THE SEASONAL DISTRIBUTION OF SOME SEABIRDS OFF WASHINGTON AND OREGON, WITH NOTES ON THEIR ECOLOGY AND BEHAVIOR

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Knowledge of seabirds in pelagic waters off the Washington and Oregon coasts is quite fragmentary. Although there are papers on a few species in or near this general region (e.g., Martin 1942; Yocom 1947a, b; Kenyon 1950; Guiguet 1953; Sanger 1965; Poole 1966), the observations were usually qualitative and made from scattered locations or during only one season. An exception is McHugh's (1955) analysis of Black-footed Albatross distribution off North America in 1949–1950. Gabrielson and Jewett (1940) and Jewett et al. (1953) summarized knowledge of seabirds within a relatively few kilometers of shore, but only speculated on distribution and abundance of species in pelagic areas. Moreover, measurement of the oceanic environment concurrent with systematic seabird observations has been virtually nonexistent. Clearly, uniform observations repeated over several seasons have been needed for a better understanding of seabird distribution in the area.

The objectives of this paper are to describe quantitatively the seasonal distribution and relative abundance of certain seabirds observed off the Washington and Oregon coasts. Also, their behavior and relationship to the oceanic environment are described where possible. The observations were made during a series of seven replicate cruises conducted by the University of Washington, Department of Oceanography, from May 1964 through November 1965. These cruises consisted of two lines of oceanographic sampling stations between the coast and about 140° W, at latitudes of about 47° 30′ N off Washington and 45° 20′ N off Oregon. Pertinent cruise data are listed in table 1.

THE CRUISE AREA

OCEAN DOMAINS AND CURRENTS

The area covered by the cruises (fig. 1) encompasses ca. 309,000 km^2 within the subarctic region of the North Pacific Ocean (Sverdrup et al. 1942), a region characterized by moderate surface temperatures (ca. 6–17°C) and surface salinities of less than 33 parts per thousand (‰). Within the subarctic a number of subregions or domains are formed by currents and the influence of local conditions (Dodimead et al. 1963). The cruise area lies mostly within the transitional domain just north of the subarctic boundary; the eastern portion is replaced by the coastal domain, depending on the season. In winter the coastal domain exists as a narrow band of water within a few kilometers of shore, and is characterized by surface salinities much lower than farther offshore. Budinger et al. (1964) explained how prevailing southerly winter winds, often of gale force, hold the low-salinity surface water against the Washington coast. As summer approaches, the predominant wind direction shifts to northerly, causing general upwelling of deep, nutrient-rich water along the coast, and carrying low-salinity surface waters from the Columbia River and the Strait of Juan de Fuca offshore to invade the transitional domain. Thus, the coastal domain is barely within the cruise area in winter, but in summer it extends westward to about 130° W, well into the cruise area (Dodimead et al. 1963).

The main ocean current at these latitudes, the eastward flowing West Wind Drift (Aleutian Current), diverges west of the cruise area, with a northerly branch forming a counterclockwise gyre in the Gulf of Alaska and a southerly branch forming the California Current, flowing parallel to the coast. For most of the year, the cruise area is within the California Current, but in winter the extreme western portion may be influenced by the Alaska Gyre. Barnes and Paquette (1957) noted, however, that currents over the entire area are somewhat ill-defined and are subject to local variations in wind and tide.

The area is generally characterized by cool summers and mild winters, with an estimated annual precipitation of 120 cm/year in nearshore areas (Budinger et al. 1964).

GENERAL BIOLOGY

Anderson (1964) discussed the primary productivity of the general area for the period January 1961–June 1962. Waters outside the influence of the Columbia River (i.e., in the transitional domain) were generally low in production, with measured values ranging from less than 0.08 g C$\cdot$m$^{-2}\cdot$day^{-1} (grams of organic carbon assimilated per square meter of sea surface per day) in winter, to 0.3–0.5 g C in spring. Waters within the coastal domain had values ranging from as low as 0.09 g C in winter, to as high as 0.38 g C in summer near the Columbia River mouth, where sustained high productivity existed all summer long, and 1.21 g C in upwelled waters.

The coastal domain supports large numbers of marine vertebrates. Fishes such as salmon and hake are harvested commercially. Smaller fishes like smelt (Osmeridae) occur in large quantities. Baleen whales are seen commonly, and before 1900 there were several successful whaling stations on the Washington coast (Scheffer and Slipp 1948). In certain summers, albacore tuna occur in the transitional domain in com-

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TABLE 1. Cruise summary.

Cruise number	Dates	Weather	Bird observer[a]	Km traveled: study area	Km traveled: total	Duration (days): study area	Duration (days): on station	Duration (days): total
	1964							
BB-344	18 May– 5 June	good, cruise went to 50° N, 145° W	P	2350	3590	11	11	18
BB-349	7–31 Aug.	relatively good; brief storm 1203 km off Washington	S	2875	4865	13	13	20
OSH-06	15–28 Oct.	fair to bad; heavy seas at times	P	2442	2442	10	10	10
	1965							
BB-352	11–28 Jan.	frequent storms	S	2344	2770	13	10	15
BB-357	14–28 Apr.	good	P	2646	2646	13	13	13
BB-368	4–22 Aug.	excellent	S	2710	2710	14	14	14
BB-380	3–18 Nov.	two-day storm, whole-gale force	P	2682	2682	14	8	14
Totals				18,049	21,705	88	79	104

[a] P = Peterson, S = Sanger.

mercial quantities, but their abundance is sporadic (Johnson 1962).

METHODS

BIRD OBSERVATIONS

The cruise procedure was to follow a fixed track, stopping the ship at 10:00 and 22:00 each day to conduct oceanographic sampling. While the ship was stopped during the day, a period of at least 4 hr, the birds in sight were identified and counted at irregular intervals. Their numbers, along with behavioral notes and other information, were logged in notebooks. In some cases there were no actual counts, and abundance was noted with words such as "several," "frequent," or "few." Furthermore, occurrence of a species was sometimes indicated only by a general reference to location. These gaps in otherwise quantitatively consistent data were filled with estimated numbers derived by making presumptions explained in table 2.

Few observations were made at night, and relatively little observing was done while the ship was underway. Binoculars (7 × 35 or 7 × 50) were used occasionally, especially on the later cruises. Pough (1957) and Peterson (1961) were the chief identification sources. Some of the identifications were based upon photographs, and a few specimens were collected.

The quality and extent of observations were largely a function of interest and the oceanographic work load of the observer, which was usually considerable. Observer interest increased with each cruise, and the 1965 data are accordingly more significant than those of 1964. The bias inherent in observing birds from a stopped ship will be discussed later.

OCEANOGRAPHIC OBSERVATIONS

Oceanographic sampling and measurements included temperature, salinity, oxygen, and nutrient chemistry, from the surface usually to 2000 m in depth. Biological observations included seawater primary productivity, chlorophyll measurements, and quantitative plankton-net hauls. Routine weather observations were also made at each station.

DATA ANALYSES

Observations were incomplete east of 125° W, and only some of the cruises went west of 140° W; therefore a quantitative comparison of the observations was made only within these longitudinal limits. This region will henceforth be known as the study area. Moreover, since the number of days spent in the study area varied from 10 to 15 per cruise, this factor was taken into account. The basic unit used for comparing the observations was the maximum number of a species seen at any single sighting during a day (MXD). This index was used by Thompson (1951) to assess Black-footed Albatross abundance. Other units used to compare abundance or occurrence for each of the predominant species for each cruise included mean daily abundance (MDA), relative abundance (RA), occurrence rate (OR, after Kuroda 1960), station OR, and cruise OR. These are defined as follows:

$$\text{MDA} = \frac{\Sigma \text{ MXD for each day in study area}}{\text{no. days spent in study area}}$$

$$\text{RA} = \frac{\text{species MDA}}{\Sigma \text{ MDA for all species}} \times 100$$

$$\text{OR} = \frac{\text{no. days species seen in study area}}{\text{no. days spent in study area}} \times 100$$

$$\text{station OR} = \frac{\text{no. days species seen at a station}}{\text{no. days stations conducted}} \times 100$$

$$\text{cruise OR} = \frac{\text{no. cruises on which species seen}}{\text{total no. cruises}} \times 100.$$

