JOURNAL OF FIELD ORNITHOLOGY

Formerly BIRD-BANDING

A Journal of Ornithological Investigation

VOL. 56, NO. 4 | AUTUMN 1985 | PAGES 321–484

J. Field Ornithol., 56(4):321–333

WINTERING PHALAROPES OFF THE SOUTHEASTERN UNITED STATES: APPLICATION OF REMOTE SENSING IMAGERY TO SEABIRD HABITAT ANALYSIS AT OCEANIC FRONTS

BY J. CHRISTOPHER HANEY

The pelagic distribution of phalaropes during winter has been one of the least-understood aspects of their life histories. The winter ranges of Red-necked (*Phalaropus lobatus*) and Red phalaropes (*P. fulicaria*) are usually given as being primarily at low latitudes in the southern hemisphere or in subtropical and tropical seas (A.O.U. 1983, Stanford 1953, Taning 1933). Both species occur off southern California in winter and the Red-necked Phalarope winters north to the Azores in the eastern Atlantic. In spite of numerous records of *P. fulicaria* off the southeastern United States during winter months (reviewed by Clapp et al. 1983), the western North Atlantic is not normally given as part of the winter range of phalaropes.

Both phalarope species have recently been found in midwinter on portions of the southeastern United States continental shelf. The seasonal and distributional occurrences of phalaropes in the middle shelf (20–40 m depths) have been linked to the presence of large and persistent oceanic fronts initially detected by remote sensing. Oceanic fronts are known to be important foraging habitats for post-breeding phalaropes, and their pelagic distribution has been considered to be largely determined by these oceanographic features (Brown 1980a). The relationships of phalaropes to these fronts and the application of remote sensing technology to studies of phalarope habitats are examined in this paper. Because fronts are prevalent elsewhere in southeastern United States' shelf waters, I discuss known aspects of frontal structure, seasonal occurrence, and distribution that may be significant to wintering phalaropes.

STUDY AREA

The topography of the southeastern United States continental shelf and the proximity of the shelf to a major western boundary current contribute to distinctive hydrographic conditions in the study area. These conditions proximately influence biological processes, and thereby ultimately affect the distribution and abundance of seabirds. The broad and shallow shelf is made up of three water masses, each differing in physical and biological properties (Atkinson et al. 1983). The Gulf Stream lies immediately adjacent to the shelf break (200 m isobath), and interacts extensively with waters on the mid- (20–40 m) and outershelf (41–200 m) on 2- to 14-day time scales (Lee and Brooks 1979, Lee et al. 1981). Following seasonal atmospheric cooling and wind mixing, steep temperature gradients in surface waters are often encountered during fall and winter (6–10° C innershelf to 22–25° C in the Gulf Stream). Frontal boundaries among the 3 water masses and the Gulf Stream are in part the result of differing thermal properties in each water mass. These frontal regions have recently been documented as having significant influences on seabirds (Haney and McGillivary 1985a,b).

METHODS

Seabirds were observed from November 1982 through October 1984 as part of a continuing study of the relationships of marine birds to environmental heterogeneity caused by physical oceanographic processes in the southern South Atlantic Bight (Cape Hatteras, North Carolina to Cape Canaveral, Florida). Counts of seabirds ($N = 1931$) were made mainly between 29° and 32°N latitude. Cross-shelf transects of the Georgia continental shelf were made each month except January. Continuous, consecutive counts across the shelf were made on 21 November 1983 ($N = 27$) and 1 February 1984 ($N = 21$) to enable resolution of seabird changes in distribution and abundance to oceanographic features (Haney and McGillivary 1985b).

Counts of seabirds, including phalaropes, were made from vessels conducting hydrographic, microbial, or zooplankton research. No counts were made from vessels trawling for or handling fish. Seabirds were counted during 15 min periods (Haney and McGillivary 1985a), and density estimates derived using a 300 m transect (instantaneously-changing 90° sector; Tasker et al. 1984). A fixed-interval rangefinder was used to adjust for observation height (Heinemann 1981). Several bias-minimizing techniques were used, including the exclusion of birds following the ship or entering the count zone from the stern. One individual recorded most (95%) of the total counts and all data reported here came from counts made by one observer.

