OBSERVATIONS ON SEA BIRDS IN THE TROPICAL PACIFIC

By JOSEPH E. KING and ROBERT L. PYLE

The Pacific Oceanic Fishery Investigations (POFI) of the United States Fish and Wildlife Service, with headquarters in Honolulu, is engaged in a program of oceanographic and fisheries research in the central Pacific. In the period from September 23 to December 17, 1955, the POFI vessel *Hugh M. Smith* made an 86-day, 13,800-mile cruise which afforded the authors an unusual opportunity to observe the sea birds in the equatorial region of the eastern and central Pacific, an area which is not frequently visited by ornithologists.

This cruise of the *Smith*, forming a part of the "Eastropic" expedition in which several research agencies collaborated, followed the route shown in figure 1. The primary objective of the cruise was to obtain information on east-west gradients in water temperature, salinity, chemical nutrients, and abundance of plankton and forage organisms in relation to the current system.

It is standard procedure on POFI cruises for the crewmen standing wheelwatch to record all bird flocks and scattered birds sighted each day. These observations are not usually to the species level, however. In addition to this watch by the crewmen, King maintained throughout the cruise a 1-hour watch each day between 4 and 5 p.m., during which period an effort was made to count and identify to species all birds sighted. On the westbound leg of the cruise, a similar watch was performed each morning, usually at 6 to 7 a.m., by Pyle, who joined the expedition at Manzanillo. The results of these observations, with particular emphasis on the variations in abundance and distribution of the sea birds in respect to the equatorial current system, and an annotated list of the species sighted, are the subject of this report.

In our record keeping we tried to distinguish between scattered birds and birds in flocks. Five or more birds traveling or feeding together as an aggregate were considered a flock. The number of flocks sighted each day and the number (frequently estimated) of individuals in each flock are given in table 1. It is evident from the table that bird flocks varying greatly in number of individuals were observed on less than half the days of the cruise, whereas scattered birds were sighted every day. Because of the small number of bird flocks and their distorting effect on the daily averages, they have been omitted from the detailed analysis in the sections to follow. The average number of scattered birds seen per hour for each day (table 1, fig. 1) was obtained by combining the number sighted by the wheelwatch in 9 to 12 hours of observation with the number sighted by Pyle in one hour and the number sighted by King in one hour, then dividing by the total hours put in each day. We recognize that the "average number" calculated in this manner is hardly an ideal statistic, but it does provide an index to the day-to-day variation in bird abundance and it seemed to be the best way to combine and utilize the available data. All observations made within one day's running (approximately 200 miles) of the Mexican coast or of the different island groups were omitted from the calculations although the species were recorded. Close to land the numbers of birds increased so markedly that an accurate count was impossible.

The identifications are based almost entirely on careful sight records, although representatives of several species came aboard the vessel and were examined in the hand. These included: Wedge-tailed Shearwater, Christmas Shearwater, Black-vented Shearwater, Tahiti Petrel, Hawaiian Petrel, White-throated Storm-petrel, Madeiran Storm-petrel, Leach Storm-petrel, and Sooty Tern. The crewmen were all skilled fishermen who were well acquainted with the common species and possessed remarkable ability to sight birds at considerable distances. There was doubtless some individual variation in the

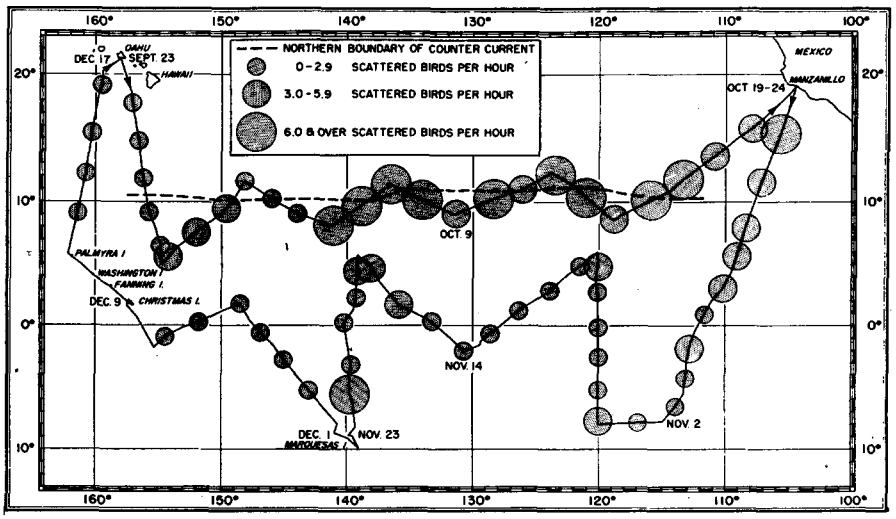

Fig. 1. Track of the M/V *Hugh M. Smith* on the "Eastropic" cruise showing variations in number of scattered birds seen per hour for each day of observation. Sightings by King, Pyle, and the wheelwatch were combined and the resulting average figures grouped into three classes: 0 to 2.9, 3.0 to 5.9, and 6.0 birds and over. The value for each day is plotted at the noon position. All observations within one day's run (about 200 miles) of land were omitted.