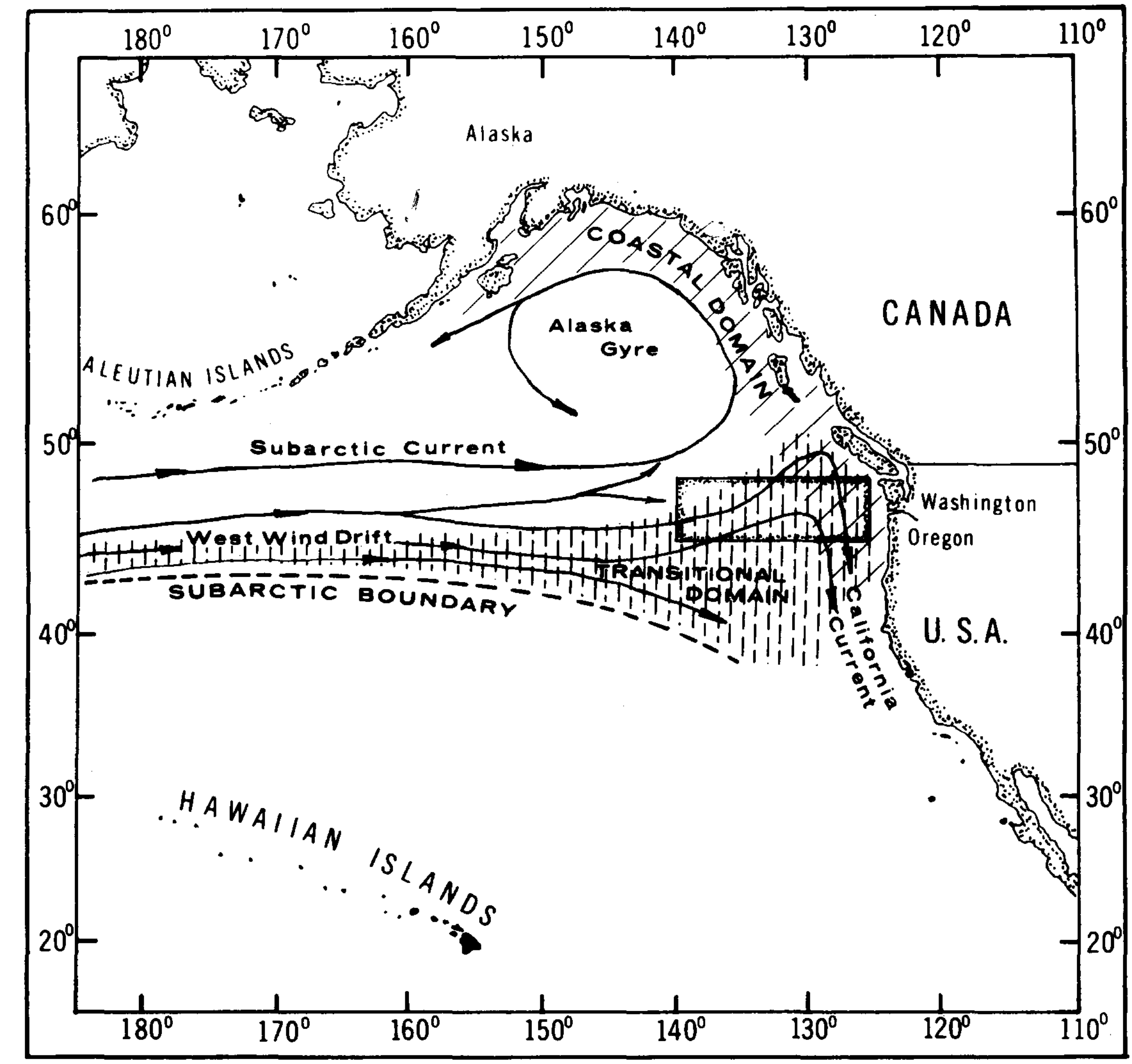

FIGURE 1. Northeast Pacific Ocean, showing the study area, schematic currents, and ocean domains (after Dodimead et al. 1963).

Also, the overall RA and OR were calculated for each species by lumping the data from all seven cruises. Since aggregate Glaucous-winged Gull-Herring Gull counts were made on some of the cruises, aggregate MXD and MDA values were calculated so that all cruises would be mutually comparable for the gull data. All of the observations and concurrent oceanographic data are stored permanently in the Smithsonian Institution's seabird Automatic Data Processing System (King et al. 1967).

For the predominant species, abundance in relation to some of the oceanographic parameters was determined. For each cruise, mean MXD's were calculated as they occurred within each of several increments of surface water temperature and salinity, noon air temperature, and primary productivity. Where significant, these data are presented as bar graphs.

For the following discussion, the word "frequent" refers to how often a species was seen but not necessarily to the numbers, while the word "abundant" (or its derivatives) refers to *numbers* but does not necessarily mean they were seen frequently.

RESULTS AND DISCUSSION

The MDA, RA, and OR data are listed in table 2. A total of 268 sightings of 3190 birds of 19 nominal species was made during the 88 days and 21,705 km it took to complete the cruises. Of the 19 species, a nominal 17 were seen in the study area, including five terrestrial or waterfowl species. Seven of these species predominated on the basis of their overall RA and OR values (table 3). These were the Black-footed and Laysan Albatrosses, Fulmar, Fork-tailed and Leach's Petrels, and Glaucous-winged and Herring Gulls. In a study such as this, one would expect the observed seabird community to be dominated by species that are attracted to ships, and this indeed was the case. The albatrosses and gulls accounted for

TABLE 2. Summary of data on relative abundance and occurrence rate.

	Relative abundance			Occurrence rate			
				No. of days seen		% of days seen	
Species[a]	Σ MXD	MDA	RA	study area	on station	study area	on station
May 1964							
BFA	55[b]	5.00	81.0	11	11	100.0	100.0
LA	4	0.36	5.8	3	2	27.3	18.1
FTP	6[c]	0.54	8.8	6	6	54.5	54.5
LP	2[d]	0.18	2.9	2	2	18.1	18.1
Bird	1	0.09	1.5	1	1	9.1	9.1
Total	68	6.17					
August 1964							
BFA	131[e]	10.07	92.2	13	13	100.0	100.0
FTP	3[f]	0.23	2.1	2	2	15.4	15.4
LP	8[f]	0.62	6.2	4	4	30.8	30.8
Brown-headed Cowbird (?)	5	0.38	3.3	1	1	7.7	7.7
Western (?) Flycatcher	1	0.08	0.7	1	0	7.7	0.0
Passerine	1	0.08	0.7	1	0	7.7	0.0
Total	149	11.46					
October 1964							
BFA	75[g]	7.50	43.8	8	8	80.0	80.0
LA	6	0.60	3.5	5	5	50.0	50.0
F	5	0.50	2.9	3	3	30.0	30.0
FTP (?)	1	0.10	0.5	1	1	10.0	10.0
All gulls	42[g]	4.20	24.6	5	5	50.0	50.0
HG				4	4	40.0	40.0
IG				2	2	20.0	20.0
Canada Goose	40	4.00	23.4	1	1	10.0	10.0
Podiceps sp.	2	0.20	1.2	1	1	10.0	10.0
Total	171	12.90					
January 1965							
BFA	48	3.69	25.0	11	8	84.6	80.0
LA	37	2.85	19.3	10	6	76.9	60.0
F	9	0.69	4.7	7	4	53.8	40.0
FTP	3	0.23	1.6	1	1	15.0	10.0
HG	18[h]	1.38	9.3	6	4	46.2	40.0
GWG	72[h]	5.54	37.5	10	6	76.9	60.0
IG	4	0.31	2.1	2	2	15.4	20.0
Unident. procellariid	1	0.08	0.5	1	1	7.7	10.0
Total	192	14.77					

[a] BFA = Black-footed Albatross, LA = Laysan Albatross, F = Fulmar, FTP = Fork-tailed Petrel, LP = Leach's Petrel, LTJ = Long-tailed Jaeger, HG = Herring Gull, GWG = Glaucous-winged Gull, IG = Immature Gull.

[b] Presumed at each station on basis of field-log notation, "BFA were common during the whole trip." Numbers estimated at 5 each station.

[c] Presumed present at each station on northern and western legs on basis of field-log notation, "FTP were very frequent on the northern and western legs of the trip." Numbers conservatively estimated at one each station.

[d] Numbers estimated at one at each of two stations.

[e] Assumed present on 5 days when no notes were recorded. Numbers at stations on these days were estimated as being equal to the MDA (10.1) of the 8 stations where counts were made.

[f] Two each estimated at a station where "Seen occasionally."

[g] Estimated from field-log notations such as "few" and "many;" some aggregate HG and immature gull counts.

[h] Some aggregate HG-GWG counts. They are divided between HG and GWG on the basis of the HG-GWG ratio (1:4) at those stations where separate counts were made. GWG numbers estimated from field-log notations for 3 stations, HG for one station.

TABLE 2. *Continued*

	Relative abundance			Occurrence rate: No. of days seen		% of days seen	
Species[a]	Σ MXD	MDA	RA	study area	on station	study area	on station
April 1965							
BFA	148[i]	11.38	80.1	13	13	100.0	100.0
LA	5	0.38	2.7	3	1	23.1	7.7
F	2	0.15	1.1	2	2	15.4	15.4
FTP	5[j]	0.38	2.7	4	4	30.8	30.8
All gulls	25[k]	1.92	13.5	5	5	38.5	38.5
HG				2	2	15.4	15.4
IG				3	3	23.1	23.1
Total	185	14.21					
August 1965							
BFA	362	25.86	75.6	14	14	100.0	100.0
F	2	0.14	0.4	2	1	14.3	7.1
LP	53[l]	3.78	11.0	7	7	50.0	50.0
FTP	34[l]	2.43	7.1	5	5	35.7	35.7
LTJ	26	1.86	5.4	6	3	42.8	21.4
Spotted Sandpiper	1	0.07	0.2	1	1	7.2	7.2
Brown-headed Cowbird	1	0.07	0.2	1	1	7.2	7.2
Total	479	34.21					
November 1965							
BFA	108[m]	7.71	25.2	13	8	93.0	100.0
LA	38	2.71	8.8	10	7	71.5	87.5
F	36[n]	2.57	8.4	9	7	64.3	87.5
FTP	2	0.14	0.4	2	2	14.0	25.0
All gulls	238[o]	17.00	55.5	11	8	78.6	100.0
HG				10	8	71.4	100.0
GWG				9	7	64.3	88.0
IG				9	7	64.3	88.0
Terns	7	0.50	1.6	3	1	21.0	12.0
Total	429	30.64					

[i] Numbers at 7 stations were estimated as being equal to the MDA (11.8) of the 5 stations where counts were made. Five BFA's were estimated to be at a station where abundance was recorded as "a few" in the field log.
[j] Numbers estimated at one for each of 3 night stations where FTP's were noted to land on the ship at night.
[k] One aggregate count, "Many gulls present, still mostly immature." "Many" estimated to equal 10 and adult gulls presumed to be HG since adult HG was the only species seen offshore during cruise (seen the next day).
[l] Aggregate FTP-LP counts at two stations.
[m] On 2 days, numbers were estimated at 5 each on basis of "a few" recorded in field log, and a third day's numbers were estimated at 9, on basis of 8.9 MDA for days with actual counts.
[n] On basis of field-log notations of "a few," F's were estimated at 3 on each of 2 days.
[o] "Numerous gulls" (GWG, HG, and IG) recorded at one station; numbers estimated at 20 in aggregate. Almost all other actual gull counts were aggregate GWG and/or HG and/or IG. "Lots of gulls" noted while underway one day (16 Nov.), numbers estimated at 12.

more than 83 per cent of all birds seen in the study area.