The distributional and seasonal occurrences of fronts in the midshelf zone (20–40 m) were analyzed using 1982–1984 Gulf Stream System Flow Charts ($N = 242$) available from the National Oceanic and Atmospheric Administration, Miami, Florida. These charts contour high-gradient surface thermal boundaries using data derived from satellite infrared reflectance photography. From the charts, the monthly number and length of the fronts were calculated (Haney and McGillivary 1985a). The number of fronts per satellite map day (SMD) was used as an index of temporal variation in frontal occurrence. This index measures variation in mean number of fronts per month, or front duration during a given month. The length of fronts per SMD was used as an index of the monthly spatial extent of fronts in the study area.

RESULTS

Both Red and Red-necked phalaropes occurred in midwinter on the Georgia continental shelf (Table 1). Total counts revealed Red Phalaropes as relatively more abundant. The ability to differentiate phalarope species at sea is affected by distance and sea conditions, and was additionally facilitated by the presence of both species for comparison. Since 43% of the total phalaropes were unidentified to species, additional counts are necessary to determine the relative winter statuses of the two phalaropes in this region.

Phalaropes occurred exclusively in the middle shelf zone of the continental shelf during midwinter. Over 80% of the shelf fronts analyzed were also confined to the midshelf zone (Table 2). Phalaropes, mainly *P. lobatus,* were occasionally observed in small numbers in nearshore or more pelagic waters during spring and fall migration. Between November and March, over 95% of all phalaropes counted occurred in the midshelf zone, though only 47% of the observation effort was expended in this region of the shelf.

The cross-shelf distribution of phalaropes corresponded to high sea surface temperature gradients (thermal fronts) between 40 and 80 km offshore (Figs. 1 and 2). Phalaropes aggregated mainly on the shoreward side of the fronts. Phalarope abundance was significantly correlated with cross-shelf temperature gradients (ΔTs) on both 21 November 1983 ($r = 0.714$, $P < 0.001$, df = 25) and 1 February 1984 ($r = 0.614$, $P < 0.005$, df = 19).

Seasonal phalarope abundance also corresponded to seasonal front frequency and extent (Fig. 3). Monthly phalarope abundance and front length were significantly correlated ($r = 0.639$, $P < 0.05$, df = 9). The relationship of phalarope abundance to front frequency was positive, but not significant at the 5% level ($r = 0.413$, $P < 0.10$, df = 9). Fronts off the southeastern United States were most persistent and attained their greatest lengths during fall and winter (Fig. 3; Haney and McGillivary 1985b).

During midwinter, fronts occasionally extend over 1800 km from Cape Hatteras, North Carolina to Cape Canaveral, Florida. Because sampling was generally directed across the shelf perpendicular to the front, it was not possible to tell whether phalaropes associated with fronts along part or most of their length. However, the front on 1 February 1984 was convoluted (Fig. 2, top) and phalaropes were encountered at both frontal crossings (Fig. 2, bottom).

All phalaropes were either resting on the ocean surface or feeding. Thus, the behavior of the phalaropes, their occurrence in both years during midwinter, and their presence on more than one date during a month (Table 1) suggest that they were wintering rather than migrating individuals.

TABLE 1. Total number (N), mean midshelf density (km^2), and species composition of phalaropes observed during winter on the Georgia continental shelf.

