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THE NEAR-SHORE AVIFAUNA OF THE MIDDLE AMERICAN WEST COAST[1]

JOSEPH R. JEHL, JR.

THE long-standing and intense interest ornithologists have shown in the land birds of Middle America has not been mirrored in studies of marine birds. The limited data on seabirds in the major distributional studies (Griscom 1932, Dickey and van Rossem 1938, Friedmann et al. 1950, Slud 1964, Wetmore 1965, Monroe 1968, Land 1970) pertain almost entirely to those large and conspicuous resident species that nest colonially and occupy coastal waters (e.g., *Pelecanus occidentalis*, *Fregata magnificens*, *Sula leucogaster*, *Phaethon aethereus*). Data on the distribution, abundance, ecology, and migration of more pelagic species are either fragmentary, inferred, or nonexistent. For example, trans-equatorial migrants from each hemisphere cross the mid-latitudes twice annually, en route to and from their breeding grounds. Yet most of the species of shearwaters, petrels, gulls, jaegers, terns, and phalaropes that might reasonably be expected to occur regularly have not even been reported—much less studied—along most of the Middle American coast. For ornithologists, the lure of the tropics seems not to have extended far seaward of the sandy beaches.

Oceanographic research off the Pacific coast of Middle America has intensified in recent years, largely as a result of studies supported by the Inter-American Tropical Tuna Commission. The region is one of high biological productivity, and it supports fisheries of great commercial importance. In view of the association between seabirds and fish, as well as the practical possibility of using seabird flocks as an indirect index to the size and location of fish populations, the absence of

[1] This paper is dedicated to Carl Leavitt Hubbs on the occasion of his eightieth birthday, 18 October 1974, in recognition of his outstanding contributions to the field of vertebrate biology.

detailed and quantitative ornithological information is all the more surprising.

From 29 March to 23 April 1973 I participated in a research expedition (M/V 73–1) of Scripps Institution of Oceanography, led by Dr. Carl L. Hubbs. The expedition's major purpose was to investigate offshore demersal and pelagic fish populations in the region between the Tres Marías Islands, Mexico, and the Gulf of Nicoya, Costa Rica. We made studies almost from the beach to as much as 60 miles at sea but mostly in deep water over the Middle America Trench 15 to 25 miles offshore. This paper presents the ornithological results of that expedition. Except for data in the Eastropac Atlas Series (Love 1970–72), there appear to be no published quantitative studies of seabird populations in the region. Murphy (1958) reported the results of a winter transect from Panama to San Diego in November–December 1956.

The bulk of this paper is based on sight records, in many cases of species that have not been reported previously from many areas off Middle America. Specimens were collected when possible, and additional identifications were verified through photography; notes on field identification are given for some species. I have not attempted to review the known status of each species, as the published data are so few as to be misleading. Nor have I attempted to point out all of the probable "first" records. Those interested in constructing faunal lists for particular Mexican states or Middle American countries should find the data in Table 1 sufficiently detailed for their purposes.

METHODS

The R/V 'Alexander Agassiz' departed La Paz, Baja California, on the afternoon of 29 March, proceeding southward west of Espiritu Santo and Cerralvo islands; 30 March and 1 April were spent in the vicinity of the Tres Marías Islands; and from 2 to 4 April we sampled fish faunas within 10 miles of shore, and usually much closer, from Jalisco to northern Guerrero. From 5 to 9 April we cruised 5 to 20 miles off the Mexican coast, passed Acapulco early on the 7th and landed at Salina Cruz, Oaxaca, on the morning of the 9th.

On the afternoon of 9 April we left Salina Cruz and spent the period through 11 April approximately 25 miles off the coast of southern Chiapas and northern Guatemala. We were 30 to 60 miles south of Champerico, Guatemala, from 12 April through the afternoon of the 15th. We then went eastward, approximately 20 miles from shore, to the Gulf of Fonseca, arriving on the morning of 17 April and spending much of the day within several miles of the beach. On the afternoon of the 17th and on the 18th our route lay 25 to 35 miles off the coast of Nicaragua. We spent 19, 20, and 21 April 5 to 20 miles off the Nicoya Peninsula of Costa Rica, and on the 22nd we were mainly in the mouth of the Gulf of Nicoya. The cruise ended at Puntarenas, Costa Rica, on 23 April (Fig. 1).

General observations were made throughout the day by me and other members of the scientific party, as well as by some members of the ship's crew.

Fig. 1. The survey area, showing major currents (arrows), the Middle American Trench (stippled), and the cruise route (dotted line).

All quantitative data were recorded by me, and only when the ship was under way. All birds were counted, except for ship-following species (mainly Black Storm-Petrels and Pomarine Jaegers), the numbers of which were estimated at approximately hourly intervals.

For increased accuracy, censuses were sometimes divided into a morning (A) and an afternoon (P) period. The data are presented as birds per hour of observation in Table 1, which also gives information on hours of observation and sea surface temperature; latitude and longitude data refer to the ship's position at the end of the census period (usually 1200 and 1800). Sea surface temperatures were taken frequently, but always near the end of the census period. All specimens and documentary photographs are deposited in the San Diego Natural History Museum (SDNHM).

Oceanography

The oceanography of the eastern tropical Pacific Ocean has been reviewed in detail by Wyrtki (1966, see also Wooster and Cromwell

TABLE 1
RESULTS OF DAILY CENSUSES[1]