Figure 2 illustrates the striking seasonal changes in the seabird community observed within the study area. Black-footed Albatrosses and storm petrels predominated in summer, whereas gulls (Glaucous-winged and Herring), Laysan Albatrosses, Fulmars, and lesser numbers of Black-footed Albatrosses predominated in winter. Numbers of these species in spring and fall were transitional between the other seasons. Detailed information on each species is given below under the species accounts.

BLACK-FOOTED ALBATROSS (*DIOMEDEA NIGRIPES*)

Distribution and abundance. The Black-footed Albatross was the most frequently seen and most abundant species within the study area. It was present during all seven cruises,

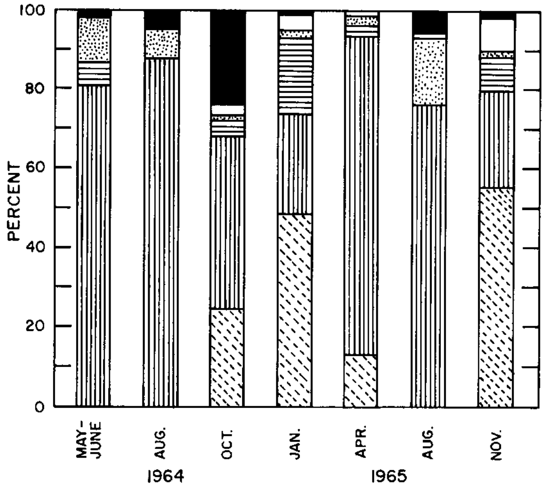

FIGURE 2. Relative abundance of birds in the study area. Vertical hatching = Black-footed Albatross; horizontal hatching = Laysan Albatross; stippled = storm petrels; diagonal hatching = gulls; open = Fulmar; solid = other.

on 94 per cent of the 88 days spent in the study area, and it accounted for 53 per cent of all birds seen (table 3). The MDA and OR both reflect the same general seasonal cycle (figs. 3, 4), with peak abundance and occurrence

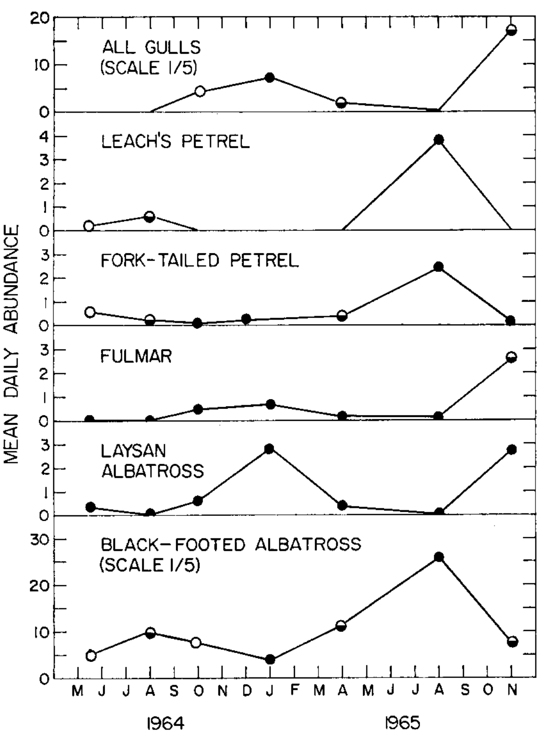

FIGURE 3. Seasonal variation in the mean daily abundance (MDA) of the predominant species in the study area. ● = actual counts; ◒ = includes some estimated numbers; ○ = numbers estimated.

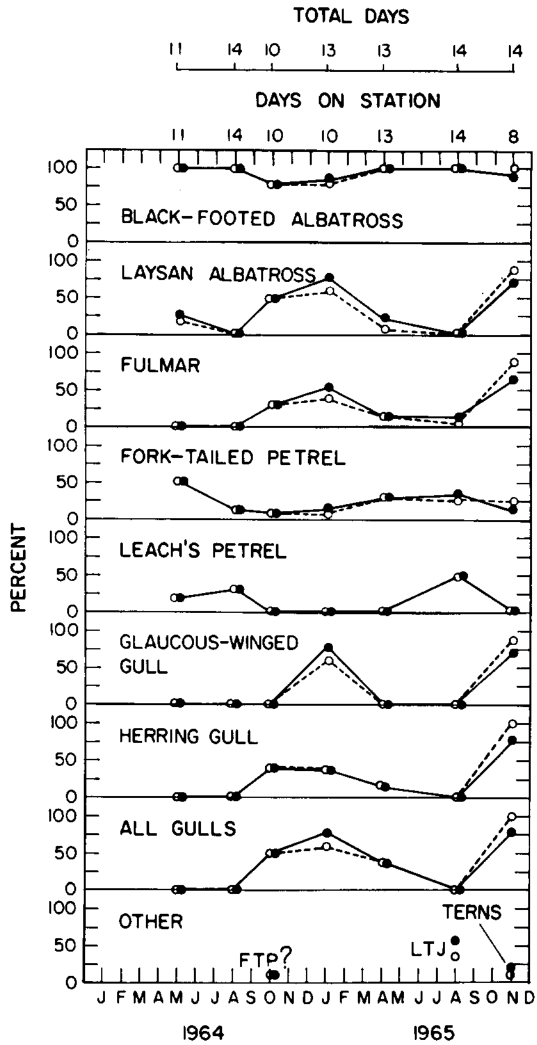

FIGURE 4. Seasonal variation in the occurrence rate (OR) of the predominant species in the study area. ● = all observations; ○ = station observations only.

coming in summer and minimums in winter. Just south of the present study area, Willis Peterson observed black-foots in an MDA of eight for five days during a cruise east of 130° W in August 1966. Thus the abundance observed in August 1965 (MDA 26) was probably unusually high for the general area. Since this species does not return to the breeding grounds until its third year (Rice and Kenyon 1962a), birds that wintered in the study area were probably prebreeding juveniles; C. S. Robbins and D. W. Rice (unpubl. MS) showed that birds of this age are the most likely to wander far from the breeding grounds during the breeding season.

Figure 5 presents, by cruise, the distribution of *Diomeda nigripes* numbers relative to shore.

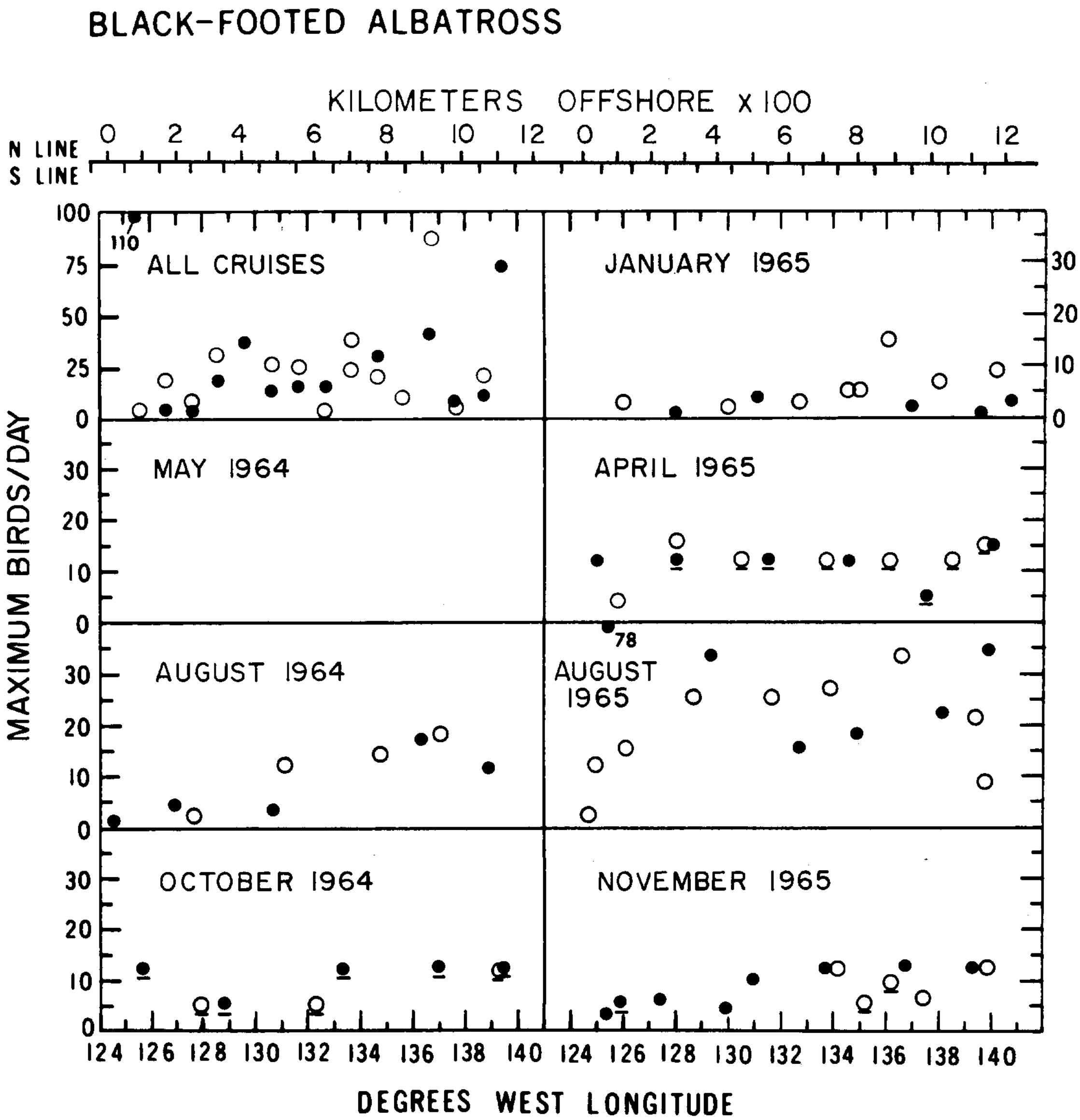

FIGURE 5. Black-footed Albatross abundance relative to shore. ● = observations along northern line; ○ = observations along southern line. Underlined symbol indicates MXD includes some estimated numbers.