Table 1

Average Numbers of Scattered Birds and Birds in Flocks Sighted Each Day of the "Eastropic" Cruise of the *Hugh H. Smith,* Omitting All Observations within One Day's Run (about 200 Miles) of Land

Date 1955	Noon position		Scattered birds				Birds in flocks	
	Latitude	Longitude	Morning watch, 1 hr.[1]	Afternoon watch, 1 hr.[2]	Wheel-watch, av. No./hr.[3]	Total, av. No./hr.[4]	No. of flocks/ day[4]	No. of birds in flocks
9/24	17°49′N	157°09′W	....	....	1.0	1.0	0	....
9/25	15°56′N	156°37′W	....	7	1.0	1.5	0	....
9/26	11°56′N	156°12′W	....	....	2.4	2.4	6	309
9/27	09°10′N	155°47′W	....	1	1.5	1.5	0	....
9/28	06°33′N	154°48′W	....	....	1.8	1.8	0	....
9/29	05°31′N	154°13′W	....	10	2.8	3.4	1	25
9/30	07°28′N	151°58′W	....	11	3.5	4.1	5	206
10/1	09°24′N	149°34′W	....	11	4.8	5.4	0	....
10/2	11°38′N	148°04′W	....	5	0.8	1.2	0	....
10/3	10°15′N	145°57′W	....	5	1.0	1.4	0	....
10/4	09°04′N	143°49′W	....	5	2.1	2.4	0	....
10/5	08°00′N	141°10′W	....	4	6.7	6.4	0	....
10/6	09°43′N	138°51′W	....	29	6.3	8.4	3	80
10/7	11°14′N	136°30′W	....	12	5.9	6.5	0	....
10/8	10°09′N	133°59′W	....	15	6.3	7.1	3	175
10/9	09°01′N	131°21′W	....	18	2.3	3.7	2	62
10/10	10°12′N	128°13′W	....	6	7.8	7.4	2	50
10/11	11°00′N	126°02′W	....	9	3.4	3.9	1	50
10/12	12°08′N	123°34′W	....	9	7.7	7.7	1	30
10/13	10°18′N	121°04′W	....	12	7.1	7.5	2	65
10/14	08°36′N	118°50′W	....	6	3.9	4.1	0	....
10/15	10°05′N	115°51′W	....	14	6.9	7.5	1	30
10/16	11°40′N	113°25′W	....	19	10.0	10.5	1	8
10/17	13°36′N	110°51′W	....	6	3.2	3.4	1	20

Date 1955	Noon position Latitude	Longitude	Scattered birds: Morning watch, 1 hr.[1]	Afternoon watch, 1 hr.[2]	Wheel-watch, av. No./hr.[3]	Total, av. No./hr.[4]	Birds in flocks: No. of flocks/ day[4]	No. of birds in flocks
10/18	15°46'N	107°57'W	....	2	4.2	3.0	1	35
10/19–24	Mexico							
10/25	15°16'N	105°44'W	4	33	7.0	8.6	1	150
10/26	11°33'N	107°08'W	8	20	4.1	5.2	3	18
10/27	07°58'N	108°25'W	14	8	6.0	5.9	0	....
10/28	05°41'N	109°06'W	19	4	4.3	5.6	0	....
10/29	03°04'N	110°10'W	4	4	3.3	3.4	1	45
10/30	00°59'N	111°32'W	0	4	1.2	1.4	0	....
10/31	01°40'S	112°52'W	15	0	4.0	4.6	0	....
11/1	04°25'S	112°50'W	....	5	1.6	2.0	0	....
11/2	06°46'S	113°54'W	1	0	1.8	1.6	0	....
11/3	07°53'S	116°50'W	0	4	1.1	1.4	0	....
11/4	07°46'S	120°00'W	7	16	2.9	4.5	2	30
11/5	05°14'S	120°00'W	3	3	1.3	1.6	0	....
11/6	02°38'S	120°01'W	1	1	1.8	1.6	1	25
11/7	00°03'S	119°52'W	1	0	2.1	1.8	0	....
11/8	02°50'N	120°00'W	1	10	1.0	1.8	1	17
11/9	04°55'N	120°05'W	18	10	2.0	4.2	0	....
11/10	04°56'N	121°26'W	0	0	1.3	1.1	0	....
11/11	02°52'N	123°50'W	0	6	1.8	2.0	0	....
11/12	01°11'N	126°23'W	0	0	0.6	0.5	0	....
11/13	00°32'S	128°40'W	4	6	2.1	2.6	1	5
11/14	02°02'S	130°46'W	3	4	1.2	1.6	0	....
11/15	00°14'N	133°12'W	0	0	1.0	0.8	0	....
11/16	01°44'N	135°50'W	4	4	4.9	4.7	0	....
11/17	04°48'N	138°16'W	2	3	3.6	3.4	0	....
11/18	04°26'N	139°09'W	0	8	6.1	5.7	1	50
11/19	02°13'N	139°11'W	0	6	1.2	1.5	0	....
11/20	00°14'N	140°10'W	2	2	0.6	0.8	0	....
11/21	03°02'S	139°44'W	1	0	1.0	0.9	0	....
11/22	05°36'S	139°50'W	1	4	8.4	7.4	1	16
11/23–12/1	Marquesas Islands							
12/2	05°13'S	143°01'W	4	2	1.0	1.3	3	113
12/3	02°40'S	145°04'W	2	3	0.7	1.0	0	....
12/4	00°27'S	146°54'W	2	0	0.3	0.4	0	....
12/5	01°42'N	148°38'W	2	1	0.9	1.0	1	25
12/6	00°17'N	151°45'W	4	1	1.3	1.5	1	80
12/7	00°51'S	154°30'W	2	1	1.2	1.2	0	....
12/8–12	Line Islands							
12/13	09°02'N	161°23'W	1	1	0.5	0.5	0	....
12/14	12°18'N	160°43'W	0	1	0.5	0.5	0	....
12/15	15°38'N	160°13'W	2	0	0.4	0.4	0	....
12/16	19°12'N	159°23'W	1	0	0.1	0.1	0	....