	La Paz, B.C., Mexico, to Salina Cruz, Mexico																
	March 29	30A	30P	31	April 1	2	3	4	5	6	7A	7P	8A	8P	10A	10P	11
Puffinus creatopus	—	—	0.2	—	0.5	—	0.2	0.3	3.0	—	—	3.0	2.6	10.0	—	—	—
P. pacificus	—	—	—	—	—	1.0	0.2	—	—	—	—	0.5	0.3	0.8	—	1.2	0.3
P. puffinus/ auricularis	0.7	—	0.7	0.8	2.0	2.5	0.5	—	0.3	1.5	0.3	—	—	—	—	0.3	—
P. lherminieri	—	—	—	—	—	—	—	—	1.2	—	—	—	—	—	1.0	1.4	10.4
Oceanites oceanicus	—	—	—	—	—	—	0.5	—	1.2	2.0	—	—	0.6	0.2	—	—	—
Oceanodroma leucorhoa	—	—	—	—	—	—	0.2	0.3	0.3	—	+	—	—	0.2	—	—	0.2
O. melania	12.5	12.2	15.0	23.0	8.0	15.0	10.0	2.2	13.3	15.0	0.6	2.0	1.6	0.5	+	0.6	0.8
Halocyptena microsoma	19.0	1.6	50+	2.0	2.0	24.0	2.5	5.0	2.3	5.2	0.6	—	—	—	—	0.3	0.2
Phaethon aethereus	0.7	0.8	—	0.2	1.0	0.5	0.2	0.8	—	+	—	0.2	—	—	0.5	—	—
Sula dactylatra	—	—	—	—	—	—	—	—	—	—	—	0.5	—	2.5	—	0.8	0.2
S. sula	—	—	—	—	—	—	—	—	—	—	—	8.5	1.6	2.5	+	—	0.5
S. leucogaster	15.0	4.4	—	2.5	1.0	7.5	7.5	1.3	17.0	11.0	0.3	3.5	10.8	8.5	0.5	0.3	—
Fregata magnificens	5.0	1.8	4.5	2.0	3.0	1.0	—	0.3	—	0.5	0.3	—	2.6	—	4.0	—	—
Phalaropus fulicarius	—	—	—	2.4	4.0	4.5	2.2	—	+	—	—	0.7	4.0	1.8	—	—	—
P. lobatus	—	—	1.2	0.4	12.0	21.0	18.0	14.0	3.3	11.0	20.0	—	4.8	5.8	6.0	1.5	1.0
Stercorarius pomarinus	—	0.6	—	0.2	—	1.5	1.5	3.8	11.0	10.0	1.3	3.2	1.6	2.8	+	0.5	1.1
S. longicaudus	—	—	—	—	—	—	—	—	0.6	1.5	0.3	—	—	—	—	—	1.3
Larus atricilla	—	—	—	—	—	18.0	0.5	+	—	+	—	—	—	—	—	—	0.2
L. pipixcan	—	—	—	—	—	—	+	+	—	1.5	—	—	—	—	+	0.1	—
Xema sabinii	—	—	—	0.4	0.5	2.5	0.7	+	0.3	1.5	—	—	0.3	—	+	0.3	1.0
Sterna hirundo	—	—	—	—	0.5	47.0	0.2	—	—	0.5	1.0	—	—	—	1.0	1.0	2.3
S. fuscata	—	0.4	5.2	21.0	9.0	—	—	—	1.3	—	—	—	—	1.2	—	—	—
Chlidonias niger	—	—	1.2	38.0	6.0	3.0	—	0.3	0.3	23.0	16.0	—	—	—	—	18.0	16.0
Latitude	24 00	22 06	21 59	21 56	21 12	19 34	18 14	18 05	17 51	17 25	16 09	15 43	15 39	15 35	15 27	14 50	14 25
Longitude	109 04	106 37	106 20	106 23	106 08	105 06	103 21	102 57	102 03	101 17	99 01	98 03	97 59	96 44	93 52	93 59	92 39
Sea temperature °C	22.0	22.2	22.2	22.8	22.8	22.5	25.0	25.6	25.0	26.0	27.0	27.8	27.8	27.8	29.0	29.0	30.5
Hours of observation	4	5	4	5	2	2	4	3.5	3	2	3	4	3	4	2	6	6

[1] Abundance indicated is number of birds per hour. + indicates species was seen but not in census period. Includes species seen on 5 or more days. Coordinates give ship's position at end of each census period.

TABLE 1—Continued

	Salina Cruz, Mexico, to Puntarenas, Costa Rica															
	12	13	14	15A	15P	16	17	18A	18P	19A	19P	20	21A	21P	22A	22P
Puffinus creatopus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P. pacificus	0.5	1.2	1.5	1.6	500.0	3.3	—	—	—	9.0	—	0.4	1.1	0.5	0.5	—
P. puffinus/ auricularis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P. lherminieri	0.4	4.5	0.5	0.3	1333.0	6.0	—	—	—	1.2	1.2	—	0.2	—	0.2	—
Oceanites oceanicus	0.4	0.6	0.5	—	10.0	—	—	—	—	—	—	—	0.2	—	—	—
Oceanodroma leucorhoa	0.2	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—
O. melania	1.0	12.0	7.5	8.3	5.0	0.6	0.3	0.5	—	1.7	1.2	1.8	3.2	4.0	2.0	1.0
Halocyptena microsoma	—	1.2	—	—	—	—	—	—	—	—	—	0.1	—	—	0.5	—
Phaethon aethereus	—	—	—	—	—	—	0.3	—	—	+	—	—	—	—	—	0.5
Sula dactylatra	0.8	1.2	0.5	—	2.3	9.0	—	1.0	0.3	—	—	0.3	0.2	—	—	—
S. sula	0.8	1.2	1.0	0.6	2.0	1.3	0.3	0.5	—	—	—	—	—	—	—	—
S. leucogaster	—	—	—	—	0.3	—	1.6	—	—	0.8	—	0.2	1.1	15.0	10.0	2.0
Fregata magnificens	—	—	—	—	—	—	+	—	—	0.8	—	0.4	0.2	1.5	—	—
Phalaropus fulicarius	—	0.6	—	1.6	—	1.0	—	5.0	0.3	—	—	—	—	45.0	—	—
P. lobatus	0.1	3.3	0.5	—	1.6	0.6	—	—	—	—	—	0.5	—	4.0	—	2.0
Stercorarius pomarinus	2.5	6.0	3.5	2.6	17.0	5.0	1.0	1.5	2.0	0.7	—	0.5	1.2	0.5	—	0.5
S. longicaudus	—	—	—	—	—	0.3	0.3	—	0.3	—	—	—	—	0.5	—	—
Larus atricilla	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
L. pipixcan	0.6	1.3	1.5	0.3	0.6	+	+	2.0	4.0	—	—	0.7	—	0.5	—	0.5
Xema sabinii	0.2	0.7	1.0	—	1.0	0.6	1.0	1.0	—	2.0	2.2	—	0.2	1.0	—	2.5
Sterna hirundo	—	3.3	0.5	—	0.3	—	+	—	—	0.5	—	—	—	—	0.5	0.5
S. fuscata	—	—	—	—	—	—	1.0	—	—	—	—	—	—	—	—	—
Chlidonias niger	—	6.3	5.0	0.6	20.0	4.3	+	1.5	1.0	3.7	0.3	0.1	1.2	6.5	—	—
Latitude	13 09	13 30	13 30	13 05	13 48	13 13	13 00	11 21	10 53	9 29	9 42	9 40	9 42	9 30	9 28	9 28
Longitude	92 08	92 00	92 04	92 05	92 01	89 50	88 05	86 46	86 24	85 10	85 34	85 53	85 50	84 50	85 51	84 22
Sea temperature °C	31.1	30.0	31.1	31.1	30.5	30.0	29.0	24.4	26.7	29.0	29.0	29.0	30.0	30.0	30.0	30.0
Hours of observation	10	1.5	2	3	3	3	3	2	3	4	3.5	7	5	2	2	2

