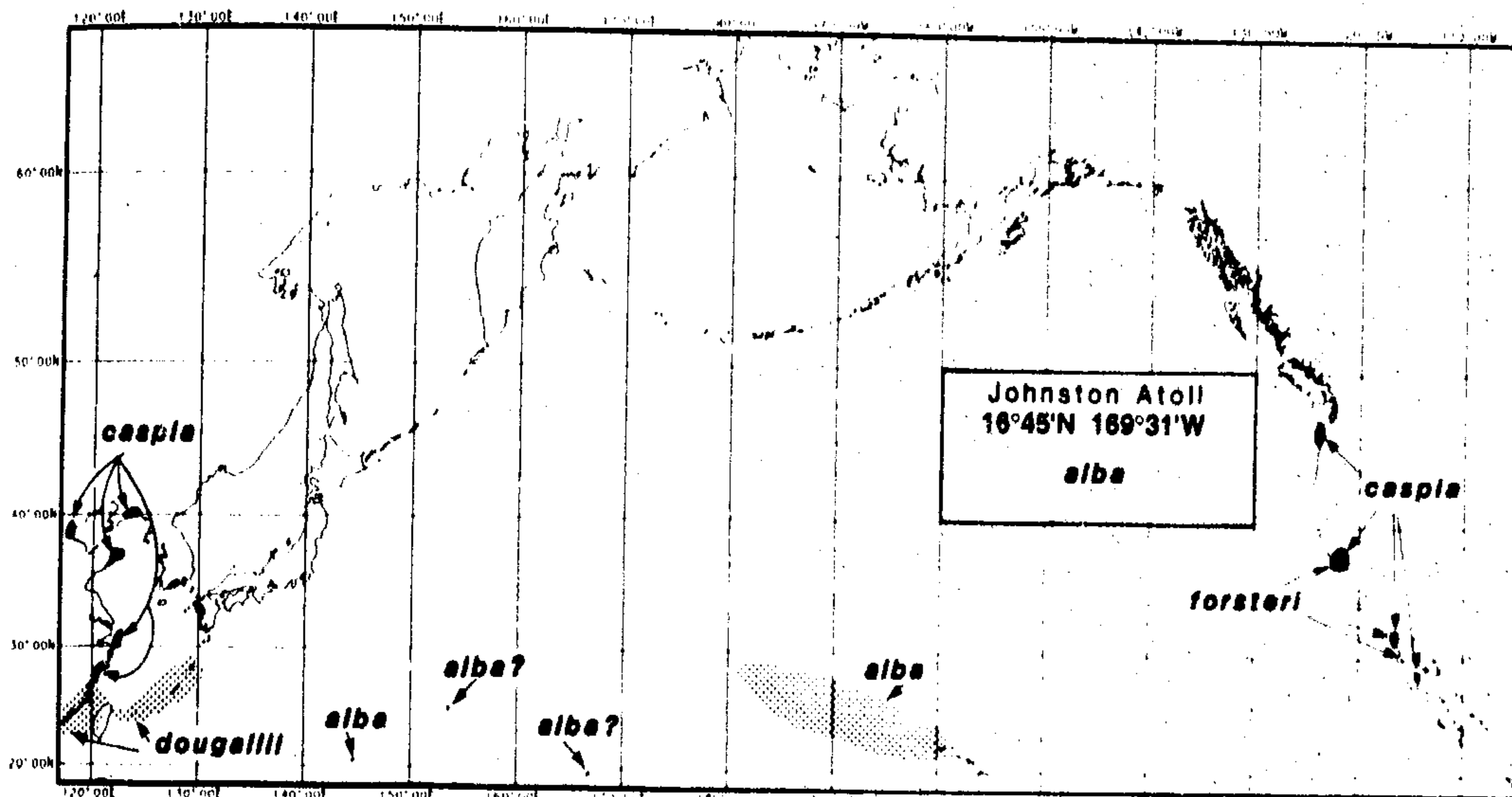


many pan-tropical/oceanic species, and two Pacific Ocean tropical endemics. All of the arctic/temperate species are migratory, as are many but possibly not all of the tropical species. Within single tropical species, some populations are resident, others migratory. Although a unified pattern of tern ecology for the TNP does not exist, the ecological diversity

shown by terns across this broad area does allow ecological comparisons not often possible within one oceanic entity.