[1] By R. Pyle, usually at 6:00 to 7:00 a.m.
[2] By J. King, usually at 4:00 to 5:00 p.m.
[3] With observations throughout a 9- to 12-hour day.
[4] Includes sightings by the wheel-watch, R. Pyle and J. King.

effort they expended and in their interest in the project, but the watch was rotated each day so that differences among observers probably did not greatly influence the results. The bulk of the time spent on these observations was contributed by the crewmen, and we wish to acknowledge and thank them for their assistance.

The most important sources of error in our records, we believe, are those related to the difficulties of accurately observing and identifying birds from a small vessel on the open sea. Many of the birds do not follow the ship but remain at a distance; they are usually seen in fast flight and rarely resting on the surface; the vessel is always rolling

and pitching to some degree, making it difficult to hold binoculars steady; and individuals of some species that have the habit of following vessels may have been counted more than once. Our observations were made from the upper deck of the vessel where visibility was excellent and a bird in flight could be followed through 360° if desired. Also, weather conditions were generally good throughout the cruise; on only a few days did heavy rain or rough seas interfere to any extent. Our data provide some measure of the variation in bird sightings in relation to sea surface and amount of cloud cover.

The most widely used reference in making identifications was Alexander (1954). In the eastern Pacific the publications of Murphy (1936), Peterson (1941), and Blake (1953) were also helpful.

Previous records, principally on the occurrence and distribution of sea birds in the central Pacific, have been provided by Murphy (1924, 1928, 1929), Jespersen (1932–33), Fleming (1950), and Macdonald and Lawford (1954). The nearest approach to an analysis of the bird populations and their relation to environmental factors is that of Murphy and Ikehara (1955) for the mid-central Pacific. No quantitative studies as comprehensive as those of Jespersen (1930) and Moore (1951) on sea birds of the North Atlantic, have been made in the Pacific, to our knowledge. The present study does not change this situation to any great degree but does provide some information on variations in the numbers of birds as related to the current system and to certain other features of the environment.

DESCRIPTION OF THE ENVIRONMENT

The general pattern of the Pacific equatorial current system has been described by Sverdrup, Johnson, and Fleming (1942:708–712). In brief, the major surface currents of this region are the North and South Equatorial Currents flowing toward the west, and the eastward-flowing Equatorial Countercurrent lying in between. Although the boundaries of the Countercurrent (CC) may vary meridionally with longitude and season, its southern and northern boundaries ordinarily occur near 5°N and 10°N latitude in the eastern central Pacific. The South Equatorial Current (SEC) is therefore on both sides of the Equator while the North Equatorial Current (NEC) is confined entirely to the Northern Hemisphere. The general features outlined here apply principally to the central Pacific and may not hold for the extreme eastern part of the region. A detailed study of the oceanographic data from this area is presently being made by POFI and other research agencies.

The Equator is the site of upwelling resulting from divergence of the surface waters. The newly upwelled water is high in nutrients and provides a favorable environment for the growth of plankton. Convergence and sinking of the surface waters, occurring between about 2°N latitude and the southern boundary of the CC, may tend to concentrate the plankton into a rich pasturage for forage organisms, which in turn serve as food for the larger fishes such as the tunas and also for the sea birds.

Enrichment of the surface water by an entirely different mechanism is thought to occur along the northern boundary of the CC. In the eastern and central Pacific this boundary region is an area of shallow thermocline with high-phosphate water occurring within the photosynthetic zone and within the reach of wind-induced turbulence. To the westward the thermocline deepens, reducing the likelihood of enrichment of the surface layer through this combination of factors.

VARIATIONS

Current system.—For purposes of examining variations in bird abundance as related to the current system, we use the six latitudinal subdivisions of the area established by

King and Hida (MS). These are based on natural features and are defined as follows: (1) the NEC from about 20°N latitude to the northern boundary of the CC; (2) the CC with its boundaries being determined at the time of each crossing from vertical temperature sections; (3) a zone of convergence in the SEC extending from the southern boundary of the CC to 1½°N latitude; (4) a zone of divergence and upwelling in the SEC along the Equator from 1½°N to 1½°S latitude; (5) the SEC from 1½°S to 5°S latitude; and (6) the SEC from 5°S to about 14°S latitude. Since special effort was spent on our cruise to investigate the northern boundary of the CC, we established a seventh subdivision of 2 degrees of latitude extending from 1 degree north of the current boundary to 1 degree south of the boundary. The latitudinal limits of these seven zones are shown in figure 2.