1958). The major features that may pertain to the ecology of pelagic birds in the survey area are discussed briefly below.

Along the coast of Central America the continental shelf is extremely narrow and exceeds a width of 30 miles only between the Gulf of Tehuantepec and Nicaragua. The continental slope is steep, and the most impressive feature is the Middle America Trench, a vast depression that parallels the coast at distances of 18 to 90 miles and extends from the Tres Marías Islands, Mexico, to the Cocos Ridge southwest of Costa Rica. It is continuous "at depths greater than 2400 fathoms (4400 m) for 1260 miles, except off Manzanillo and Zihuantanejo, Mexico, where submarine mountains lie in the trench. It is deeper than 3000 fathoms (5500 m) for 380 miles as the Guatemalan Deep" (Fisher 1960). The geological significance of this and similar trenches bordering continents to studies of plate tectonics has only recently become clear. Its biological significance is that it creates deep water environmental conditions close to the Central American landmass.

Surface circulation in this region is complicated and varies from month to month, but three basic seasonal patterns can be recognized. From February to April, which includes the period of the present study, "the intertropical convergence is in its most southerly position near 3° N. During this period the California Current is strong, penetrates far to the south, and supplies most of the water for the North Equatorial Current. Off the coast of Mexico between 10° and 20° N the circulation is anticyclonic with a flow to the southeast along the coast that turns west off the Gulf of Tehuantepec. The Equatorial Countercurrent is completely absent during this period, and in that area where it is usually found, water movements are to the west and northwest. Off the coast of Central America two huge eddies are developed; one is cyclonic around the Costa Rica Dome, and the other is anticyclonic around a point at 5° N, 88° W (Wyrtki 1965: 277). The major features of this pattern are shown in Fig. 1.

Surface salinities are relatively uniform, ranging from a high of 35‰ at the mouth of the Gulf of California to 34‰ off Costa Rica. Bennett (1966) states that the highest salinities for the year along the southern coast of Mexico (20–14° N) are attained in April and May and average greater than 34‰.

Surface temperatures are much more variable. Some of the warmest waters in the eastern tropical Pacific are found in a broad band extending from Panama to Guerrero, Mexico (Eber et al. 1968). Farther north temperatures decline rapidly under the influence of the California Current. We found surface temperatures greater than 29°C from the Gulf of Tehuantepec to the Gulf of Nicoya, and the warmest waters (31°C) more than 30 miles off the coast of Guatemala.

The near-shore waters are highly productive. The thermocline lies very close to the surface and, as a result, vertical mixing is good and surface concentrations of silicates and phosphates are high (Cromwell 1958; Wooster and Cromwell 1958). Chlorophyll levels, primary production, and zooplankton volumes are also very high (Holmes et al. 1957). The eastern tropical Pacific is also characterized by the presence of a pronounced oxygen minimum layer. In the survey area it varies between 1000 and 1200 m in thickness and may come to within 50 m or less of the surface; it contains less than 0.25 ml/1 of dissolved oxygen. Few forms of life are adapted to these conditions, and the great thickness of the almost oxygen-free barrier seems sufficient to preclude the vertical migration of most fishes and invertebrates from greater depths into the surface layers. The ornithological consequence is that seabird faunas in the area must rely largely or entirely on the productivity of the upper 50 m of the sea.

Species Accounts

Parkinson's Petrel (*Procellaria parkinsoni*).—The occurrence of this species was unexpected. On 14 April at 13° 15′ N, 92° 04′ W, approximately 50 miles off the coast of Guatemala, a Parkinson's Petrel landed near the stern of the ship (Fig. 2). For 3 hours it followed the ship, robbing bait from fishhooks and chasing Pomarine Jaegers from choicer bits of table scraps we tossed over the side. Although it was often within shotgun range, it was not collected because trawling operations in progress made retrieving the specimen impossible.

On 21 April at 9° 42′ N, 85° 12′ W, approximately 17 miles off the Nicoya Peninsula of Costa Rica, another Parkinson's Petrel landed near the ship and was collected. The next day, Richard Lee, a graduate student at the University of California, Santa Barbara, saw another individual which he carefully described to me, about 5 miles south of the entrance to the Gulf of Nicoya. It, too, landed near the stern looking for scraps of food. All three birds were seen in waters where the surface temperature was 30–31°C.

The specimen (SDNHM No. 38460) was a female, largest ovum 2 mm, weight 675 g, little subcutaneous fat; molt was evident over most of the body, and all but the outer two remiges had been replaced. Measurements: exposed culmen 42.0, tarsus 56.6, tail 99, wing (chord) 340 mm. The bird seen off Guatemala had replaced all but the outer four or five primaries. In both individuals the bill was greenish and the legs and feet were black.

In the field, Parkinson's Petrel might be confused with two other species of *Procellaria*, the Shoemaker (*P. aequinoctialis*), which in the Pacific wanders north through the Humboldt Current to Peru, or to the Westland Petrel (*P. westlandica*), which has not been reported away from the Australia-New Zealand region. Parkinson's Petrel is much smaller than those species, and its bill is relatively much stouter, which should provide a useful fieldmark. It reminded me more of a Northern Fulmar (*Fulmarus glacialis*) than a Shoemaker. Serventy et al. (1971: 119) state that "at sea it is unlikely that this bird can be reliably separated from the Fleshy-footed Shearwater" (*Puffinus carneipes*). Although both are dark-bellied, light-billed shearwaters, the flight and shape of

Fig. 2. Parkinson's Petrel (*Procellaria parkinsoni*) off the coast of Guatemala at 13° 15′ N, 92° 04′ W: note the extent of molt in the primaries. A Black Storm-Petrel (*Oceanodroma melania*) is in the background.

carneipes is unlike that of a *Procellaria* and the differences should be evident to observers aware of the presence of both species. Because *parkinsoni* was not previously known to occur off Middle America, I suspect that many, if not most, of the sightings attributed to *carneipes* in that region actually pertain to *parkinsoni*.