The August 1964 and November 1965 data suggest a slight trend for numbers to level off at 550–750 km offshore, after an initial increase with distance from land, while the others generally indicate that maximum numbers usually occurred relatively far offshore. There seemed to be no difference in distribution between the northern and southern lines except for January, when the most birds were seen far off Oregon. There was no noticeable difference in numbers of Black-footed Albatrosses between the northern and southern lines for the "all cruises" data (fig. 5); generally, maximum numbers occurred far offshore, although smaller numbers were equally frequent there. The glaring exception to this, 110 birds occurring within 90 km of Washington, is due largely to the sighting of 78 blackfoots during the August 1965 cruise. It should be noted that little time was spent within 90 km of shore, compared with farther offshore. More intensive observations closer to shore might show that the Black-footed Albatross is more concentrated here, as Miller (1940) found off southern California in summer, and McHugh (1955) found off northern California and Oregon in spring. However, McHugh also found uniform Black-footed Albatross distribution off Washington and Oregon (to 130° W) in August 1949, and, for the northern

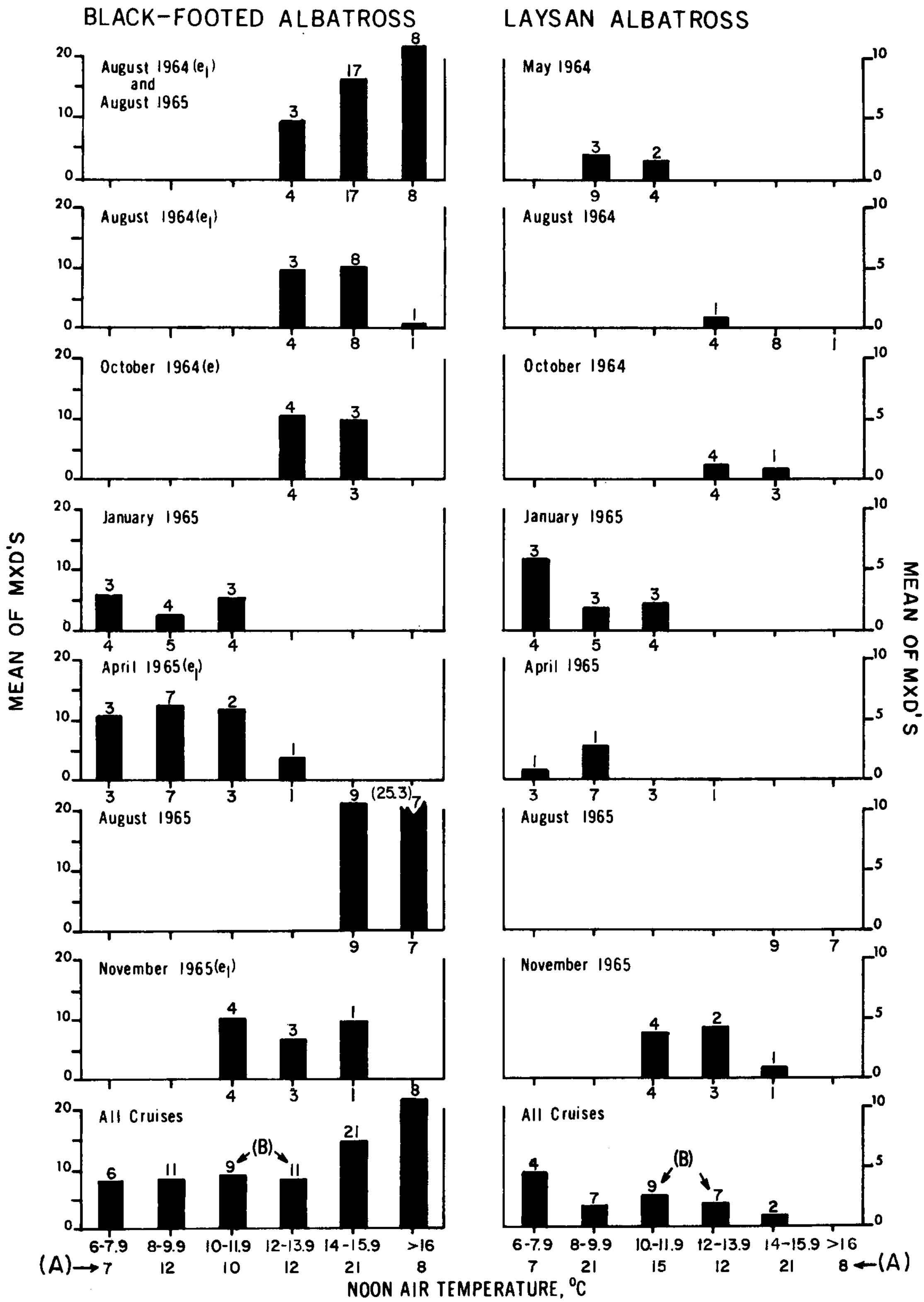

FIGURE 6. Albatross abundance in relation to noon air temperature. e = numbers estimated; e_1 = includes some estimated numbers; (A) = number of temperature observations; (B) = number of MXD units contributing to mean.

Washington and Vancouver Island coasts in August 1950, distribution generally similar to that found in this study. The rest of McHugh's (1955) data for Washington and Oregon showed a range from a general increase in abundance with distance from shore (June, July, Oct., Nov. 1949; June 1950) to uniform distribution (Sept. 1949, July and August 1950). Martin (1942) noted that on the off-shore banks off British Columbia *D. nigripes* "is a constant companion of the fishermen, at least from April until the end of August."

It is curious that of the six records of the Black-footed Albatross from Washington quoted by Jewett et al. (1953), all except one (October 1932) were either in May or June. Gabrielson and Jewett (1940) listed sight records for the Oregon coast for May and August, and considered the black-foot to be a regular summer visitor. Other recent sight records of *Diomeda nigripes* off Washington and Oregon include those of Yocom (1947b) for July, August, and September 1945; he observed that black-foots were generally abundant at 135° W off Oregon, with as many as 53 seen at once. Kenyon (1950) sighted the species off Washington and Oregon in December 1948; Powell et al. (1952), noted black-foots at Cobb Seamount, 537 km off southern Washington in August 1950; and Hamilton (1958) noted an abundance of *D. nigripes* following his ship east of 130° W off Washington in June 1955, with as many as 30 individuals seen at once. Other sight records include Kenyon and Scheffer's (1962) sighting of an individual four miles off northern Washington in July 1955, Sanger's (1965) general comments on occurrence in 1963, and Poole's (1966) noteworthy sighting of a single bird 110 km inside the Strait of Juan de Fuca.

I conclude that there is little relationship between black-foot numbers and distance from shore per se. Their longitudinal distribution is probably largely influenced by the distribution of food organisms.

Environmental notes. Figure 6 shows the relationship between albatross numbers and noon air temperatures. There is no clear-cut trend within individual months, but maximum numbers of birds and maximum temperatures were concurrent in August 1965, and minimums of each occurred in January 1965. The "all cruises" data show essentially no difference in numbers of birds from 6 to 12°C, but successively sharp increases are noted from 14°C to the > 16°C increment. The highest temperature noted during the cruises was 18.0°C, when 25 black-foots were counted (August 1965), and the lowest temperature when black-foots were seen (one bird) was 7.2°C in January 1965. These data suggest that warm air temperatures in this area are conducive to the presence of Black-footed Albatrosses. However, this apparent direct relationship could be due partly to the winter breeding habits of this species, resulting in the lowest number of birds at sea at the season with the lowest air temperatures in the area. The graph of the two August cruises, the only ones that can safely be assumed to have occurred when all black-foots were at sea, shows a decided trend for a positive correlation between air temperature and bird numbers. My conclusion is that, other factors being equal, warm air temperatures favor an increased Black-footed Albatross abundance in this area.

The relation between surface water temperature and Black-footed Albatross numbers is shown in figure 7. The general trends shown for air temperatures are repeated: highest black-foot numbers were seen during the cruise with the highest water temperatures (August 1965), and lowest numbers were concurrent with lowest temperatures (January 1965). The "all cruises" data show a parallel increase in black-foot numbers and surface water temperatures, as do the lumped August 1964 and August 1965 data. The highest and lowest surface water temperatures at which black-foots were seen were 16.8°C in August 1965 (25 birds) and 6.6°C in January 1965 (one bird). I conclude that, other factors being equal, increased surface water temperatures are conducive to increased Black-footed Albatross abundance in this area. Kuroda (1960) observed that, in the Northwest Pacific in June and July 1954, *D. nigripes* distinctly preferred the "warm current zone."