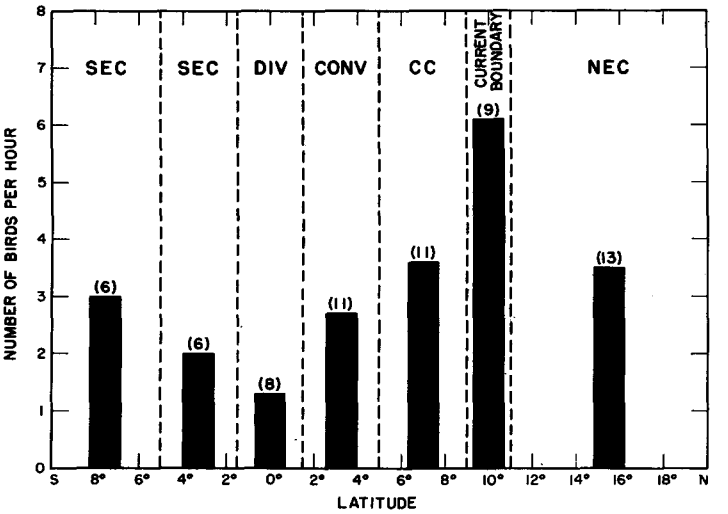

Fig. 2. Variation in numbers of scattered birds sighted per hour of observation in relation to the current system. All sightings within one day's run (about 200 miles) of land were omitted. Number of days on which each average value is based is shown in parentheses.

When the numbers of scattered birds are combined in accordance with these subdivisions of the current system, omitting all sightings within one day's run of land and disregarding differences associated with longitude, we find the largest number of birds occurring along the northern boundary of the Countercurrent and the least number in the zone of divergence on the Equator (fig. 2). It is evident from table 1 that the number of bird flocks was also greater in the region of the Countercurrent than near the Equator; for example on the eastbound leg, 30 bird flocks including a total of about 1145 birds were seen on 25 days (1.2 flocks or 38 birds per day) whereas on the westbound leg south of the CC (south of 5°N) only 13 flocks including about 406 birds were seen on 31 days (0.4 flocks or 13 birds per day). This distribution is generally similar to that described by Murphy and Ikehara (1955, fig. 7) for the central Pacific and also closely parallels the abundance of bigeye tuna (*Parathunnus sibi*) as determined from POFI longline fishing, but is inversely correlated (King and Hida, MS) with the catch of yellowfin tuna (*Neothunnus macropterus*). Reasons for these apparent relationships between birds and subsurface fish are obscure and will not be discussed further in this paper.

In the eastern Pacific (120°W–140°W longitude) the distribution of zooplankton shows a double peak, being high both at the Equator and at the northern boundary of the CC (King and Hida, MS). Of these two "enriched" areas the sea birds, as well as the bigeye tuna, seem to find better foraging conditions at the northern boundary of the CC.

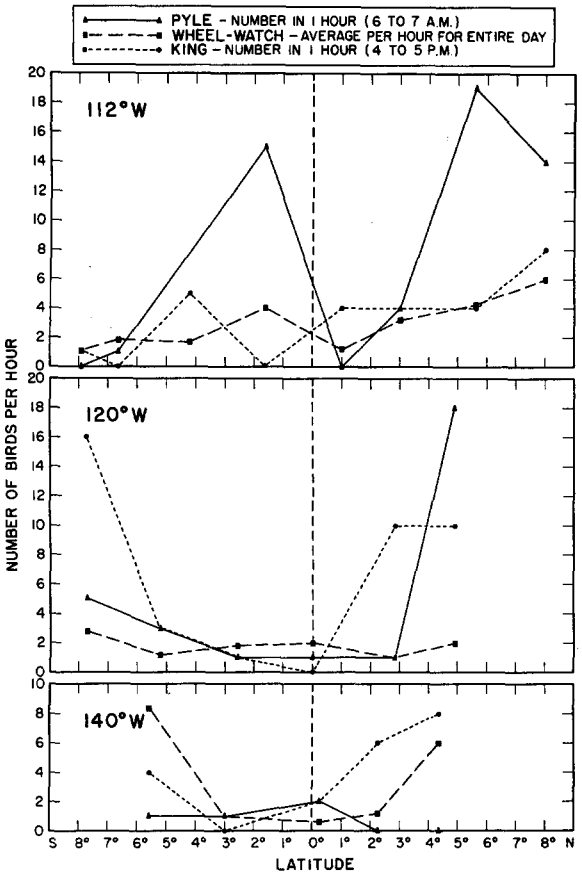

Fig. 3. Variation in numbers of scattered birds comparing the sightings of Pyle, King, and the wheelwatch on three north-south section lines crossing the Equator on longitude 112°, 120°, and 140°W, with the values for each day's observations plotted on the noon position. All sightings within one day's run (about 200 miles) of land were omitted.