The identification of the specimen was confirmed by comparison with reference material in the San Diego Natural History Museum and the California Academy of Sciences. Photographs of the Guatemalan bird (on file in SDNHM) confirm its identification as *parkinsoni*; it lacked the white chin of *aequinoctialis* (see Fig. 2) and its bill was shorter and stouter than in that species. By inference, the third bird is also assigned to *parkinsoni*.

Practically nothing seems to be known about the natural history of Parkinson's Petrel. It nests on a few islands off the coast of North Island, New Zealand (where it is known as the Black Petrel), but it is considered relatively rare (Imber 1971). Vooren (1972) stated that it "has not often been identified at sea," and its pelagic distribution in the nonbreeding season is almost unknown, except that R. H. Beck collected three near the Galapagos Islands in 1905–06 (Loomis 1918: 108). On this basis Murphy (1936: 648) stated that it "ranges over the South Pacific from Australia to the Galapagos." The present records, which are the first for the Northern Hemisphere, indicate that Parkinson's Petrels winter regularly in warm water areas off the coast of northern South America and in Central America north to Guatemala.

This idea is supported by two additional unpublished reports of *Procellaria* or probable *Procellaria* off the coast of Panama: a single bird at 6° 59′ N, 79° 45′ W on 25 April 1965, which was reported as *P. aequinoctialis* (Watson and Angle,

MS), but is now considered as "most probably *parkinsoni*" (G. E. Watson, pers. comm.); and two in the same general area on 31 March 1965 (J. P. Chapin *fide* E. Eisenmann). Furthermore in unpublished reports of the POBSP Pelagic Eastropac Cruises, on file in the Smithsonian Institution, are several additional sightings. P. Woodward (Eastern Area Cruise 19, 7 August–26 September 1967) reported a single *P. parkinsoni* on 31 August at approximately 1° N, 98° W. Interestingly, on the previous day he reported a single Flesh-footed Shearwater, the only one of the entire cruise! B. Harrington (Eastern Area Cruise 26, 19 October–3 December 1967) gave a convincing description of a bird thought to be *P. parkinsoni* at ca. 3° N, 98° W on 20 November. R. Crossin (Eastern Area Cruise 36, 19 February–4 April 1968) did not report *Procellaria* in transects between southern Mexico and 20° S. His observations of *Puffinus creatopus* and *P. carneipes* are especially interesting, in that his nine records of *creatopus* are from the vicinity of the Tres Marías (22° N) northward, whereas his eight sightings of *carneipes* are from warm water areas (surface temperatures 23.3–27.4°C) between 12° N and 13° S. As these forms are very closely related, and perhaps conspecific, the disjunct distributions are curious. I suspect that the records ascribed to *carneipes* could pertain to *parkinsoni*.

PINK-FOOTED SHEARWATER (*Puffinus creatopus*).—Uncommon to rare between the Tres Marías and the Gulf of Tehuantepec. The largest flock was 30 off southern Oaxaca. Although this species was sometimes associated with Wedge-tailed Shearwaters, more commonly it occurred in pure flocks. It was distinguishable from that species by its pale bill, heavier flight, and general bulkier shape.

WEDGE-TAILED SHEARWATER (*P. pacificus*).—Uncommon in near-shore waters from Jalisco (Bahía Chamela) to Chiapas, and somewhat commoner from there to the Gulf of Nicoya. Most birds occurred singly or in small flocks, but feeding flocks of 1000 or more were in association with other pelagic species near the head of a submarine canyon at 13° 31′ N, 92° 00′ W off the coast of Guatemala (photos SDNHM). Off Mexico I saw only one black-phased bird. To the south they composed 3–5% of the population. Although this species was found in a wide range of water temperatures, most individuals were seen in waters warmer than 29°C. Buffy or grayish edgings on the mantle feathers give light-phased birds a scaly-backed appearance. As noted by Jenkins (1973), the flight characteristics of this species are reminiscent of *Puffinus bulleri*.

SOOTY SHEARWATER (*P. griseus*).—Very rare. Individuals were seen on only 3 days between the Tres Marías and northern Guatemala.

MANX (BLACK-VENTED) SHEARWATER (*P.* [*puffinus*] *opisthomelas*), TOWNSEND'S SHEARWATER (*P. auricularis*).—The taxonomy and field identification of small dark-and-white shearwaters is a problem. I saw three probable *opisthomelas* in the southern part of the Gulf of California near Cerralvo Island. Farther south, between the Tres Marías and Guerrero, we encountered similar shearwaters, but which were decidedly brownish (most seemed to be excessively worn). Probably these were also *opisthomelas*, and one specimen of that form was collected off the coast of Guerrero on 6 April (SDNHM No. 38461). Several birds in that area seemed to be smaller and more distinctly blackish; they were thought to be *auricularis*. Two brownish birds (*opisthomelas*?) in the southern part of the Gulf of Tehuantepec on 10 April were associated with the smaller, faster-flying, and more sharply marked Audubon's Shearwaters. Except for these last two birds, all *P.* [*puffinus*] *opisthomelas/auricularis* were in waters cooler than 27° C.

AUDUBON'S SHEARWATER (*P. lherminieri*).—Several individuals were seen as far

north as Guerrero, but the species did not occur regularly until we reached warm water areas off the coast of Chiapas. From there to the Gulf of Nicoya it was regular in waters warmer than 29°C. The northernmost previous records are from Oaxaca (Binford 1970). Several flocks totalling 4000 birds occurred off Guatemala near the head of a submarine canyon at 13° 50′ N, 92° 00′ W on 15 April, and approximately 1000 were in the area on 13 April. On both days small groups of two to four, but usually three, calling, chasing birds circled so close to the ship for up to 20 min that they could have been caught in a hand net. Similar pursuit behavior was going on over the open sea away from the boat. There was no set leader in these groups, as the birds constantly alternated position. I assumed that this behavior might represent courtship, but Murphy (1958) noted similar "playful" behavior in November 1956.