The great increase in Black-footed Albatross abundance in August 1965 over August 1964 (2.5 times more abundant) may have been influenced by a large-scale weather aberrancy over the North Pacific in the summer of 1965, which caused the warm air and water temperatures noted above. Air flow possessed a strong anomalous onshore component in August 1964, but a strong offshore component in August 1965. Also in August 1965, a strong anomalous longitudinal trough was present in the North Pacific, slowly moving from west to east, and extending from far off Washington, southward to the Hawaiian Islands. To the west of the trough, abnormally cold and stormy conditions prevailed, while off North America to the east of the trough, abnormally warm and calm weather conditions prevailed,

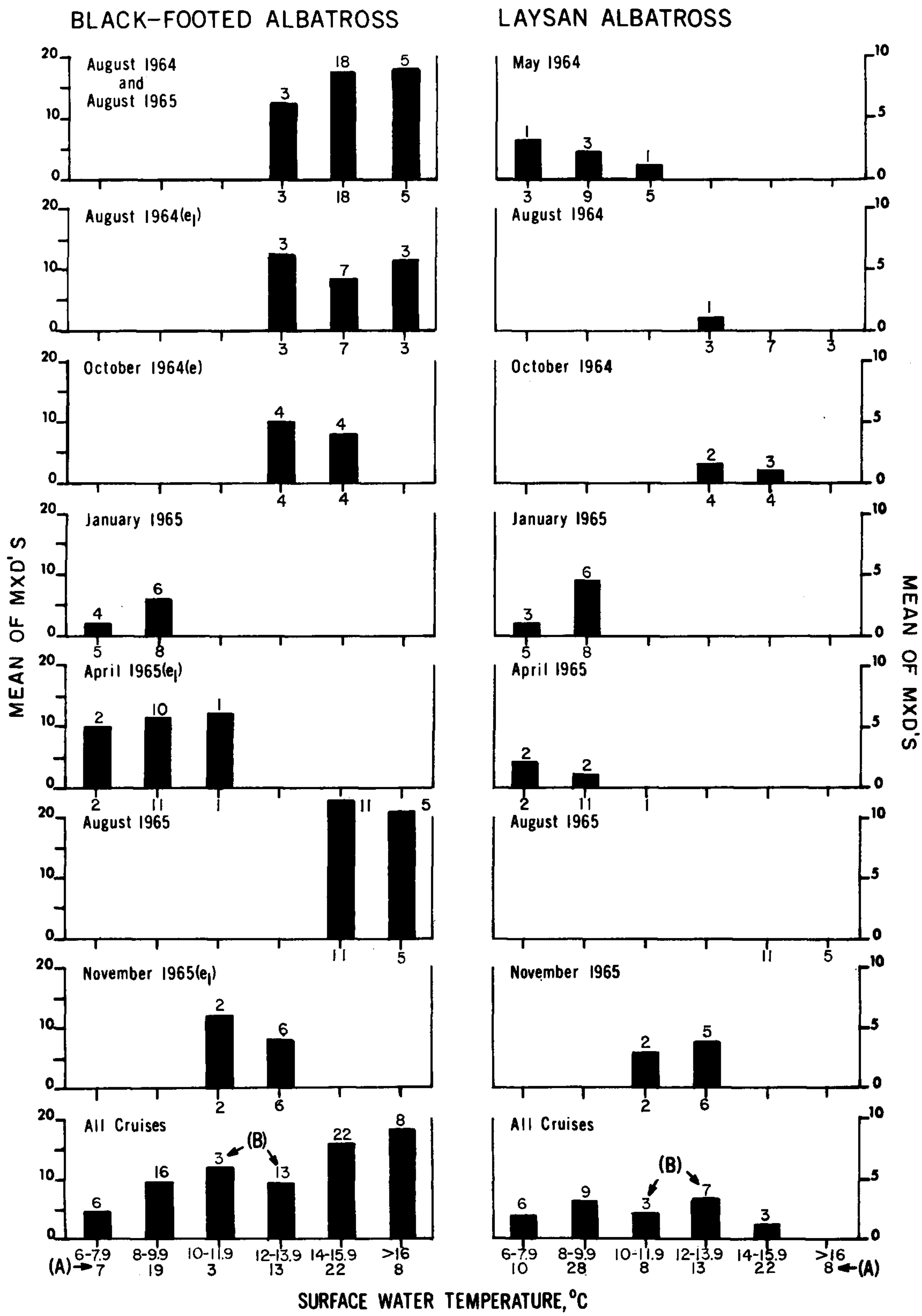

FIGURE 7. Albatross abundance in relation to surface water temperature. e = numbers estimated; e_1 = includes some estimated numbers; (A) = number of temperature observations; (B) = number of MXD units contributing to mean.

including the warmer than normal surface water temperatures (Jerome Namias, pers. comm.). Also associated with the warm temperatures and unusually high black-foot abundance were the occurrence of countless thousands of the pelagic siphonophore *Velella* sp. and the frequent occurrence of the pelagic barnacle *Lepas fasticularis* throughout most of the 2710-km cruise track. Fifty-six albacore, *Thunnus alalunga*, were caught in offshore waters by trolling feathered jigs behind the ship while traveling between oceanographic stations. In addition, the occurrence and abundance of storm petrels were unusually high (see below). This evidence suggests that food for a variety of marine organisms, including Black-footed Albatrosses, was abundant in the area. Despite the fact that the measured rate of primary productivity during this cruise was only average for the area and season (except for a station 74 km off Washington, which had a productivity rate about five times that of the oceanic areas and at which 78 black-foots were counted; see below), there had to be an unusually large food supply to support the abundance of animals. The increased temperatures possibly allowed an influx of mobile food organisms, such as squid and small schooling fishes, from farther south. However, there is no evidence that large albatross concentrations normally occur farther south in August; the contrary seems to be true off California (unpubl. California Cooperative Oceanic Fisheries Investigations data). The longitudinal anomalous trough also may have acted as something of a physical restraint to birds that would ordinarily have migrated into the western Pacific from the breeding grounds in July, but found the relatively warm and mild conditions to the east of the trough more to their liking.

There seemed to be no trend between black-foot numbers and surface salinity, either for individual cruises or data lumped from all cruises. Birds were seen in virtually the entire range of salinities encountered during the cruises, from values just below 30‰ to just above 33‰. During a cruise east of the study area in June 1965, I counted 22 black-foots just off the mouth of the Columbia River in a surface salinity of 14.98‰, which is less than half that of normal seawater (ca. 35‰). My conclusions are that Black-footed Albatross abundance off Washington and Oregon has no relation to surface salinity and that the species occasionally enters areas with surface salinities far below those of normal seawater.

The relationship between albatross numbers and primary productivity observed during the cruises is uncertain. Without knowing the transfer rate of the assimilated carbon up the food chain, it is difficult to relate primary productivity rates to organisms as high on the food chain as albatrosses. The simultaneous occurrence in August 1965 of the highest number (78) of Black-footed Albatrosses in a single sighting and the highest productivity rate (5.22 g $C \cdot m^{-2} \cdot day^{-1}$) of all seven cruises may be significant. The zooplankton data were unavailable for analysis.

Behavioral notes. Noteworthy sailing times were observed during the January 1965 cruise. Miller (1940) and Yocom (1947b) both recorded sailing times for this species of no more than 60 sec, "even in a smart gale" (Miller). With the ship steaming at 7 knots, with a following wind (37 knots) and sea (6–10 m), I timed *D. nigripes* sailing without wing flapping for as long as 11 min. A wing flap is defined as both wings simultaneously moving perpendicular to the axis of the bird's body, excluding minor changes in pitch or angle of the wing and wing movements caused by wind buffeting. The 11-min observation should be regarded as minimal since the bird was sailing when timing started and ended when it was lost from view. During a severe storm in November 1965, Peterson observed black-foots sailing in winds of 60–70 knots, with occasional higher gusts, with no observable ill effects. In August 1965, three Albatrosses mauled a dead Long-tailed Jaeger about the head and neck; it had been shot for a specimen. Also in August 1965, black-foots occasionally nibbled at the floating *Vellela* and pelagic barnacles, but they apparently never ate them. Other behavior during the cruises paralleled the well-known accounts of others (e.g., Miller 1940).

LAYSAN ALBATROSS (*DIOMEDIA IMMUTABILIS*)

Distribution and abundance. The Laysan Albatross had an overall relative abundance of 5.6 in the study area, making it the fourth most abundant species seen, after the Black-footed Albatross and Glaucous-winged and Herring Gulls (table 3). The MDA and OR (figs. 3, 4) show the pronounced seasonal cycles of the Laysan Albatross in the study area. It was entirely absent on both August cruises, yet MDA = 3 and OR = 75 in January and November 1965. The other cruises were transitional between these extremes. The striking thing about these data is that peak abundance was in winter, when 82–90 per cent of the population is on the breeding grounds (Rice and Kenyon 1962a). Like the Black-footed Alba-

TABLE 3. Overall relative abundance and occurrence rate in the study area, all cruises.

Species	Relative abundance	Occurrence rate Daily	Occurrence rate Cruise
Predominant species			
Black-footed Albatross	53.2	94.3	100.0
Fork-tailed Petrel	3.3	23.9	100.0
Laysan Albatross	5.6	35.2	71.4
Fulmar	3.3	26.1	71.4
Herring Gull	12.4	26.1	57.1
Glaucous-winged Gull	12.4	22.7	28.6
Leach's Petrel	3.7	14.8	42.8
Other species			
Brown-headed Cowbird	0.4	2.2	28.6
Long-tailed Jaeger	1.6	10.2	14.3
Canada Goose	3.4	1.1	14.3
Unidentified terns	0.4	3.4	14.3
Unidentified grebes	0.1	1.1	14.3
Unidentified procellariid	< 0.1	1.1	14.3
Glaucous (?) Gull	< 0.1	1.1	14.3
Spotted Sandpiper	< 0.1	1.1	14.3
Western (?) Flycatcher	< 0.1	1.1	14.3
Unidentified passerine	< 0.1	1.1	14.3

tross, these wintering birds were most likely pre-breeding juveniles (C. S. Robbins and D. W. Rice, unpubl. MS).