Figure 3 shows the latitudinal distribution of scattered birds on the three long station lines crossing the Equator on 112°, 120°, and 140°W longitude. Despite the considerable variation among observers there is evidence of reduced numbers on the Equator and increases to the north and south.

Longitude.—When numbers of scattered birds are combined by 10-degree intervals of longitude, disregarding differences associated with latitude, we obtain a picture (fig. 4) of generally increasing abundance from west to east, with peaks at 140°W and at 110°W longitude. This distribution is probably influenced by the occurrence of the Marquesas

Islands at about 10°S latitude, 140°W longitude and the nearness of the Mexican coast on the east, even though observations within one day's run of land were omitted. The generally low abundance west of 140°W longitude and the increase in numbers along the northern boundary of the CC east of 140°W longitude are clearly shown in figure 1.

There was apparently little variation from east to west in number of bird flocks. The highest average number of flocks (1.1) and the largest average number of birds in flocks (43) sighted per day was recorded for 130°W longitude.

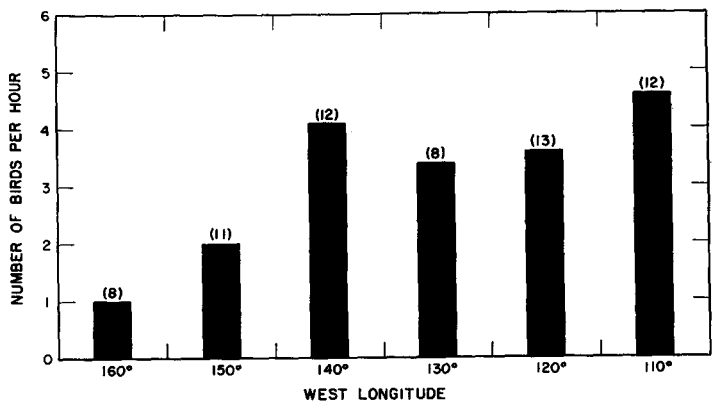

Fig. 4. East-west variation in numbers of scattered birds by 10-degree intervals of longitude. Number of days on which each average value is based is shown in parentheses.

Diurnal.—Our data provide some indication that, during daylight hours, scattered birds were most numerous in the late afternoon period. Numbers of scattered birds sighted by the wheelwatch for each hour from dawn to dusk (6 a.m. to 7 p.m.), and averaged for the entire cruise, but omitting all observations within one day's run of land areas, are shown in figure 5. As the plankton work was conducted each day between 9 and 11 a.m., the bird observations during this period were few and probably not of

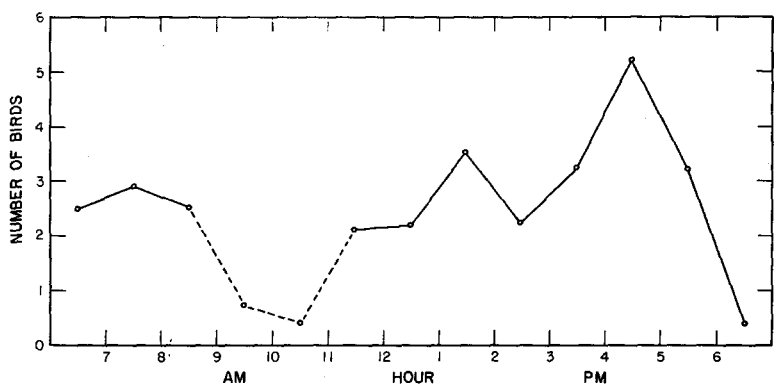

Fig. 5. Variation in number of scattered birds from dawn to dusk as sighted by the wheelwatch. Sightings during 9 and 10 a.m. hours are probably not quantitative. All observations within one day's run (about 200 miles) of land were omitted.

quantitative nature. The peak between 4 and 5 p.m. seems significant although it is partly explained by the presence on the bridge of two observers who were of some assistance to each other in locating birds.

Further evidence of a slightly greater number of scattered birds in flight in the late afternoon, as compared with the early morning, is given by the average sightings of the two special observers on the westbound leg. In the afternoon watch King sighted an average of 4.5 birds per hour whereas in the morning watch Pyle sighted an average of 3.5 per hour. The number of bird flocks varied irregularly with the hour of day, but 36 flocks were sighted between 12 noon and 6 p.m. as compared with 11 flocks between 6 a.m. and 12 noon.

Miscellaneous.—Two factors which may affect the observer's ability to see birds at sea are amount of overcast or cloud cover and the nature of the sea surface. On a clear, calm day bird flocks can be seen with fair regularity at two to three miles with the unaided eye and single birds at one to two miles. With reduction in light through cloudiness and with higher waves and swell to hide low-flying birds it is reasonable to suppose that fewer birds will be seen than under ideal conditions, assuming their actual numbers remain the same.