A female taken at this locality (SDNHM No. 38463) is referable to the Galápagos race *P. l. subalaris*; weight 175 g, largest ovum 3 mm, wing (chord) 189 mm, tail 74 mm.

When chased by Pomarine Jaegers, Audubon's Shearwaters plunge into the sea and remain submarged for up to 10 seconds. The jaegers swim overhead, patiently marking their progress, until the shearwaters emerge. They then resume the chase and make them disgorge their prey almost immediately.

WILSON'S STORM-PETREL (*Oceanites oceanicus*).—Although this species is considered to be extremely rare in the eastern North Pacific, we found it regular though uncommon between Michoacán and Guatemala. The only observation farther south was of a single bird 15 miles off the Nicoya Peninsula on 21 April. A similar species, *Oceanites gracilis*, has been reported off Panama (Wetmore 1965: 45) and might be expected occasionally to range farther north. That species is smaller than Wilson's Storm-Petrel and has extensive white markings on the lower abdomen. I saw no such birds among the Wilson's Storm-Petrels that closely followed the ship.

GALÁPAGOS STORM-PETREL (*Oceanodroma tethys*).—Three birds assigned to this species were sighted at 12 April at 13° 09′ N, 92° 08′ W, approximately 60 miles off Guatemala. In all respects, except for the white rump, they were remarkably similar to Least Storm-Petrels. They were associated with a small petrel flock that included *Oceanodroma leucorhoa*, *O. melania*, and *Oceanites oceanicus* for comparison. This petrel occurs regularly in the Gulf of Panama (E. Eisenmann) and perhaps off the coast of Mexico. Murphy (1958) reported taking two specimens off Baja California in November 1958 and saw it frequently to the south.

LEACH'S STORM-PETREL (*O. leucorhoa*).—Rare. Scattered individuals were observed between Colima and northern Nicaragua, where one white-rumped bird (SDNHM No. 38480) flew aboard on the night of 7 April. Only one bird, off Oaxaca on 8 April, had a dark rump, though other dark-rumped individuals could have been overlooked among the Black Storm-Petrels. Similarly, Harcourt's Storm-Petrel (*O. castro*), although unreported in the eastern tropical Pacific north of Cocos Island, could have been missed among the white-rumped races of *O. leucorhoa*. The southernmost Leach's Storm-Petrel sighting was just south of the entrance to the Gulf of Fonseca on 17 April.

BLACK STORM-PETREL (*O. melania*).—Common to abundant in near-shore and offshore waters between the Gulf of California and northern Guerrero, much less common southward in waters warmer than 27°C, though regular along the entire route to the Gulf of Nicoya. In the northern part of the area it was not unusual to have flocks of up to 50 (maximum 75) in the wake almost constantly. Twenty

were feeding over the slick of a humpback whale (*Megaptera novaeangliae*) off the coast of Colima. Beef suet was very effective in attracting these birds and they would dive as long as 4 sec in pursuit of sinking pieces. Three females collected 5 miles off the coast of Michoacán on 3 April were approximately 900 miles south of the nearest known breeding colony in the central Gulf of California. All three had enlarged ovaries, and one had a brood patch. Weights, 48.8, 52.4, and 59.4 g.

LEAST STORM-PETREL (*Halocyptena microsoma*).—Although this Mexican species winters off the coast of Panama, it is unreported, except for the casual statement of Murphy (1958) in the area from Guatemala to Costa Rica. We found it common as far south as Oaxaca. Farther south, where water temperatures exceeded 27°C, it was rare, though present to the Nicoya Peninsula. Maximum abundance was near the Tres Marías, where we encountered a flock of 200.

RED-BILLED TROPICBIRD (*Phaethon aethereus*).—Uncommon though regular within 10 miles of the beach, south to Colima. Much rarer southward but scattered individuals were seen to the Gulf of Nicoya. No more than one bird was seen at a time.

BROWN PELICAN (*Pelecanus occidentalis*).—Our few observations of this species were made within 1 mile of the coast. Its absence at sea suggests that it is rare and local over much of the area.

BLUE-FOOTED BOOBY (*Sula nebouxii*).—This is one of the few seabirds that has been recorded along most of the Central American coast. Yet, except for a few near the Tres Marías, our only sighting was a single bird near the Oaxaca coast. Presumably most birds were in the vicinity of nesting colonies farther north.

BLUE-FACED BOOBY (*S. dactylatra*).—Fairly common more than 10 miles from shore and in waters warmer than 27°C between southern Guerrero and Costa Rica. The local abundance of the species off El Salvador on 16 April (up to 20 birds per hour) was related to concentrations of driftwood that gave the birds resting sites. This species was often associated with Red-footed Boobies and feeding flocks of Wedge-tailed Shearwaters.

RED-FOOTED BOOBY (*S. sula*).—The distribution of this species was similar to that of the Blue-faced Booby, although it tended to be more highly pelagic. It appeared suddenly and in good numbers off the coast of Guerrero, as soon as the water temperature exceeded 27°C, and was seen daily as far south as the northern border of Costa Rica. Its absence farther south probably reflects our proximity to shore there. I saw no white-phased individuals.

BROWN BOOBY (*S. leucogaster*).—Common near shore between the Gulf of California and Costa Rica. Rare more than 20 miles from the coast.

MAGNIFICENT FRIGATEBIRD (*Fregata magnificens*).—Fairly common in the southern part of the Gulf of California, near the Tres Marías, and near harbors to Costa Rica. Virtually all were seen within 5 miles of shore.

RED PHALAROPE (*Phalaropus fulicarius*).—Very few published reports and apparently no specimen records exist for this species off Central America. Yet it was uncommon but regular everywhere from Nayarit to Costa Rica. Most were encountered more than 5 miles from shore and usually in association with small flocks of Northern Phalaropes, which afforded good comparison for identification. Few of the birds, except those seen late in the cruise, showed any sign of breeding plumage. The largest concentration was 90 in the mouth of the Gulf of Nicoya on 21 April. Murphy (1958) found it "along course" in November 1956 but gave no locality data south of Baja California.