Figure 8 shows that there was a definite seasonal trend in the distribution of Laysan Albatrosses in the study area. During the January and November 1965 cruises they were generally scattered across the cruise area, although maximum numbers occurred relatively far offshore. The occurrence of half of the January 1965 sightings in the western portion of the southern line suggests that the population center lay south and west of the cruise area. The spring cruises, May 1964 and April 1965, show a definite withdrawal from the coast or the coastal domain; of the six sightings for both cruises, five were more than 925 km from land. The single sighting for both August cruises was more than 1200 km offshore (west of the study area), indicating that any Laysans present at these latitudes normally would be found well away from the coast. However, G. Alcorn's sightings of Laysan Albatrosses 46 km off northern Washington on two consecutive days in August 1949 (Kenyon 1950) indicate that they may occasionally wander close to shore in summer. Although a single *D. immutabilis* was sighted a scant 74 km off Washington during the October 1964 cruise, the remaining four sightings were more than 600 km off the coast, with three of these being 925 km or more out. The "all cruises" data (fig. 8) show a pronounced increase in numbers with distance from shore.

On the basis of 11 sight records in February and March 1958 and of a few literature records, Holmes (1964) suggested that the Laysan Albatross may be a regular visitor to the California coast in late winter and early spring. McHugh (1950) indicated that Laysans were seen off northern California and Oregon in February and March 1949. Other winter records off Washington, Oregon, and Vancouver Island, Canada (Sanger 1965), and unpublished winter records (from the University of Washington) show that the Laysan Albatross ranges off the Washington-Oregon coast in winter as a rule rather than as an exception. The only specimens for the area are those of McAllister (1954) and Fredrich (1961) for birds found dead on the northern Oregon coast.

Environmental notes. The data in figure 6 show no trend in the relationship between noon air temperatures and albatross numbers during individual cruises for the Laysan, although the most birds seen in one cruise and the lowest air temperatures were concurrent in January 1965. The air temperature was 7.5°C during the largest MXD sighting (15 birds, January 1965), 12.7°C during the sighting of a lone Laysan in August 1964, and ranged from 14 to 18°C when none were seen in August 1965. The "all cruises" graph suggests an inverse correlation between number of birds and air temperature. A total of 44 birds was seen at 46 per cent of the 43 stations where air temperatures were less than 12°C, while only 16 birds were seen at 22 per cent of the 41 stations with noon temperatures of 12°C or greater.

The relationship of Laysan numbers to surface water temperature (fig. 7) is less clear than to air temperature. The May 1964 data suggest an inverse correlation between bird numbers and this parameter within the 6–11.9°C range, but in January 1965 the mean MXD was four times higher at 8–9.9°C than at 6–7.9°C. It may be significant that the species avoided the study area in summer, when surface water temperatures were the highest (range in August 1965: 15.1–16.8°C). Moreover, a total of 47 birds was seen at 39 per cent of the 46 stations with surface water temperatures of less than 12°C, while only 28 birds were counted at 23 per cent of the 43 stations with temperatures of 12°C or greater. These facts, when considered with the summer absence of *D. immutabilis* in the study area, suggest an inverse correlation between this species

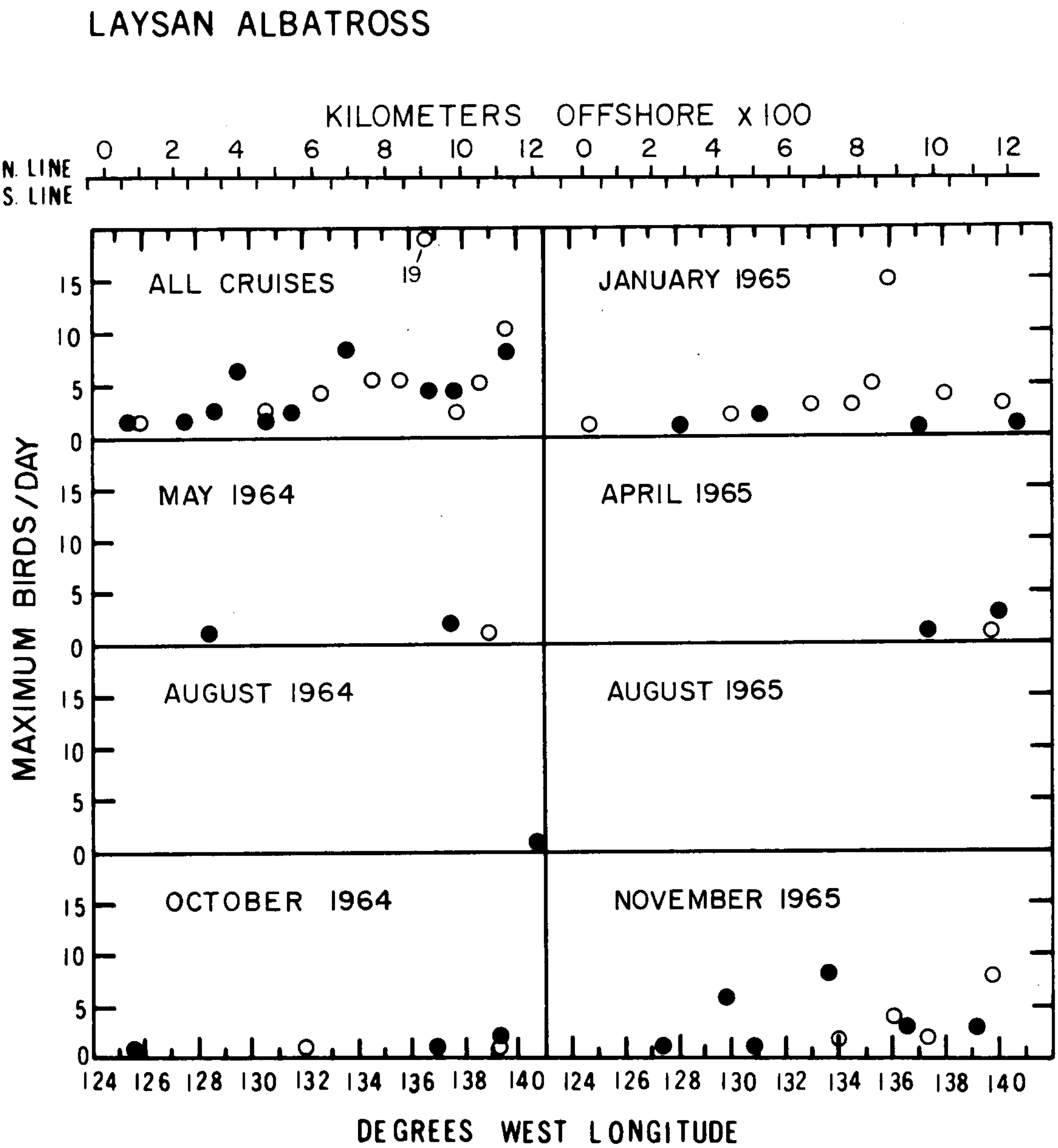

FIGURE 8. Laysan Albatross abundance relative to shore. ● = observations along northern line; ○ = observations along southern line.

and surface water temperature. On the basis of his observations in the Northwest Pacific in June and July 1954, Kuroda (1960) felt that *D. immutabilis* was less warm-adapted than *D. nigripes*, an observation corroborated by the present data.

Laysans were observed within only an extremely narrow range of surface salinity. Only one bird was seen in a salinity of less than 32‰ (31.98, October 1964). The highest in which they were observed was 32.78‰ (MXD = 2; May 1964), and most of the sightings occurred when the salinity was greater than 32.5‰. From these data, I conclude that the Laysan Albatross may avoid waters of relatively low salinity. Indeed, this may partly explain the usual late summer absence of the species in the study area, when relatively low surface salinities can occur far offshore.

Behavioral notes. Noteworthy behavior was seen during the January 1965 cruise. Like the Black-footed Albatross, *D. immutabilis* sailed for long periods without wing flapping. The longest recorded time was 11 min 3 sec, noted while the ship was steaming at 8 knots with a following wind (18 knots) and sea (3–4.5 m).

Ship-following was the rule rather than the exception during this cruise; one Laysan Albatross followed the ship continuously for 25 min. Some display behavior was noted, including a mouthing (Rice and Kenyon 1962b) episode that was photographed when a pair of Laysans approached to within 10 m of the ship.

SHEARWATERS (*PUFFINUS GRISEUS* and/or *P. TENUIROSTRIS*)

The only sightings of shearwaters from these cruises were during August 1964, when they were seen in flocks of 100–300 birds east of the study area off extreme northern Washington, southern Washington, and northern Oregon. Although these species were not seen in the study area, they undoubtedly occur, if only during migration. In August 1950 Powell et al. (1952) noted Sooty Shearwaters at Cobb Seamount, located 537 km off Washington and within the present study area.

FULMAR (*FULMARUS GLACIALIS*)

Distribution and abundance. Although the Fulmar accounted for only 3.3 per cent of the birds seen in the study area, it had a relatively high overall OR (table 3). Seasonal cycles in abundance were similar to those of the Laysan Albatross, with maximum numbers and occurrence in winter and minimums in summer (see figs. 3, 4). These data supplement the records of Gabrielson and Jewett (1940) and Jewett et al. (1953) for the fall and winter occurrence of this species along the Washington and Oregon coasts. Fulmars were common close to the Washington coast in September–October 1963, but were not recorded farther offshore (Sanger 1965).

The observations suggested a general trend for numbers to increase with distance from shore in winter (January and November 1965), but data from the other cruises were too sparse for conclusions. The largest numbers of birds generally tended to occur farthest offshore. More Fulmars were seen off Washington than Oregon.