Although our data are perhaps not sufficient to provide definite conclusions, it would appear from table 2 that increasing cloudiness had no effect on the numbers of scattered birds sighted. Table 3 indicates, on the other hand, that increasing wave height resulted in fewer birds seen. We have no way of knowing, of course, if the true abundance of birds in flight changed with changes in sea surface.

Table 2

Variation in Number of Scattered Birds Sighted in Relation to Amount of Cloud Cover[1]

	Cloud cover, in eighths		
	0–2	3–5	6–8
Average number of birds/hour	5.4	4.3	5.9
Number of hours observed	38	18	46

[1] Based on observations by R. Pyle and J. King during early morning and late afternoon watches.

It is believed that sharp temperature discontinuities or "fronts" occurring in the ocean surface layer may have a concentrating effect on plankton, the basic food in the sea, and consequently influence the distribution of other marine animals. On the westbound leg of our cruise the ship's thermograph (not operating on the eastbound leg of the cruise) recorded 17 fronts with temperature differences across the front ranging from ½° to 4°F. When the positions of these sharp temperature breaks were plotted on a chart similar to figure 1, together with numbers of scattered birds and bird flocks, we could see no evidence of a causal relationship. In only four instances were bird flocks sighted either working over a front or within an hour's run of the temperature discontinuity. We conclude, therefore, that on this cruise the phenomenon had little or no influence on bird distribution or overall bird abundance.

Table 3

Variation in Number of Scattered Birds Sighted in Relation to Sea Surface[1]

	Sea surface, height of waves, in feet			
	< 1	1–3	3–5	5–8
Average number of birds/hour	9.3	6.4	5.0	3.1
Number of hours observed	3	36	55	8

[1] Based on observations by R. Pyle and J. King during early morning and late afternoon watches.

ANNOTATED LIST OF SPECIES

The following species of birds were recorded at sea during the cruise. In many instances records are given by date: the approximate coordinates of these observations may be determined from figure 1 and table 1. Peters (1931, 1934) has been followed in respect to scientific names and order of listing; common names are as given in Alexander (1954).

Puffinus pacificus. Wedge-tailed Shearwater. Recorded on 10 days in the course of the eastbound leg, including a flock of 20 on October 6. Individual birds came aboard the ship on October 4 and 13. A total of eight was seen on October 24 just off Manzanillo, and one was recorded on October 27.

Puffinus griseus. Sooty Shearwater. This completely dark shearwater replaced the very similar Christmas Shearwater in the northeastern portion of the cruise track. It was recorded on October 13, 14, and 15 near 10°N, and again on October 24, 25, and 26, all in the general area southwest of Manzanillo. One bird was seen on November 4 near 7°S, 120°W.

Puffinus nativitatis. Christmas Shearwater. Observed on September 29 and 30 and daily from October 5 to 10 between 141° and 128°W. It was not identified again until November 13 when we had reached 129°W on the west-bound leg. Thereafter it was seen irregularly in the general area north of the Marquesas Islands, including one flock of about 20 recorded on November 18. It became far more abundant near and just north of Christmas Island and was last recorded on December 12 just north of Palmyra Island. On Motu Tabu in Christmas Island lagoon, this species was observed nesting in numbers. Many of the shallow nesting burrows or depressions contained an egg, and several half-grown chicks were seen.

Puffinus opisthomelas. Black-vented Shearwater. First recorded on October 4 when one came aboard the ship. Eight were observed on October 6, and thereafter occasional individuals were seen until October 26, all north of 9°N.

Puffinus assimilis. Dusky Shearwater. Recorded on October 24 and 25, just off Manzanillo, including a flock of about 24 individuals on the 24th, most of which were identified as this form.

Puffinus lherminieri. Audubon Shearwater. Recorded on November 23 and 25 and December 1 in the immediate vicinity of the Marquesas Islands. Several were seen on December 9 within a few miles of Christmas Island.

Pterodroma rostrata. Tahiti Petrel. On November 29 some Marquesan boys brought a bird of this species to the ship while at anchor in Taa Huku Bay, Hiva Oa Island. They stated it had been taken from a burrow on Hiva Oa that same morning. It was identified as this species, rather than *P. alba,* by the large bill, the complete absence of any white flecking on the throat, and by the entirely black outer toe. The bird was photographed and later released. Another bird, probably of this species, but possibly *P. alba,* was seen from the ship on November 30 while still close to Hiva Oa.

Pterodroma alba. Phoenix Petrel. Recorded on September 29 near 6°N, 154°W, and again on December 5 near 1°N, 149°W. The species was abundant on and near Christmas Island, and it was seen frequently in flight over both the lagoon and the land areas of the atoll. On Motu Tabu, Christmas Island, many were observed in and near burrows, and although most nests contained a single egg, no chicks were found. No birds were seen over the ocean out of sight of the atoll, except the two already noted.

Pterodroma phillipii. Kermadec Petrel. Recorded in the course of the eastbound leg on October 5, 7, and 9 near 10°N between 141° and 131°W. Three birds, probably of this species, were seen November 4 near 7°S, 120°W. Distinguished from the Herald Petrel (*P. heraldica*) by the larger body size and the distinct white area toward the tip of the under surface of the wings.