NORTHERN PHALAROPE (*Phalaropus lobatus*).—Fairly common along the entire coast of Mexico, less common southward to Costa Rica. This species was more likely to occur near shore than was the Red Phalarope, which probably explains why there are so many more Middle American records for it. On 8 and 10 April we saw flocks apparently migrating due north in the Gulf of Tehuantepec. In mid-morning on 10 April, for example, 5–15 miles offshore, we counted 118 birds in 1½ hours, mostly in flocks of 10 or so. This suggests the possibility of a trans-isthmus crossing.

POMARINE JAEGER (*Stercorarius pomarinus*).—Widespread and common, occasionally abundant, along the entire transect, though markedly less common south of the Gulf of Fonseca. As many as 17 followed in the ship's wake on 5 April, and we found a flock of 50 in a large concentration of seabirds off the coast of Guatemala on 15 April. I estimated that 5% of the birds were dark-phased. One collected at 18° 09′ N contained a half-grown oceanic puffer (*Lagocephalus lagocephalus*: Lagocephalidae) 130 mm in standard length; this is a wide-ranging pelagic fish living at or near the surface. It also contained a Panaman lightfish (*Vinciguerria lucetia*: Gonostomatidae) about 40 mm in standard length; this species usually lives below the sea surface, but in some places comes to the surface at night in swarms (Carl L. Hubbs pers. comm.). Weights, 9 males: 486–723 (617) g; 3 females: 690, 704, 716 g.

PARASITIC JAEGER (*S. parasiticus*).—A small jaeger seen at a distance near the Tres Marías on 30 March was tentatively identified as this species.

LONG-TAILED JAEGER (*S. longicaudus*).—Several Long-tailed Jaegers were seen off the coast of Guerrero on 5–7 April: two adults 16 miles off the coast (5 April), three immatures (two collected) and one adult 2 miles offshore (6 April), and an adult 5 miles offshore 20 miles east of Acapulco (7 April). Other observations were: 8 adults harrying Black Terns in the southeastern corner of the Gulf of Tehuantepec near the Guatemala border (11 April), an immature 20 miles off Guatemala (16 April), an adult harrying Franklin's Gulls 3 miles off the mouth of the Gulf of Fonseca (17 April), an adult off the Nicoya Peninsula (18 April), and an immature in the same area (21 April). In Middle America this species has been previously reported only off Mexico (Murphy 1958, Binford 1970) and Panama (Wetmore 1965).

None of the adults had yet developed long central rectrices, although such were present in many adult Pomarine Jaegers. Yet these birds were immediately recognizable by their size, gray backs, large golden collars, and dark crissums. Presumably the slender central rectrices of the Long-tail are more fragile, and thus their replacement is postponed until shortly before the birds arrive on the nesting grounds. G. E. Watson (pers. comm.) reports a specimen in the National Museum of Natural History taken on 7 May 1965 with regrowing central rectrices.

The presence of Long-tailed Jaegers off the central Middle American coast in spring is interesting because the only previous spring record is from Oaxaca, Mexico (Binford 1970) and because they are virtually unknown from the west coast of the United States in spring. I have previously suggested (Jehl and Smith 1970) that Long-tails may arrive on their breeding grounds in the central Canadian Arctic after an overland flight, the exact route of which remains to be determined. If, as seems likely, the species' main wintering grounds are off the northwest coast of South America, the most favorable direct route to the central Arctic would seem to be northwestward along the coast of Middle America to the Gulf of Tehuantepec, thence due north across the Isthmus of Tehuantepec, the eastern side

of the Gulf of Mexico, and the central United States and Manitoba, to the west shore of Hudson Bay. The apparent abundance of Long-tailed Jaegers near the Gulf of Tehuantepec and the scattered late spring records from the central U.S. and Manitoba give some support to this hypothesis. Field studies in the Gulf of Mexico in late spring may add to the few records there (see Williams 1965).

WESTERN GULL (*Larus occidentalis livens*).—An adult (SDNHM No. 38466) collected 17 miles off the coast of northern Guerrero on 5 April apparently represents the southernmost record for this form. The only other sighting was a single bird near the mouth of the harbor at La Paz on 29 March.

CALIFORNIA GULL (*L. californicus*).—A few scattered birds in the lower Gulf of California on 29 March.

LAUGHING GULL (*L. atricilla*).—Uncommon to rare within 2 miles of shore between Jalisco and Oaxaca.

FRANKLIN'S GULL (*L. pipixcan*).—Uncommon but regularly distributed from Jalisco to the Gulf of Nicoya. Most birds were seen within 5 miles of shore, and the species was fairly common at the mouth of the Gulf of Fonseca, but some individuals were observed up to 60 miles from land. A few small flocks were migrating northward along the Nicoya Peninsula on 19–22 April. Over 90% of the birds seen were adults.

BONAPARTE'S GULL (*L. philadelphia*).—One immature in the lower Gulf of California on 29 March.

HEERMANN'S GULL (*L. heermanni*).—Several individuals between the Tres Marías and northern Jalisco.

SABINE'S GULL (*Xema sabinii*).—Uncommon but regular and seen almost daily along the entire route. Although most birds were from 5 to 20 miles offshore, in several places birds were within 1 mile of the beach; others were as much as 60 miles from the coast. Usually I saw only single individuals. Several flocks of 6 to 8 birds working northward along the Nicoya Peninsula on 19–22 April provided the only evidence of migration. Murphy (1958) saw the species "occasionally" between Baja California and Panama in November 1956, but gives no details. Otherwise this gull is unreported between Mexico and Panama.

COMMON TERN (*Sterna hirundo*).—Uncommon, principally near the coast from the Tres Marías to Costa Rica; locally common off the coast of Michoacán on 3 April. At sea most terns did not approach the ship closely and similar species could have been overlooked at a distance. The northward migration route of the Arctic Tern (*S. paradisaea*) is unknown. I made special efforts to look for white-bodied terns well offshore, but saw none. Several Forster's Terns (*S. forsteri*) were present in the harbor at Bahía Chamela on 2 April.

SOOTY TERN (*S. fuscata*).—Seen irregularly between the Tres Marías, where it breeds, and the Gulf of Fonseca. Most birds were feeding over flocks of spotted porpoise (*Stenella graffmani*) with Black Terns and other seabirds.