Environmental notes. All of the Fulmar sightings were within the 6–15.9°C range of both noon air temperatures and surface water temperatures. The highest MXD values for air temperature and surface water temperature both occurred in the 12–13.9°C increment, as a result of a relatively high abundance of birds noted in this temperature range during the November 1965 cruise. Kuroda (1960) considered Fulmars to prefer 6–11.5°C air temperatures and 3.5–7°C water temperatures in the western North Pacific in June–July 1954. Fulmars were seen during the present cruises in salinities ranging from 32.14 to 32.73‰.

FORK-TAILED PETREL (*OCEANODROMA FURCATA*)

Distribution and abundance. The Fork-tailed Petrel was the only species, besides the Black-footed Albatross, seen during each cruise, although it had an overall RA of only 3.3 (table 3). The MDA and OR (figs. 3, 4) give a slight indication of a seasonal cycle, with maximum abundance and occurrence in summer and minimums in winter, but this could have been partly a result of the better observing conditions (visibility) in summer.

Sightings of Fork-tailed Petrels were generally few and scattered, and showed no apparent relationship to distance from shore. Sightings of large flocks west of 138° W in August 1965 could have been partly a result of the excellent weather. The flock of 20 at 140° W was 1–1.5 km away, and could well have been missed in rough weather.

Powell et al. (1952) noted this species at Cobb Seamount in August 1950. Hamilton (1958) saw scattered single Fork-tailed Petrels at distances greater than 185 km off Washington in June 1955. Sanger (1965) noted this species off Washington and Oregon to 130° W in June, September, and October 1963. Gabrielson and Jewett (1940) listed a single breeding place of the Fork-tailed Petrel in Oregon, and Richardson (1960) recently discovered the species breeding in Washington.

Environmental notes. As with the Fulmar, sightings of this species were too few for a detailed comparison with the environmental data. Birds were seen within a range of air temperatures of 7.5°C (January 1965) to 16.2°C (August 1965); the highest MXD of all cruises, 20 birds, was seen at the latter temperature. The species was seen within a surface water temperature range of 7.0°C (April 1965) to 15.9°C (August 1965). The 20-bird flock (August 1965) occurred at a 14.4°C water temperature. The surface salinity ranged from 32.24 to 32.67‰ for the sightings. Most of Kuroda's (1960) sightings of *O. furcata* occurred in 5–11.5°C air temperatures and 3–8°C surface water temperatures.

Behavioral notes. Fork-tailed Petrels frequently followed the ship. On 15 August 1964 up to five Fork-tailed and/or Leach's Petrels were constantly in sight behind the moving *Brown Bear* for a period of about 3.5 hr, but it is unknown whether the same individuals were involved the whole time. This species sometimes came as close as 5 m to the stopped ship, sometimes briefly alighting on the water among the ever-present Black-footed Albatrosses. They were occasionally observed at night, flying beneath the ship's working lights at a station.

LEACH'S PETREL (*OCEANODROMA LEUCORHOA*)

Distribution and abundance. This species was the least abundant and least often seen of the seven predominant species in the study area (table 3). The MDA and RA data (figs. 3, 4) suggest a seasonal cycle, with the species present in summer and absent in winter.

Like the preceding species, Leach's Petrel sightings were generally scattered across the study area, and showed no apparent relation to distance from shore. Sightings were usually of single birds, but a flock of 25 was noted at 45° 20′ N, 126° 00′ W, on 9 August 1965.

Powell et al. (1952) noted "Beal's Petrels" (= *O. l. beali*) at Cobb Seamount in August 1950. Gabrielson and Jewett (1940) and Jewett et al. (1953) listed numerous breeding localities on the coast and coastal islets. In February-March, May, and June of 1963, the species was seen west to 130° W within the present cruise area (Sanger 1965).

Environmental notes. Leach's Petrels were noted within a noon air temperature range of 10.3–18.0°C, a surface water temperature range of 9.3–16.7°C, and a surface salinity range of 30.82–32.66‰. The flock of 25 Leach's Petrels seen in August 1965 occurred at a noon air temperature of 15.1°C, a surface water temperature of 16.7°C, and a surface salinity of 30.82‰. In the northwestern Pacific, Kuroda (1960) noted this species in air temperatures of 3.5–22°C (especially 13–15°C) and surface water temperatures of 2.3–16°C (especially 6–8°C). Considering the extremely wide pelagic range of this species, one would expect it to be found in wide ranges of oceanographic parameters.

Behavioral notes. A significant factor in the present data is that many of the Leach's Petrel sightings were at night, often when none were seen on the preceding or following days. This suggests a repulsion (or at least an indifferent response) during the day and an attraction factor for the ship at night. Continuous observing in daylight hours, especially when the ship was moving, undoubtedly would have revealed more birds, giving a better idea of the species' true abundance in the study area.

CANADA GOOSE (*BRANTA CANADENSIS*)

A flock of 40 Canada Geese was seen flying (presumably south) some 650 km off northern Washington on 19 October 1964. Apparently the only other record at sea in the Northeast Pacific is Poole's (1966); he saw a flock of 50 heading SE in September 1953, some 370 km S of Unalaska in the Aleutians. Willis Peterson quoted members of the *Oshawa* crew as previously having seen Canada Geese far offshore in the Northeast Pacific.

SPOTTED SANDPIPER (*ACTITIS MACULARIA*)

An immature male was collected at 45° 20′ N, 136° 23′ W, on 13 August 1965 (Washington State Museum No. 21225) as it weakly flew around the stopped ship. This position is ca. 800 km offshore.

LONG-TAILED JAEGER (*STERCORARIUS LONGICAUDUS*)

During the August 1965 cruise, Long-tailed Jaegers were seen frequently in the study area, with an OR of 43 (fig. 4) and an RA of 5 (see table 2). A light-color-phase adult female was collected (Washington State Museum No. 21227), confirming the sight observations.

GLAUCOUS (?) GULL (*LARUS HYPERBOREUS*)

During the January 1965 cruise a 35 mm photograph of an aggregation of gulls and Laysan and Black-footed Albatrosses was obtained some 925 km off Oregon. Subsequent examination of the transparency revealed an immature gull with a decidedly pinkish basal half of the bill and very light primary feathers, suggesting a Glaucous Gull.

GLAUCOUS-WINGED GULL (*LARUS GLAUCESCENS*)

Glaucous-winged Gulls were seen in the study area during only two cruises, January and November 1965 (fig. 4). They were surprisingly frequent and locally abundant far offshore, but were not seen on other cruises, even relatively close to shore. During the January cruise, adult Glaucous-winged Gulls accounted for 38 per cent of all birds seen in the study area. The OR of adults was 88 at the stations during the November 1965 cruise (fig. 4). Neither Gabrielson and Jewett (1940) nor Jewett et al. (1953) mentioned the offshore occurrence of this species. Aggregate gull data, which include Glaucous-winged Gull counts, are discussed in the Herring Gull account.

Yocom (1947a) recorded this species far off southern California in late winter, and Sanger (1965) first observed Glaucous-winged Gulls off Washington and Oregon to 130° W in March and to 138° 45′ W in December 1963. A number of winter records (from the University of Washington) of "gulls" are probably referable to this species, at least in part. Poole