Table 1 compares the taxa of terns in the three major portions of the TNP where terns breed, viz. the coasts and nearshore islands of North America, of Asia, and Pacific oceanic islands, graphically demonstrating that except for

Figure 5
Present temperate North Pacific distributions for breeding Forster's, Roseate, Caspian, and White terns



pan-tropical *fuscata* there is little commonality of taxa among the three areas.

In terms of species richness, coastal Asia supports 13 species, North America nine, and the Pacific oceanic islands seven. Among the last seven are two Pacific endemics, *caerulea* and *lunata*; both are essentially tropical and barely reach into the TNP in the Hawaiian complex. Asia's unique true endemic, *bernsteini*, is so poorly known that some regard it as extinct (but see below for recent contrary evidence). The only widespread TNP endemic, *aleutica*, breeds on both Alaskan and Siberian coasts, and is tolerably numerous. *Antillarum* and *forsteri* are endemic to continental North America, but are more widespread and abundant at inland, Gulf of Mexico, and Atlantic locales than on Pacific shores. Subtropical *elegans* is the only North American endemic tern restricted by our definition to the TNP. The remaining tern species are more or less well distributed across their respective areas with the exception of *dougallii*, *bergii*, *anaethetus*, and *sumatrana*, whose small populations on the coast of Asia could reasonably be described as marginal in the TNP. Likewise, *alba*, *caerulea*, and *lunata* reach the TNP only in the Hawaiian complex, where, however, they have substantial populations.

Table 2 summarizes population data available on the 21 species for the TNP. Obvious and significant are the major gaps in information, not only on absolute numbers of breeding birds, but even on whether many species occur at all in various countries or areas. For three species there are no numbers from the TNP (*bergii*, *bernsteini*, and *sinensis*). *Bernsteini* is close to extinction and *dougallii* is endangered elsewhere (South Africa, North America, and Western Europe). For *fuscata*, *minutus*, and *stolidus* we have solid counts only from the Hawaiian complex. We have no tern numbers from Korea (one to perhaps seven species) and China (11 species), and only scattered counts from Russia (three species) and Japan (eight species).

Table 1

Zoogeographic affinities of the breeding terns of the temperate North Pacific. Dashed lines connect taxa breeding in more than one region. "Pacific Ocean" includes only Wake Island, Johnston Atoll, and the Hawaiian archipelago. "Asia" includes all Japanese or other islands out to Marcus.

North America	Asia	Pacific Ocean
		<i>alba</i>
<i>aleutica</i>	<i>aleutica</i>	
<i>antillarum</i>	<i>anaethetus</i>	
	<i>bergii</i>	
<i>caspia</i>	<i>bernsteini</i>	
	<i>caerulea</i>	
<i>elegans</i>	<i>dougallii</i>	<i>caerulea</i>
<i>forsteri</i>		
<i>fuscata</i>	<i>lunata</i>	<i>fuscata</i>
	<i>longipennis</i>	
<i>maxima</i>		<i>lunata</i>
	<i>minutus</i>	<i>minutus</i>
<i>nilotica</i>	<i>nilotica</i>	
<i>paradisaea</i>	<i>paradisaea</i>	
	<i>sinensis</i>	<i>sinensis</i>
	<i>stolidus</i>	<i>stolidus</i>
	<i>sumatrana</i>	

At the other end of the scale, *fuscata* accounts for 85% of the known terns in the TNP, adding *stolidus* raises the total to 92%, *lunata* to 95%, and *paradisaea* to 97%, emphasizing the lognormal-like distribution of terns in the TNP. There are too few data to make many valid statements about the population health of most species, except to comment that endemic *bernsteini* is on the edge of extinction; that *nilotica vanrossemi*'s entire population might not exceed 100 pairs and thus deserves Endangered status; that endemic *elegans* may be declining; that *sinensis* is said to be declining in Japan; and that

Table 2

Estimated (1980s) breeding populations (in pairs) for the coastal North Pacific by geopolitical units. Symbols used: — nonoccurrence; ? uncertainty; + occurs in small to moderate numbers, ++ occurs in large numbers, both unquantified; ± fluctuates; tr. handful; > greater than.