BRIDLED TERN (*S. anaethetus*).—Two birds seen at a distance among a flock of Black Terns in the southeastern part of the Gulf of Tehuantepec on 10 April were probably Bridled Terns.

LEAST TERN (*S. albifrons*).—Four near the Tres Marías on 30–31 March.

ROYAL TERN (*Thalasseus maximus*).—Several in the lower Gulf of California and near the Tres Marías. Otherwise seen only in coastal waters at Salina Cruz, Mexico (10 April), and at the Bay of Fonseca (17 April).

ELEGANT TERN (*T. elegans*).—Several individuals near shore between Jalisco (2 April) and southern Oaxaca (10 April).

BLACK TERN (*Chlidonias niger*).—Fairly common and occasionally abundant between the Tres Marías and Acapulco; not seen between Acapulco and the northern Gulf of Tehuantepec; uncommon between southern Chiapas and Costa Rica. Many of the birds were in small migrating flocks, though very few were in breeding plumage. We were often able to discover sea turtles by looking for Black Terns that roosted on them.

BROWN NODDY (*Anous stolidus*).—Two Brown Noddies occurred 20 miles off the coast of Guerrero on 6 April in a feeding flock of Black Terns and Brown Boobies. The only other record was a flock of 15, along with Wedge-tailed Shearwaters, Pomarine Jaegers, and Black Terns, feeding over a school of skipjack tuna off the Nicoya Peninsula on 19 April.

CRAVERI'S MURRELET (*Endomychura craveri*).—I tried to collect a murrelet 60 miles off the coast of Guatemala on 13 April (13° 30′ N, 92° 00′ W), but it dived and was not seen again. I did not see the underwing color, but the face pattern and bill shape were more like *E. craveri* than *E. hypoleuca*. Although the specific identification must remain tentative, the generic identification is certain. The bird was definitely not a diving petrel, the presence of which seems only slightly less probable. This is apparently the southernmost record for any alcid.

OTHER SPECIES.—Except for Mourning Doves (*Zenaida macroura*), which were seen on an average of every other day, land birds were rare. One or two individuals of each of the following, all migrants to North America, were seen on or near the ship: *Falco sparverius*, *Empidonax* sp., *Catharus* sp., *Dendroica petechia*, *D. coronata auduboni*, *Wilsonia pusilla*, and *Pheucticus melanocephalus*. The most unusual record was a male Cerulean Warbler (*Dendroica cerulea*) 30 miles southwest of San José, Guatemala, on 17 April (SDNHM No. 38462). There are very few records of this species in Central America, especially on the Pacific Slope, and Land (1970) mentions only one record for Guatemala.

DISCUSSION

Seabird zonation and surface water temperature.—The distribution of many species of seabirds is influenced and indirectly limited by surface water temperature (Murphy 1936, Szijj 1967, Jehl 1973). In this transect I recognized two distinct assemblages. *Puffinus creatopus*, *P. [puffinus] opisthomelas/auricularis*, *Halocyptena microsoma*, and probably *Oceanodroma melania* occurred largely or entirely in waters cooler than 27°C. *Puffinus pacificus*, *P. lherminieri*, *Sula sula*, *S. dactylatra*, *Procellaria parkinsoni*, and *Oceanodroma tethys* were largely or entirely restricted to waters warmer than 27°C. Note that each group contains one large and one small species of *Puffinus* shearwater. More extensive studies would probably reveal other cases of "ecological replacements" in different zones of surface water.

Concentrations.—We saw a few flocks of up to 200 seabirds (mainly Brown Booby, Pomarine Jaeger, Wedge-tailed Shearwater, Sabine's Gull, Black Tern, Sooty Tern) feeding over schools of skipjack tuna, but the only significant concentration occurred 30 miles off the coast of Guatemala near 13° 50′ N, 92° 00′ W. We crossed this area several times,

and each time marine life was abundant. Large numbers of spotted porpoise, sailfish, dolphins, sea turtles, and a few whales were feeding there, in addition to 5000 Wedge-tailed Shearwaters, 4000 Audubon's Shearwaters, 80 Pomarine Jaegers, and a scattering of other birds. Apparently the concentration was attributable to upwelling at the head of a large submarine canyon; surface temperatures averaged 0.5°C cooler than in surrounding waters. No data are available to determine possible correlations between birds and prey density.

Migration.—The migration periods of many species had already started—and in the case of some storm-petrels may have been largely completed. Yet we saw little evidence of active migration except for a few Franklin's and Sabine's Gulls moving along the Nicoya Peninsula in mid-April, scattered but widespread flocks of Black Terns, and small flocks of Northern Phalaropes near the Tres Marías on 31 March and in the Gulf of Tehuantepec on 8 and 10 April. Even at the end of the survey period there was no indication of northward migration among the two southern hemisphere-breeding *Puffinus* shearwaters, *griseus* and *creatopus*, that summer in abundance off the west coast of North America.

Density.—The number of seabirds per hour per observation period varied from 4.9 to more than 1800, with a mean of 93. As might be expected, density tended to decrease with distance from shore (Fig. 3), but the relationship is not statistically significant. More interesting was a latitudinal decrease in density southward, which is statistically significant ($P < 0.01$) if the huge concentration of 1844 birds per hour (off Guatemala at 13° 50′ N) is ignored (Fig. 3).

One possible interpretation is that biological production, at the level it is appreciated by a wide variety of seabirds, varies clinally, but various indices of biological production (see maps of plankton, fish distribution in Love 1970–1972) show no obvious latitudinal gradients off Middle America. The only important physical parameter that varies latitudinally is surface temperature, but it alone cannot account for this trend.