Pterodroma phaeopygia. Hawaiian Petrel. This bird was observed more frequently throughout the cruise than any other species. It was first seen September 27 near 9°N, 155°W and from then until October 30 it was recorded on 24 out of 28 days at sea. Usually about one to three individuals were seen each day, although unusually large counts of nine birds each were noted on October 16, 26, and 28. It was not seen for four consecutive days (October 31 to November 3) at the extreme southeast portion of the cruise track, but scattered birds were seen again on 13 of the next 20 days, in equatorial waters between 120° and 140°W. This included three birds recorded November 22 on 140°W near 6°S. Most of a flock of 25 shearwaters seen on November 6 were thought to have been

this species. Single birds were recorded on 4 of the 8 days between the Marquesas and Christmas Island, and one was seen on December 11 near Washington Island. This species is reported to breed only in Hawaii and the Galapagos Islands (Richardson and Woodside, 1954). However, we failed to record it in the Hawaiian area and it was not seen as we neared the Galapagos Islands.

Pterodroma cookii. Cook Petrel. Small, fast-flying, white-breasted petrels were seen on 19 days in the course of the westbound leg, between Manzanillo and Christmas Island. Fifteen birds were counted on October 25, just off the Mexican coast, but usually there were not more than one or two individuals sighted per day. They were also recorded on four days on the eastbound leg (October 1, 3, 9, and 12). Most of these were thought to be *P. cookii* since the crown appeared gray, concolor with the gray of the upper back, as described by Murphy (1936:720). On the basis of the known range (Murphy, 1929; Jespersen, 1932–33) of these small "gadfly" petrels, many of the examples sighted may have been the Gould Petrel.

Pterodroma leucoptera. Gould Petrel. On the eastbound leg of the cruise this petrel was recorded on September 27 and 30 near 155°W and 151°W, respectively, between 8°N and 9° N.

Bulweria bulwerii. Bulwer Petrel. Fairly abundant around the Marquesas Islands. Many were seen while traveling between islands, but only one was recorded away from the island group; this was seen on November 18 near 4°N, 139°W.

Fregetta grallaria. White-bellied Storm-petrel. Three birds seen on November 3 and single birds observed on November 17 and December 1.

Nesofregetta albigularis. White-throated Storm-petrel. One bird observed on October 6 near 10°N, 138°W. The species was not sighted again until we reached the Marquesas, where single birds were observed on three days. On December 1, one came aboard and was banded and released. One was seen on December 8 as we approached Christmas Island, and several were observed on December 9 over Christmas Island lagoon and also in the ocean nearby.

Oceanodroma castro. Madeiran Storm-petrel. *Oceanodroma leucorhoa.* Leach Storm-petrel. Small, white-rumped petrels were seen east of 144°W almost daily from October 4 to November 20. One bird came aboard the vessel on October 6 and was tentatively identified in the hand as *O. castro.* They were not recorded on November 3, 4, or 5 at the extreme southeast portion of the cruise track, but otherwise during this period we never failed to sight them for more than one day consecutively. From October 31 to November 19, on both sides of the Equator between 113°W and 140°W, a total of 11 storm-petrels came aboard the ship during the evening hours. These birds all belonged to the same species. Seven were captured, banded, and released, and one was preserved as a specimen which was later sent to the United States National Museum and there identified as *O. leucorhoa.* After leaving the Marquesas, storm-petrels were recorded only on December 6, 7, and 8 southeast of Christmas Island, and on December 11 between Christmas and Palmyra. Most of the storm-petrels observed from the vessel during daylight hours appeared to have a broad rectangular rump patch similar to the example of *O. castro* which was examined in the hand. A few were observed to have markedly forked tails.

Oceanodroma melania. Black Storm-petrel. Seen only close to the Mexican coast. One recorded on October 19 and three together on October 24.

Phaëthon aethereus. Red-billed Tropic-bird. Seen on October 19 and 24 close to the Mexican coast.

Phaëthon rubricauda. Red-tailed Tropic-bird. The only species of tropic-bird regularly seen more than 200 miles from land. Infrequently sighted on the eastbound leg to the east of 150°W, but after leaving Manzanillo individuals and pairs were seen frequently from October 26 to November 20, and again from December 4 to 15. Not recorded in or near the Marquesas group. On Motu Tabu, in Christmas Island lagoon, about ten nests were located, each containing an egg or a chick. The chicks were in all stages from very young to nearly full grown.

Some individuals in the open ocean either lacked the long central tail feathers altogether, or had two very small white feathers protruding from the tail. While these individuals did not have the typical mottled pattern of young birds, they sometimes appeared dingy on the back and usually the bill was darker than normal. They were usually seen in the company of a bird in typical adult plumage.

Phaëthon lepturus. White-tailed Tropic-bird. Recorded near the Hawaiian Islands on September 24 and December 15 and 16. Common in and around the Marquesas Islands.

Fregata magnificens. Magnificent Frigate-bird. Common in Manzanillo harbor, and individuals

seen at sea on October 24 and 25 were probably this species. A flight of six birds seen on October 29 was also presumed to be this species.

Fregata minor. Great Frigate-bird. Common in and around Christmas Island.