Species	Baja	U.S.A.	Alaska and B.C.	Russia	Korea	China	Japan	Johnston and Hawaii	Wake	Rounded totals
<i>alba</i>	—	—	—	—	—	—	—	8–16 000	12±	8–16 000
<i>aleutica</i>	—	—	10 000	>2100	—	—	—	12 100	—	12 100
<i>anaethetus</i>	—	—	—	—	—	1000	1000	—	—	>2000
<i>antillarum</i>	>300	1000±	—	—	—	—	—	—	—	>1300±
<i>bergii</i>	—	—	—	—	—	+	+	—	—	?
<i>bernsteini</i>	—	—	—	—	?	+?	—	—	—	?
<i>caspia</i>	20	5600	—	—	?	+	—	—	—	>5620
<i>cerulea</i>	—	—	—	—	—	—	—	>3–4000	—	>3–4000
<i>dougallii</i>	—	—	—	—	?	+	>700	—	—	>700
<i>elegans</i>	10–80 000?	2000±	—	—	—	—	—	—	—	12–82 000
<i>forsteri</i>	30	1800	—	—	—	—	—	—	—	1830
<i>fusca</i>	250±	—	—	—	—	+	>5000	1.02–1.88 mil	150–450 000	1.2–2.3 mil
<i>longipennis</i>	—	—	—	>2000	?	+	—	—	—	>2000
<i>lunata</i>	—	—	—	—	—	—	—	36–52 000	2–300	36–52 000
<i>maxima</i>	>8–10 000	tr.	—	—	—	—	—	—	—	>8–10 000
<i>minutus</i>	—	—	—	—	—	—	+?	6.6–17 000	45	>7–17 000
<i>nilotica</i>	?	5±	—	—	—	—	—	—	—	5
<i>paradisaea</i>	—	10–20	>25 000	>5000	?	—	—	—	—	>30 000
<i>sinensis</i>	—	—	—	?	+	+	++	tr.?	—	?
<i>stolidus</i>	—	—	—	—	—	3000±	+	91–138 000	21–2600	>93–141 000?
<i>sumatrana</i>	—	—	—	—	?	+	>200	—	—	>200
Species	6	7	2	3	1–?	11	8	7	5	21
Breeding pairs	19–91 000	10 500	>35 000	>9100	?	4000±	>6900	>1.16–2.11 million	152–453 000	>1.4–2.7 million

the western North American race of *antillarum* (*browni*) is officially Endangered.

2. Distribution and numbers

2.1. Aleutian Tern *Sterna aleutica*

The Aleutian Tern is an inshore-feeding TNP endemic that breeds in North America from the Bering Strait south through the Aleutians to the mid Gulf of Alaska shore, and in Asia on the Pacific coasts of Kamchatka and Sakhalin, probably north on the Chukotsk Peninsula, and along the Sea of Okhotsk (Fig. 1). Most recent Russian counts (e.g., Litvinenko and Shibaev 1991) estimate about 2100 pairs, but these counts are acknowledged to be incomplete. The latest published account of the Alaskan population suggests 10 000 pairs (Lensink 1984), but this may also be an underestimate. The Aleutian Tern is completely migratory; its winter range is unknown and therefore presumed to be at sea in the Pacific. Its population health in the TNP seems to be good.

2.2. Arctic Tern *Sterna paradisaea*

The Arctic Tern is an offshore-feeding migrant that occurs widely across the northern end of the TNP, breeding along Alaskan shores south to south-central Alaska and in Asia south along Pacific shores to Kamchatka and Sakhalin, and, especially, along the inland Sea of Okhotsk (Dement'ev and Gladkov 1951; Golovkin 1984; Kaverkina 1986; Kondratiev 1991; Litvinenko and Shibaev 1991) (Fig. 2). South of Alaska, this species breeds in very low numbers in northwestern British Columbia near Stewart (Campbell et al. 1990). Some 1110 km farther south, a small colony (10–20 pairs) was discovered along Puget Sound (48°05'N) in the 1970s (Manuwal et al. 1979). Approximately 5000 pairs nest in the Russian part of the TNP (Table 2), where it is not regarded as rare or vulnerable.

In North America, Alaskan coastal populations have been estimated at 25 000 pairs (Lensink 1984), and it is also a widespread inland breeder there. Migrating primarily at sea, Arctic Terns typically winter in antarctic and subantarctic waters, avoiding entirely the western Pacific southward of their southernmost breeding locations, and instead crossing the ocean to pass along the west coast of the Americas. Globally and in the TNP, their breeding populations and sites are not at risk.