	19 Feb 1983		1 Feb 1984		8 Feb 1984		18 Feb 1984		Total	
Species	N	Density	N	Density	N	Density	N	Density	N	Density
Red Phalarope	5	0.34	278	8.84	401	36.20	35	1.78	719	9.38
Red-necked Phalarope	6	0.42	240	7.63	1	0.09	0	0.00	247	3.22
Unidentified phalarope	120	8.32	549	6.49	59	5.32	0	0.00	728	4.99
Total	131	9.08	1067	22.96	461	41.61	35	1.78	1694	17.59

DISCUSSION

Phalaropes are surface-seizing feeders (Ainley and Sanger 1979), and food items (zooplankton) are inaccessible except at fronts and similar oceanographic features that concentrate these prey (Brown 1980a). Post-breeding flocks of phalaropes have been observed at fronts off British Columbia (Martin and Myres 1969), California (Briggs et al. 1984), New England (Lamb 1964), and Nova Scotia and New Brunswick (Brown 1980a,b). Outside of North America phalaropes associate with fronts off western Africa (Brown 1979, Stanford 1953) and apparently western South America (Brown 1980a). Fronts are important to marine organisms, including seabirds, because of the elevated levels of biological activity and increased biomasses of prey (Iverson et al. 1979, Pingree et al. 1974).

The midshelf front off the southeastern United States has several properties that make it particularly favorable as a foraging area for wintering phalaropes. This front is a "shallow sea" front-type (Bowman 1978), a consequence of shallow nearshore waters being mixed more extensively (due to wind stress and tidal stirring) than the stratified, deeper outer-shelf waters. Divergent circulation at the front may result from shoreward Ekman transport during northerly wind events common in this region during fall and winter (Haney and McGillivary 1985b, Weber

TABLE 2. Seasonal variation in shelf front measurements (per satellite map day).

	Mean length (km)	Range (km)	Mean number	Range	Fronts in middleshelf (%)
Dec–Feb	487	0–1828	0.49	0–2	83
Mar–May	152	0–965	0.27	0–2	85
Jun–Aug	8	0–302	0.03	0–1	100
Sep–Nov	423	0–1838	0.70	0–3	100