I suspect that the correlation is largely a result of two factors. First, islands suitable for seabird nesting are not uniformly distributed. In fact the major colonies for several of the species encountered most commonly (Black Storm-Petrel, Least Storm-Petrel) are beyond the northern part of the survey route, in the Gulf of California. Thus the increased density northward is partly a consequence of geography and the necessity for birds to remain within cruising range of their nests. Second, surface temperature does affect the distribution of many species. Possibly the temperature preferences of some transequatorial migrants are exceeded by the warm waters that persist south of 16° N, causing

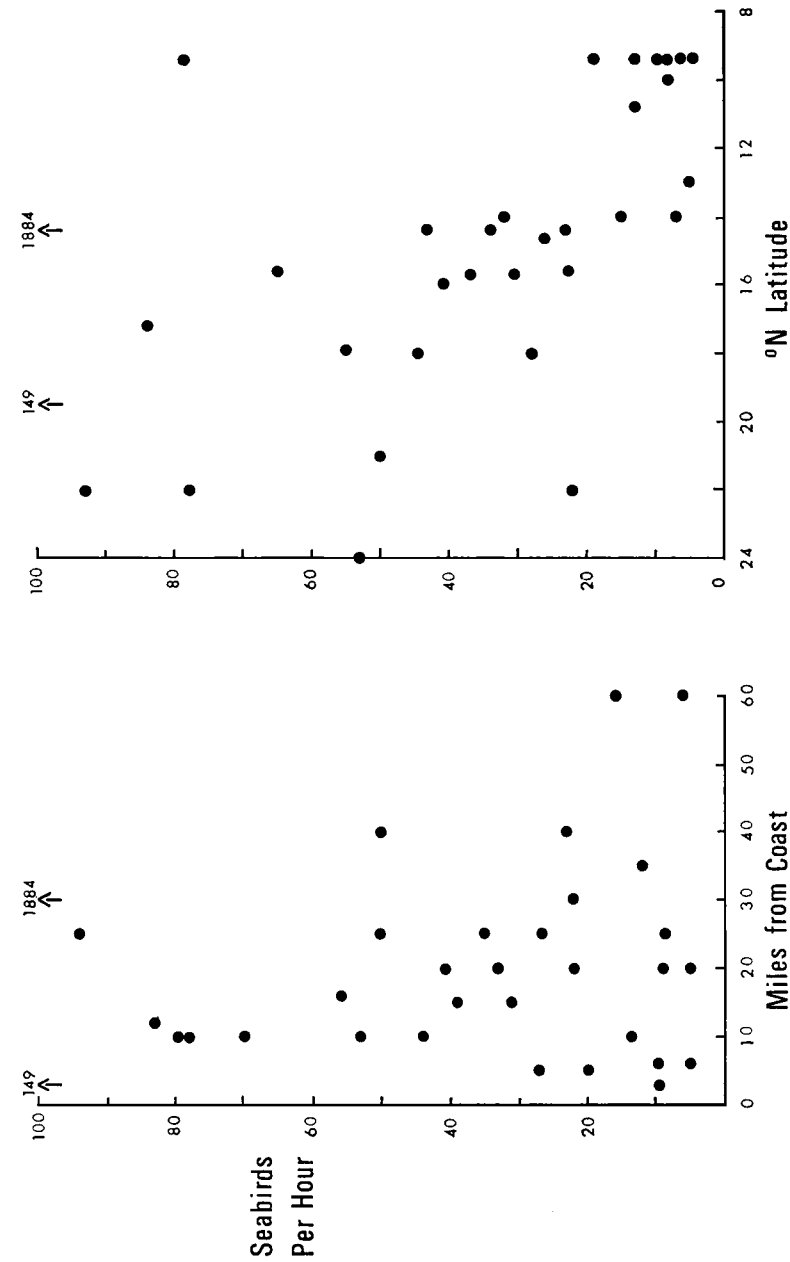

Fig. 3. Seabird density (number of birds per hour) in relation to distance from shore (left) and latitude (right).

them to migrate rapidly through this area and to congregate in cooler waters farther north. Data in the Eastropac Atlas are not sufficiently detailed for critical comparison. A possible latitudinal gradient in the density of plankton-feeding birds (vol. 4, Fig. 30-BP), with maximum concentrations near the tip of Baja California was found in June-July 1967; this also suggests concentrations of petrels near their nesting areas as no gradient was found at the end of the breeding season in August-September (vol. 6, Fig. 40-BP).

At similar latitudes over a broad expanse of the Central Pacific, King (1970) found densities of 13.8 and 16.7 birds per hour in April 1964 and 1965, respectively. In the immediate vicinity of the Hawaiian Islands, a region more comparable to that of the present study, densities were much higher, ranging from 41 birds per 10 linear miles in winter to 88 in summer. The Middle American data (93 birds per hour at an assumed average speed of 8 knots) when transformed to this base result in a mean density of 115 birds per 10 linear miles. As King's data are for the entire spring and include migration peaks for all species, whereas my data do not include, at least, the passage of southern hemisphere shearwaters, one might conclude that the Middle American waters support a far higher density of pelagic birds. This may be true, but the data are too few for conclusions, nor are the areas, survey techniques, and observation dates fully comparable. Additional detailed, year-round studies of distribution and ecology will be required to clarify the impact of pelagic birds on ocean ecosystems.

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SUMMARY

Quantitative studies of marine birds were made off the west coast of Middle America between La Paz, Baja California, Mexico, and Puntarenas, Costa Rica, from 29 March to 22 April 1973. The survey resulted in a number of new distributional records including: (1) the discovery that *Procellaria parkinsoni* winters in warm waters as far north as Guatemala, and (2) an observation of a probable *Endomychura craveri* off Guatemala, the southernmost record for any alcid. An apparent concentration of *Stercorarius longicaudus* near the Gulf of Tehuantepec supports the possibility that this species makes a long overland migration in spring.

Surface temperature had a marked effect on distribution of several species. *Puffinus creatopus*, *P. [puffinus] opisthomelas/auricularis*, *Halocyptena microsoma*, and probably *Oceanodroma melania* were found mostly in waters cooler than 27°C. *Puffinus pacificus*, *P. lherminieri*, *Sula dactylatra*, *S. sula*, *Procellaria parkinsoni*, and *Oceanodroma tethys* were largely or entirely restricted to warmer waters.

The mean density of seabirds over the entire route was 93 birds per hour, and approximately 115 birds per 10 linear miles. Density varied latitudinally, being greater in the northern part of the survey area. This may, in part, reflect a concentration of seabirds near breeding grounds in the Gulf of California, and the avoidance of warm waters to the south by other species.

In this survey, the near-shore waters off Middle America seemed to support a greater density of seabirds than waters at similar latitudes in central Pacific near Hawaii, the only other region for which density figures are available. This conclusion is tentative and requires confirmation from detailed studies through the entire year.

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