2.3. Black Noddy *Anous minutus*

The Black Noddy is an inshore-feeding, tree-nesting, tropical resident. It reaches the TNP only at Johnston Atoll and in the Hawaiian Islands (*melanogenys*), where its population is estimated between 7000 and 17 000 pairs (Harrison 1990), and on Marcus Island, where there is no recent information on the local race (*marcusi*) (Fig. 3). *Minutus* is doing well in the Hawaiian Islands, and the recent establishment of a new colony in the outermost islands (Morin 1985) plus several individuals on offshore Japanese islands in recent years (Brazil 1991) suggest range expansion.

2.4. Black-naped Tern *Sterna sumatrana*

The Black-naped Tern is a nearshore-feeding, southwest-Pacific-to-central-Indian-Ocean endemic. Nominate *sumatrana* reaches the TNP in the Ryukyu Islands (Hasegawa 1984), the Pescadores (Melville 1984), off southwest Taiwan, and along the mainland China coast in Fujian and Zhejiang provinces (Cheng 1987) (Fig. 4). It seems not to be abundant anywhere in this area, and the only counts are ca. 200 pairs at 4–6 sites in Japan (Brazil 1991). Although the species is apparently resident near its preferred bare-sand island colony sites in the tropical parts of its range, we do not know if this is the case within the TNP. We are unaware of any particular concern about *sumatrana*.

2.5. Blue-gray Noddy *Procelsterna cerulea*

The Blue-gray Noddy, a Pacific Ocean endemic, is the smallest tern in the world. *Cerulea* is an inshore-foraging, rock-cavity-nesting resident, which reaches its northernmost distribution in the outer Hawaiian Islands (Fig. 2). Although not numerous (3–4000 pairs), its status there is regarded as stable (Harrison 1990).

2.6. Bridled Tern *Sterna anaethetus*

The Bridled Tern is a pan-equatorial, inshore-feeding species, with disjunct populations off central West Africa, in the West Indies, off the Pacific coast of Central America, and from the extreme western Pacific westward to the southwest Indian Ocean and Red Sea/Persian Gulf area (Fig. 2). In the TNP, nominate *anaethetus* breeds locally in China on islands off the coasts of Fujian Province and on Hainan Island (Cheng 1987), in the Pescadores (Melville 1984), and at three or more Japanese sites in the Ryukyu and possible Senkaku islands (Hasegawa 1984), and it has bred in northern Taiwan. Populations are small at this northern end of the species' range, with fewer than 1000 pairs in the Ryukyus (Hasegawa 1984) and perhaps 1000 pairs at one site in the Pescadores (Melville 1984). Recent and systematic censuses are so lacking that general breeding distribution is really only suggested. It is not known if the TNP race is migratory/dispersing, or, if so, where they spend the nonbreeding season. Thus, its population health in the TNP cannot be assayed.

2.7. Brown Noddy *Anous stolidus*

The Brown Noddy is an offshore-feeding, usually ground-nesting and nonresident pan-tropical tern. It occurs in the TNP (*pileatus*) in apparently small numbers in the Pescadores (± 3000 pairs; Melville 1984), in the Bonin, southern Ryukyu, Senkaku, and Marcus islands (Hasegawa 1984), and formerly (?) in the Taiwan Strait (Cheng 1987). The main TNP *pileatus* population (91–138 000 pairs) is in the Hawaiian Islands (Harrison 1990), with another 2000+ pairs on Johnston and Wake (Fig. 4). Asiatic populations are small, uncensused, and probably threatened by development and disturbance, but the Hawaiian birds seem to be doing well.

2.8. Caspian Tern *Sterna caspia*

The Caspian Tern is a nearshore feeder with coastal and inland breeding populations on all continents other than South America and Antarctica. Although most individuals nest in north and south temperate areas, it does enter the tropics in both Africa and Australia. In the TNP nominate *caspia* breeds locally from Washington south to central Baja, and again on the China coast in Liaoning, Shandong, and Fujian provinces (Cheng 1987) (Fig. 5). The health of populations in Asia is unknown; in North America, Caspian Terns may be increasing in coastal Washington/Oregon, and are stable in California and in Baja. North American birds normally winter south to southern Mexico, whereas Asiatic birds overwinter primarily in Japan, and occasionally further south in southeast Asia.