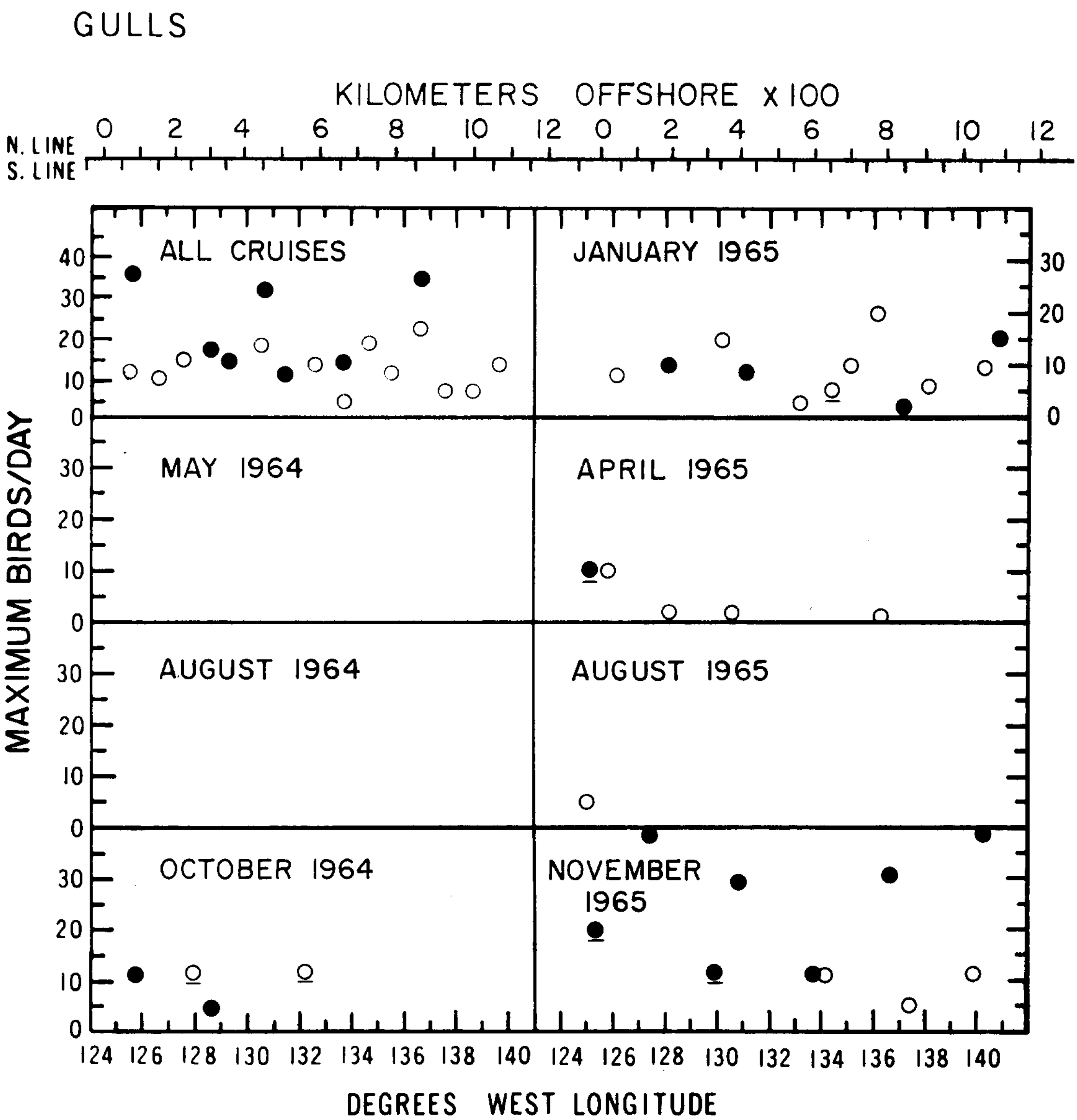

FIGURE 9. Gull abundance relative to shore (aggregate GWG-HG-Immature). ● = observations along northern line; ○ = observations along southern line. Underlined symbols indicate MXD includes some estimated numbers.

(1966) stated that Glaucous-winged Gulls followed his ship from Vancouver, British Columbia, to Yokohama, Japan, from October to March, presumably in the winters of 1962–1963 and 1963–1964.

Glaucous-winged Gulls were seen within a surface water temperature range of 7.1–13.4°C, and a salinity range of 32.14–32.76‰. The temperatures are clearly within the extreme range of freshwater temperatures that this species must encounter on land.

WESTERN GULL (*LARUS OCCIDENTALIS*)

The only sightings of this species during the cruises were for August 1964, when individuals were infrequently seen east of the study area within a few kilometers of southern Washington. Unpublished records (from the University of Washington) note this species at Cobb Seamount in March 1960, but confusion with Herring Gulls is possible.

HERRING GULL (*LARUS ARGENTATUS*)

Distribution and abundance. Herring Gulls had an overall RA of 12 (table 3) and were seen in study area every cruise day except May and August 1964 and August 1965. A pronounced seasonal cycle is shown for both abundance and occurrence (figs. 3, 4), with maximum numbers and widest distribution occurring in winter (fig. 9; includes Glaucous-winged Gull counts in January and November), none seen in summer, and other seasons being transitional between these extremes. Moreover, the October 1964 and April 1965 distributions (fig. 9), albeit sparse, suggest a land orientation. In view of the January 1965 distribution pattern, a dispersal away from land in fall and a return to land in spring is indicated. A continual back-and-forth movement between land and offshore areas seems possible, but there is no definite evidence to support this. The "all cruises" data show that, surprisingly, numbers of gulls were scattered across the cruise area, with as many seen well offshore as close to shore. More gulls were seen off Washington than Oregon. The January 1965 cruise was the only one during which separate counts of all gull species were made. Like the Glaucous-winged Gull, this species was seen in offshore areas by Yocom (1947a) and Sanger (1965), who noted that they were more abundant and common than the Glaucous-winged Gull; this observation parallels the present data (table 3).

The surface water temperature range within which Herring Gulls were seen was 7.1–15.2°C, and the surface salinity range was 31.98–32.75‰.

Behavioral notes. Both Glaucous-winged and Herring Gulls were often observed following the ship, but there were also times when none was seen; none was seen at night. It is not likely that the observed wide distribution in the study area in winter merely represented a relatively few gulls following the ship about. During the severe storm in November 1965, Peterson noted Herring Gull behavior. Unlike the Black-footed Albatrosses, they stayed on the water as much as possible. They headed into the wind and compressed their bodies tightly, offering the wind as little resistance as possible. With half-spread wings, they left the water only briefly, to avoid combers which surely would have inundated them.

BLACK-LEGGED KITTIWAKE (*RISSA TRIDACTYLA*)

The only occurrences of this species were in January 1965 in the extreme western and southwestern portions of the cruise area, west of the study area. Gabrielson and Jewett (1940) and Jewett et al. (1953) indicated a sporadic and scattered occurrence along the coast and occasionally inland (Seattle) from fall through spring. The two sightings, of nine and two birds, respectively, occurred in noon air temperatures of 9.1 and 10.2°C, surface water temperatures of 7.7 and 8.4°C, and surface salinities of 32.73 and 32.78‰.

TERNS

Unidentified terns, apparently migrating, were sighted three times during the November 1965 cruise.

COMMON (?) MURRE (*URIA AALGE*)

Murres, probably this species, were observed east of the study area off Washington during the August 1964 and November 1965 cruises.

GENERAL DISCUSSION

In this study an effort has been made to quantify the temporal and seasonal abundance of the predominant seabird species seen; however, this approach has obvious limitations. Observing seabirds from a stopped ship biases the resulting picture of kinds of species and numbers of birds seen. Compared with other species, the abundance of albatrosses and gulls, which are strongly attracted to ships, is overestimated. Abundance of species like the Fulmar and Fork-tailed Petrel, which are less often attracted to ships, is underestimated, while abundance of species like the Leach's Petrel, some other procellariids, and the alcids, which are indifferent to or repelled by ships, is severely underestimated or missed altogether. Figure 2 illustrates the disparity in relative numbers of birds seen from a stopped ship. The observed bird community is clearly dominated by albatrosses and gulls. However, the seasonal occurrence cycles of all species are evident.

For most seabird species, continuous watching from a moving ship has proved to be the most reliable way to estimate abundance; a unit of birds observed per linear kilometer may be calculated, with which a species density on a temporal or seasonal basis may be uniformly compared (see King, in press). However, for albatross and gull species that habitually follow moving ships, the number of birds observed per linear kilometer is meaningless since there is no way of knowing how long individual birds follow the ship (unless only a few identifiable birds are involved). Counting these species from a stopped ship probably provides the most reliable estimates of relative abundance, since the ship attracts (samples) birds from a discrete area, i.e., a circle, the radius of which is the distance from which the species can see the ship. However, there is no way of knowing the size of this circle, so it is still impossible to infer the actual density of a species in an area. It must be assumed that the area of the circle remained constant, although the varying weather and sea conditions undoubtedly affected the birds' visual acuity.

Thus the most significant quantitative data, notwithstanding aggregate counts and estimated numbers, are those for the Black-footed Albatross and the Glaucous-winged and Herring Gulls. Because the Laysan Albatross is usually not strongly attracted to ships, it is possible that the relative abundance noted during these cruises (except January 1965) was underestimated. The quantitative data for the Fulmar and two storm petrel species are scanty, but their qualitative occurrence cycles in the study area are probably valid; at least they provide points of departure for future studies.

Kenyon (1950) first suggested that the Laysan Albatross may be a casual visitor near the coast at the latitudes of the present study area; later data (Sanger 1965) corroborated this idea. The present study and papers such as Holmes (1964) have presented mounting evidence that the Laysan is indeed a regular visitor near coastal North America, south of Alaska. The trend suggested seems clear. In late fall, the Laysan Albatross population starts migrating southward, mostly heading for the breeding grounds on the Hawaiian Leeward Islands. Some nonbreeders advance toward the North American coast, peaking in abundance and appearing closest to shore in winter. It seems quite possible that this population of probable nonbreeders is a dynamic one, with a continual ingression and egression of birds from other pelagic areas and of unemployed birds from the breeding islands (Rice and Kenyon 1962a) into and from the area. As spring approaches, the Laysans start retreating seaward and northward, and by summer all but a few rare stragglers are well away from eastern Pacific coastal areas.

Although both albatross species displayed degrees of relationship to the oceanographic conditions, it seems quite unlikely that these were cause-and-effect relationships. More likely, the oceanographic conditions affected the distribution of food organisms, which in turn more directly affected the albatross distribution.

Obviously, much still remains to be learned about the seabirds off Washington and Oregon. I strongly urge that any future work on the distribution and abundance of seabirds in this area be conducted by observing from a moving ship. Observations from oceanographic survey ships would simultaneously provide environmental data.

SUMMARY

Seabirds were observed off the coasts of Washington and Oregon during seven oceanographic cruises between May 1964 and November 1965. Seasonal cycles in occurrence and abundance were noted for the seven predominant species seen within a discrete area bounded by the longitudes of 125° W and 140° W (the study area). Black-footed Albatrosses were present year-round, but numbers dropped appreciably in winter. Laysan Albatrosses were seen in the study area from fall through spring, peaking in numbers and occurring closest to shore in winter. Fulmars were most frequent from fall through spring, and Fork-tailed and Leach's Petrels were seen most often in summer. Both Glaucous-winged and Herring Gulls were frequent and surprisingly abundant far offshore in winter, but were absent from the study area in summer.

An apparent direct relationship between Black-footed Albatross numbers and both surface water temperature and air temperature was observed. The black-foot was noted in areas encompassing a wide range of surface salinity from ca. 33‰ down to values far below that of normal seawater. Laysan Albatross numbers were highest when air and water temperatures were the lowest, and the species occurred in a very narrow range of relatively high surface salinity.

Both Black-footed and Laysan Albatrosses sailed for as long as 11 min without wing-flapping.

The validity and significance of these data are discussed briefly.

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ERRATUM

The scientific name "Diomedea" was misspelled on pp. 344, 347 and 349 of this article. Please note that the correct spelling is "Diomedea."