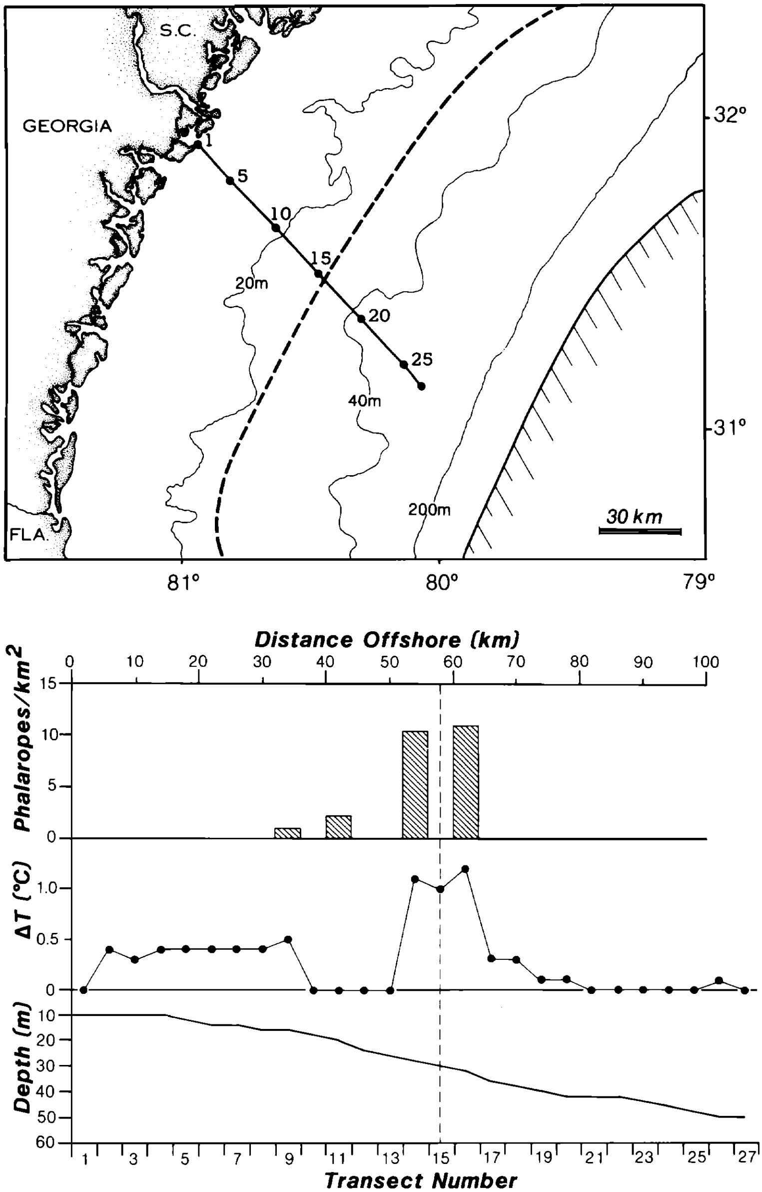
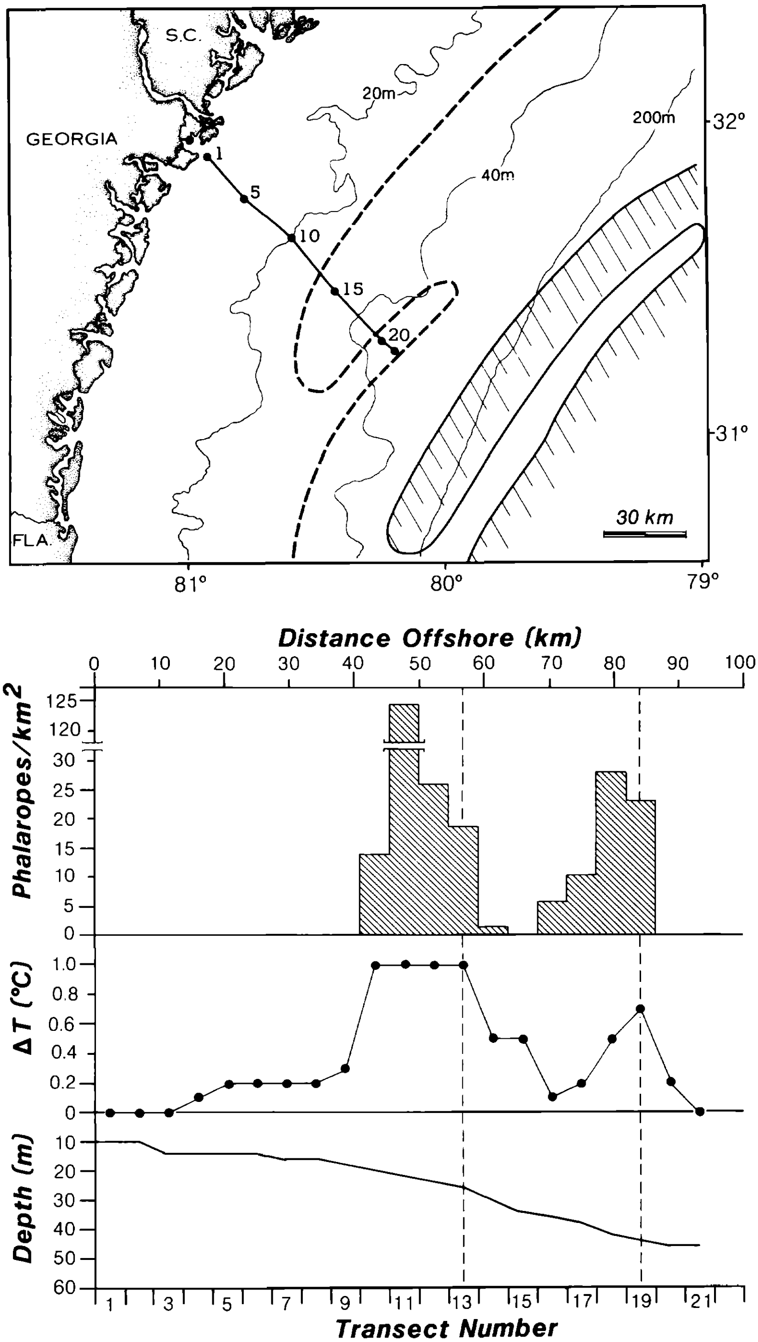