2.9. Chinese Crested Tern *Sterna bernsteini*

The Chinese Crested Tern is a TNP endemic and the rarest tern in the world. As a "crested" tern it is presumably an inshore-feeder, but its ecology is undescribed. Its breeding grounds are also unknown, but are assumed to be in coastal Shandong Province in eastern China—largely because the last known specimens were taken there in 1937 (Shaw 1938) (Fig. 3). Until recently, these were the last records in the world,

but in 1980 a flock of 10–20 was reported in July near Libong in southern Thailand (Bain and Humphrey 1982). There also have been recent reports from the Philippines (e.g., Dickinson and Eck 1989), one of the areas from which winter specimens are known, the others being coastal China (Foochow), Sarawak, Halmahera, and the Moluccas. Mees (1975) suggests that *bernsteini* might have been overlooked because its plumages and field marks were not well described or it might have been confused with the far more common *bergii* or *bengalensis* (Lesser Crested Tern), especially south of China.

2.10. Common Tern *Sterna hirundo*

The Common Tern is a widespread inshore species represented in the TNP by *longipennis*. This distinctive subspecies breeds along the Sea of Okhotsk, on Kamchatka, and on Sakhalin (Dement'ev and Gladkov 1951; Kaverkina 1986; Kondratiev 1991; Litvinenko and Shibaev 1991), as well as in coastal China (Shandong Province; Cheng 1987); Russian populations are estimated to be in excess of 2000 pairs (Table 2). A long-distance migrant, *longipennis* passes in numbers through Japan, winters between southeastern Asia and Australia, and seems to be in good health at this time.

2.11. Crested Tern *Sterna bergii*

The Crested Tern is a tropical/subtropical oceanic and coastal feeder and the largest in the "crested" tern group. It occurs from the central Pacific and Australia to the Indian Ocean and along the west coast of Africa to Namibia. In the TNP *cristatus* has bred locally along the Asian coast as far north as Fujian Province in coastal China and in the Pescadores (Melville 1984), and possibly at one site apiece in the Bonin, Ryukyu, and Daito islands (Hasegawa 1984) (Fig. 3). Several colonies on Keelung and other islands off Taiwan have been described by Hachisuka and Udagwa (1951) as "large," but there are only a few isolated colony counts in the TNP. Asiatic populations presumably migrate southwards after breeding, but their wintering areas are not clearly known. The Crested Tern's exact population health in the TNP is unknown.

2.12. Elegant Tern *Sterna elegans*

The Elegant Tern is a nearshore-feeding, Sea of Cortez endemic tern that winters along the Pacific coast from Guatemala to central Chile. There are currently only three known colony sites, the largest (Isla Raza in Mexico) having a population estimated between 10 000 pairs (Schaffner 1986) and 80 000 pairs (Everett and Anderson 1991) (Fig. 2). The best current evidence suggests that Isla Raza contains at least 90% of the species' global breeding population, and perhaps as much as 97%. Four or five other historical colony sites in Mexico which have not been surveyed since the early 1900s should be investigated; immediate protection of all occupied sites is required. In the last few decades two or three colonies have expanded or been established in southern California; they now total nearly 2000 pairs, although numbers vary considerably from year to year. Elegant Terns' breeding population health seems tied to that of its principal food in the area, the anchovy *Engraulis mordax*. Elegant Terns should be immediately designated as Endangered.

2.13. Forster's Tern *Sterna forsteri*

The Forster's Tern is a monotypic, marsh-nesting, North American endemic that is most numerous inland and along the Atlantic and Gulf of Mexico coasts, where it forages in estuarine and nearshore locations. Occurring in western North

America from inland British Columbia south, it reaches the TNP only in salt marshes along the Pacific coast from the greater San Francisco Bay area south to San Diego Bay, with a stable population of about 1800 breeding pairs (Carter et al. 1990). The first Mexican breeders (30 pairs) were recently found in two different lagoonal salt marshes in Baja, some 300 km south of San Diego Bay (Palacios and Alfaro 1991) (Fig. 5). In winter, *forsteri* occurs coastally from central California south to Guatemala, inland and coastal individuals apparently mixing. It is not yet known where Baja and coastal California breeders winter.

2.14. Gray-backed Tern *Sterna lunata*

The Gray-backed Tern is a central tropical Pacific endemic that forages near shore on neuston. It occurs only in Hawaii, where its population is estimated in the neighbourhood of 36–52 000 pairs, plus a few hundred pairs on Johnston Atoll (Harrison et al. 1984); whether it still breeds on Wake is uncertain (Fig. 1). No reliable estimate exists for the species' total population size, but populations elsewhere are on the order of that recorded for the TNP. Before World War II it was reported breeding on Marcus Island (Kuroda 1954), and its extirpation there may typify its vulnerability to disturbance. It was recently found breeding in the northern Marianas (Clapp and Hatch 1986), where the population is about 1000 pairs (Reichel 1991).