Fregata ariel. Lesser Frigate-bird. Frigate birds were fairly common in the Marquesas Islands, and every adult male definitely identified belonged to this species.

Pelecanus occidentalis. Brown Pelican. Common in and near Manzanillo.

Sula nebouxii. Blue-footed Booby. Several seen on November 19 just off the Mexican coast, but they were much fewer in number than *S. leucogaster*.

Sula dactylatra. Blue-faced Booby. Four birds recorded on September 28 and 29 between 5°N and 3°N, 110°W. Not definitely identified again until December 8 when we were approaching Christmas Island. Many were seen on and around Christmas Island on December 9, and several were recorded over the ocean between Christmas and Palmyra. One was seen on December 14 near 12°N, 160°W.

Sula sula. Red-footed Booby. Common around the Marquesas Islands, where all individuals sighted were in the brown phase. At Christmas Island, most of the birds had brown wings and back, but were otherwise white. Birds seen between Christmas and Palmyra were in the white phase typical of the Hawaiian Islands.

Sula leucogaster. Brown Booby. Abundant close to the Mexican coast and also around the Marquesas Islands. Several were seen at Christmas Island. None recorded at sea more than 100 miles from land.

Pluvialis dominica. Golden Plover. One observed in flight at sea on September 28.

Arenaria interpres. Ruddy Turnstone. On October 3, near 10°N, 146°W one circled the ship for about 10 minutes. A flock was observed on October 19 near the Mexican coast.

Phalaropus fulicarius. Red Phalarope. Four unidentified phalaropes were recorded on October 19 just off the Mexican coast, and four more were observed in the same general area on October 24. Again, four were seen on November 8, near 4°N, 120°W in association with a marked convergence or "front" in the upper layer of the ocean. On the following morning, still in the convergence zone, an individual phalarope was observed very close to the ship and identified as this species.

Catharacta skua. Great Skua. A bird identified as this species passed close by the ship on November 13, near 1°S, 129°W.

Stercorarius pomarinus. Pomarine Jaeger. Jaegers probably of this species were recorded occasionally on all portions of the cruise track, between September 29 and December 6.

Larus sp. One gull, possibly *L. californicus* in second-year plumage, followed the ship briefly on October 13, more than 1000 miles from the Mexican coast.

Sterna sp. Two or three large flocks of medium-sized white terns with light gray mantles were observed together on October 24, about 50 miles off the Mexican coast.

Sterna fuscata. Sooty Tern. Observed far more frequently than any other tern. Recorded on only four days on the eastbound leg, but abundant close to the Mexican coast. Between Manzanillo and the Marquesas it was seen occasionally, including a flock of 25 to 30 birds on November 4 and a flock of 14 birds on November 8 in association with a convergence front in the upper layers of the ocean. The species was abundant in and around the Marquesas and was observed daily at sea between the Marquesas and Palmyra Island. It was not seen after December 11.

Thalasseus bergii. Crested Tern. Nine individuals recorded on Christmas Island, on the same sand bar at the lagoon entrance where King (1955) found them in 1953.

Procelsterna cerulea. Blue-gray Noddy. Common in and near the Marquesas and Christmas Island. On Motu Tabu in Christmas Island lagoon several eggs were found.

Anoüs stolidus. Common Noddy. Several birds of this species were seen in the Marquesas Islands and on Christmas Island. In addition, two birds were recorded at sea on October 10 near 10°N, 128°W.

Anoüs minutus. White-capped Noddy. Common in and near the Marquesas and Christmas Island. On Motu Tabu in Christmas Island lagoon nesting was nearly completed and only a few nearly full grown young were seen.

Gygis alba. White Tern. Abundant in and around the Marquesas Islands. Although many were observed on Nukuhiva Island, none was captured or collected so that the form *G. a. microrhyncha* was not definitely identified. This species was also abundant on Christmas Island, where on Decem-

ber 9 nesting was in progress and all stages from eggs to nearly grown chicks were seen. Recorded at sea each day between Christmas and Palmyra islands.

Unidentified Ducks. A flock of about 12 ducks flying south was recorded on October 5. Individual ducks were observed on October 6, 9, 10, and 27. None was close enough to identify the species.

SUMMARY AND CONCLUSIONS

Forty species of sea birds, principally shearwaters, petrels, storm-petrels, tropicbirds, frigate-birds, boobies, and terns, were sighted on the "Eastropic" cruise of the M/V *Hugh M. Smith* to the central and eastern tropical Pacific.

Scattered sea birds were most abundant along the northern boundary of the Countercurrent at about 10°N latitude. The largest numbers occurred near 110°W longitude, influenced no doubt by the nearness of the Mexican coast; and on 140°W longitude a second area of high abundance was found which may be related to the shallow thermocline, high phosphate concentrations, and rich zooplankton conditions characteristic of this region.

There is some indication that in the daylight hours scattered birds were most numerous during the late afternoon period. Increasing cloudiness had no effect on the numbers of birds sighted; but when the wave height increased, fewer birds were recorded.

There was little or no evidence that birds occurred in greater frequency in areas of marked temperature change in the sea surface.

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