2.15. Gull-billed Tern *Sterna nilotica*

The Gull-billed Tern is a cosmopolitan, freshwater/inland species with a disjunct distribution on all continents in warm-temperate/subtropical areas. It nests on marshes as well as on sandy/cobbled shores and islands. *Nilotica* reaches the TNP in only two areas. On the coast of China, *affinis* (= *addenda*) is listed by Cheng (1987) as a breeder, but no numbers or colony sites are known. On the eastern Pacific shore, about five pairs of *vanrossemei* breed in the San Diego area, and fewer than 100 pairs occur in two colonies along the Salton Sea (C.A. Molina, pers. commun.) (Fig. 1). Because the entire known population of *vanrossemei* is only about 100 pairs, its designation as Endangered is warranted. Most populations winter in tropical estuarine areas; presumably the small TNP populations behave similarly. Its health in the TNP should be considered precarious.

2.16. Least Tern *Sterna antillarum*

The Least Tern, recently separated from *albifrons*, is an inshore-feeding North American endemic that is most abundant on the Atlantic and Gulf coasts. Inland and coastal California/Baja populations (the latter being *browni*) have been designated as Endangered. *Browni* breeds from southern Baja north to San Francisco Bay. Only a few recent data are available from Baja where it is rare and local, but numbers probably exceed 300 pairs (Everett and Anderson 1991). In California the population is stable at about 1000 pairs (Ainley and Hunt 1991); most are protected and/or managed (Fig. 4). *Browni* apparently winters along the Pacific coast from Baja to southern Mexico.

2.17. Little Tern *Sterna albifrons*

The Little Tern is represented in the TNP by the western Pacific form *sinensis*. It is a littoral feeder nesting in widely dispersed colonies on beachfronts from southern Japan and Korea south along the China coast through the Philippines to New Guinea (Vaurie 1965; Hasegawa 1984; Cheng 1987). *Sinensis* may be undergoing a range expansion, with recent (?)

colonizing of Saipan (15°N, 146°E) in the northern Marianas (Reichel et al. 1989) and presumed breeding in the northwestern Hawaiian Islands (Conant et al. 1991) (Fig. 4). There is no information on total numbers of *sinensis* breeding in the TNP.

2.18. Roseate Tern *Sterna dougallii*

The Roseate Tern is a nearshore feeder which usually nests on sandy islands. The species has a disjunct breeding range in eastern North America, northwestern Europe, and southern Africa (endangered in all three areas), the West Indies, Australia, and the Indian Ocean west to central East Africa. In the TNP, *bangsi* breeds (or has bred) on islands off the Asiatic coast in Fujian and Zhejiang provinces, China (Cheng 1987), formerly on Taiwan (Melville 1984), and at least into the 1970s, at eight sites in the Ryukyus, where two colonies totalled 700 pairs (Hasegawa 1984) (Fig. 5). The health of the population in the TNP is unknown.

2.19. Royal Tern *Sterna maxima*

The Royal Tern is a nearshore, subtropical/tropical "crested" tern with one subspecies resident on the West African coast, and the other (n nominate *maxima*) ranging along the southeastern Atlantic and Gulf coasts, through the West Indies, and sporadically down the east coast of South America. It just penetrates the TNP in Mexico's Sea of Cortez where 8–10 000 pairs breed at several sites, often in dense colonies with *elegans* (Everett and Anderson 1991). It has also bred sporadically with *elegans* in southern California (McCaskie 1988) (Fig. 3). In winter birds depart the colony areas, and may be found as far north as southern California or as far south as the west coast of South America. At the moment, the species seems in good health in the TNP.

2.20. Sooty Tern *Sterna fuscata*

The Sooty Tern is a widespread, pan-tropical and pelagic feeder, and is possibly the most abundant bird in the world (ca. 40 million pairs). In the TNP *oahuensis* is most numerous in the Hawaiian Islands, with a population estimated at between one and two million pairs (Harrison 1990), with up to another 450 000 on Wake and Johnston. Elsewhere in the TNP, colonies of *oahuensis* in the Japanese islands are largely uncensused. Abe et al. (1986) reported an average of 4500 pairs in the southern Ryukyu Islands in 1981–1983. The estimated 500 pairs on Marcus Island in 1952 (Kuroda 1954) represent an enormous decline, presumably a result of the feather trade, from the "hundreds of thousands" present there in 1902 (Bryan 1903). To the east, *crissalis* was recently "rediscovered" on Alijos Rocks off Baja, where the population is ca. 250 pairs (Pitman 1985)—the only TNP breeding Sooty Terns known east of Hawaii (Fig. 1). Hawaiian birds probably winter in the Philippine Sea. The total TNP Sooty Tern population is probably only about 5% that of the world's, and the species seems in good health.

2.21. White Tern *Gygis alba*

The White Tern is a tree-nesting, offshore-feeding, oceanic, migratory, pan-tropical species of the south Atlantic, central Indian, and central/western Pacific oceans. In the TNP it reaches its northernmost limits, occurring certainly only in the Hawaiian Islands (*rothschildi*), where its population is estimated at 8–16 000 pairs, with another 45 pairs or so on Johnston Atoll (Fig. 5). Bryan (1903) called the species "common" on Marcus Island; if tern populations have recovered there, *candida* (regarded by some as a separate species) might have

recolonized that site, although we are unaware of its having been recently surveyed. Because there have been only two inter-island banding recoveries out of more than 1000 bandings of White Terns in the northwestern Hawaiian Islands and on Johnston Atoll, it seems likely that postbreeding White Terns disperse at sea.

3. Conservation concerns

Known problems include habitat loss to development, especially of beachfront and nearshore islands, with attendant human activity and pets. Shorefront ground nesters such as *albifrons* have been especially hurt by the proximity of coastal development. Population pressures on the coast of southeast Asia, coupled with eggng and killing of adult terns, have doubtless led to drops in numbers of terns along the southeast Asiatic coast (*anaethetus*, *bergii*, *dougallii*, *fuscata*, *minutus*, *stolidus*, and *sumatrana*).

It cannot be overemphasized that the endemic seabird avifauna in the Sea of Cortez and on both shores of Baja California is at risk from tourism, increased resort activities, eggng pressures, and the anchovy fishery problems discussed earlier. This remarkable area has six endemic species of seabirds (Black-vented Shearwater *Puffinus opisthomelas*, Least Storm-Petrel *Oceanodroma microsoma*, Yellow-footed Gull *Larus livens*, Heermann's Gull *L. heermanni*, *Sterna elegans*, and Craveri's Murrelet *Synthliboramphus craveri*), and the specific status of two endemic Leach's (?) Storm-Petrels (*O. leucorhoa socorroensis* and *O. l. cheimommestes*) has not been examined biochemically. This fauna needs further censusing, taxonomic clarification, protection, management, and ecologically based regional planning (Anderson and Keith 1980; Anderson 1983; Everett and Anderson 1991).

Military activities have probably been both bane and boon to TNP terns. Various species of rats are now on Pacific islands where they had not been before World War II; large portions of Midway, Kure, and French Frigate Shoals were altered for base and runway construction; and the U.S. Coast Guard crushed more than 30 000 *fuscata* eggs on Tern Island (French Frigate Shoals) as recently as 1977 (Harrison 1990). On the plus side, the mere presence of military bases has preserved major coastal and island locations from development (the largest California colony of Endangered *albifrons browni* is on Fort Ord; the planting of Casuarina trees on Midway Atoll led to the largest populations of *alba* and *minutus* in the TNP indeed, larger than on most relatively unaffected atolls and islands elsewhere. Paradoxically, dispute over various islands in southeastern Asia (Kurils, Senkakus, Pescadores [Penghu Leidao], islands off Korea, among others) has kept people and domestic animals to a minimum, benefiting breeding terns in an increasingly stressed area.

Direct consumption of adult terns may still take place along the coast of southeast Asia, but elsewhere is no longer a problem. Eggng, however, still occurs throughout southeast Asia (e.g., Japan, Hasegawa 1984), and even though abundant *fuscata* is most frequently involved, local reductions or extirpations can still occur. Eggng is also a source of concern for *dougallii* in coastal China (Melville 1984), *sinensis* in coastal Korea (Won 1988), and endemic *elegans* in Baja (Jehl 1984). Legal protection of seabirds including terns is the norm in Russia, North America, and Hawaii, but in Asia the picture is quite different. Although all terns are fully protected in Taiwan, they are all unprotected in mainland China (Melville 1984), and for reasons unknown to us, in Japan all but *sinensis* are

protected (Hasegawa 1984). Everywhere, though, legal protection is meaningless without adequate enforcement, and enforcement is often inversely related to colonies' isolation, even infrequent raids on an isolated colony can be devastating.

The effects of exotic species on insular birds have been addressed in a recent book (Moors 1985), readers are particularly referred to Atkinson's review chapter on exotic rats on Pacific Islands. In Hawaii, rats of three species have played a role in local extirpations of various seabirds including terns, chronicled by Harrison et al. (1984), who also discuss the adverse effects of a wide array of noxious exotics, including such unexpected candidates as Common Mynas *Acridotheres tristis* that harass nesting *alba* and *minutus* on Midway (Grant 1982). Two interesting aspects of exotic rat ecology are pointed out by Atkinson (1985): (1) World War II resulted in the only statistically significant (and major) increase in rat colonization of islands in the entire period since 1840; and (2) not all rats are equal in their effects on seabirds: the tree-climbing abilities of *Rattus rattus* are not always appreciated.

Organochlorine pollutants are well-known to have adversely affected seabird numbers along the California coast (e.g., Anderson et al. 1975). Among terns, high mortality in young *caspia* in San Diego Bay was associated with high DDE levels (9.30 ppm in eggs) although adjacent *elegans* eggs had significantly lower concentrations (3.79 ppm, Ohlendort et al. 1988). In San Francisco Bay, *caspia* also showed high levels (6.93-7.64 ppm) and adjacent *forsteri* was much lower (1.92 ppm). Oddly, eggshell thickness was found to be correlated with DDE levels in *forsteri* but not in *caspia* or *elegans* (Ohlendort et al. 1985, 1988). In general, present levels of organochlorines in terns along the North American Pacific coast are declining and at levels not threatening populations (Henry et al. 1982; Elliott et al. 1989).

The state of chemical pollution along the Asiatic coast is much less clear. We have been unable to find any published information from Russia or Korea, and although industry-related pollution is well studied in Japan (e.g., Tanabe et al. 1989; Phillips and Tanabe 1989), effects on seabirds, especially terns, are apparently unrecorded. China is devoting increasing attention to marine pollution problems (e.g., Zhijie 1989b), and recently has focused on the Bohai Sea, the almost-enclosed northwestern arm of the Yellow Sea (Huang Hai), where oil concentrations in the water column had reached 130 ppm in the late 1970s (Zhijie and Zhang 1988) and heavy metal and other pollutant levels were high enough to be causing human health problems (Zhijie 1989b). Strict controls and cleanup efforts have now reduced ambient oil levels to about 13 ppm. Although the effects of these oil levels on tern reproduction are unknown and are undocumented within China, fishery resources in the area have been badly damaged (Zhijie 1989a). The implications of these findings for the conservation of TNP terns are immediate: the world's last known breeding location for *bernsteini* was in 1937 from Quingdao, near the mouth of the Bohai Sea. As if that were not enough, one of the important wintering areas of *bernsteini* has been suspected of being in coastal Thailand where marine pollution is also severe (Hungspreugs et al. 1989).

4. Recommendations

- (1) **Species distributions and numbers** are required as rapidly as possible for: (a) *bernsteini* in China, and possibly also in Thailand if it breeds or winters there; (b) *antillarum (browni)* and *nilotica vanrooyeni* along

the eastern border of the Gulf of California; (c) all species of terns breeding in Russia, Korea, China, and Japan; (d) the entire winter ranges of *aleutica* and *lunata*; (e) all other adult TNP terns on their wintering/postbreeding grounds; (f) immature terns of all TNP species.

- (2) **Identified threats to TNP terns** need to be investigated by: (a) monitoring alterations in the prey community of coral reefs as a result of environmental degradation; (b) monitoring levels of eggng and disturbance to terns along the coasts of eastern Asia; (c) implementing monitoring of chemical pollutants in terns of the Hawaiian Islands and the Asiatic coast; and (d) identifying problems with exotic animals and implementing control programs.
- (3) **Protection efforts** should be undertaken immediately as follows: (a) China should declare *bernsteini* an Endangered species and initiate plans to locate and protect all surviving colonies and sites; (b) China should also promulgate regulations fully protecting all tern species occurring there; (c) Japan should add *sinensis* to its list of protected species; (d) the United States and Mexico should designate both *elegans* and *nilotica vanrossemi* Endangered and begin joint recovery programs; (e) census, protection, and enforcement efforts in Baja California/Sea of Cortez seabird colonies of all species should be escalated and integrated with ecotourism and regional planning.

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