FIGURE 1. Cruise track of cross-shelf section on the Georgia continental shelf on 21 November 1983 (top). Phalarope abundance (bottom) is shown relative to water depth, distance from shore, and sea surface temperature gradients (ΔTs). The locations of the midshelf front (dashed line: transect 15) and western Gulf Stream front (solid line) are derived from satellite composites.


S.C.
GEORGIA
FLA.
20m
40m
200m
1
5
10
15
20
32°
31°
30 km
81°
80°
79°
Distance Offshore (km)
0
10
20
30
40
50
60
70
80
90
100
Phalaropes/km²
125
120
30
25
20
15
10
5
0
ΔT (°C)
1.0
0.8
0.6
0.4
0.2
0
Depth (m)
10
20
30
40
50
60
1
3
5
7
9
11
13
15
17
19
21
Transect Number

and Blanton 1980). The physical processes (vertical and horizontal circulation) at the front are responsible for concentrating larval Clupeiiform fish and the copepod *Eucalanus pileatus* (Yoder et al. unpubl. data, Paffenhofer et al. unpubl. data). Copepods have been implicated elsewhere as important prey items for pelagic-foraging phalaropes (Briggs et al. 1984; Brown 1980a,b; Dodson and Egger 1980) and may comprise parts of the diets of phalaropes at midshelf fronts in the South Atlantic Bight. However, Briggs et al. (1984) found phalaropes to be opportunistic feeders and it is possible that larval fish or other zooplankton form part of their diets at these sites as well.

Phalaropes did not occur in midwinter at other front-types present in the study area. Phalaropes were never observed during midwinter at the western Gulf Stream front (Figs. 1 and 2). Nearshore fronts, 5–15 km offshore, also occur in the South Atlantic Bight (Blanton 1981). Because salinity differences between the fresher estuarine waters and shelf waters are the principal physical gradients at this front-type, detection of the front was not possible using infrared radiometry or ship-board sea surface temperature measurements. Phalaropes were not observed in the innershelf zone, however, making it unlikely that this front is a significant influence on local phalarope distribution.

The seasonal and spatial variations exhibited by midshelf fronts are of interest because they represent variation in a marine habitat important to phalaropes during the pelagic period of their life histories. In this context, remote sensing data can enlarge our understanding of the ways phalaropes interact with a changing marine environment. The qualitative (shelf location, geographical distribution) and quantitative (seasonal and temporal occurrence, size) attributes of fronts may be measured directly from satellite-derived maps and then used to generate hypotheses that can be tested by additional field observations.

A number of features of midshelf fronts as revealed by remote sensing may influence phalarope distribution or abundance. For instance, fronts occur in two surface dimensions, one of width (cross-shelf dimension) and one of length (alongshore dimension). Phalaropes associate with fronts in the cross-shelf or width dimension, mainly within 10–15 km shoreward of the front (Figs. 1 and 2). Because midshelf fronts off the southeastern United States extend up to 1800 km throughout this region (Haney and McGillivary 1985b), it may be that phalaropes aggregate at the fronts along much of their length as well. If so, greater numbers of phalaropes may winter off the southeastern United States than are pres-

←

FIGURE 2. Cruise track of cross-shelf section on the Georgia continental shelf on 1 February 1984 (top). Phalarope abundance (bottom) is shown relative to water depth, distance from shore, and sea surface temperature gradients (ΔTs). The locations of the midshelf front (dashed line: transects 13 and 19) and western Gulf Stream front (solid line) are derived from satellite composites.

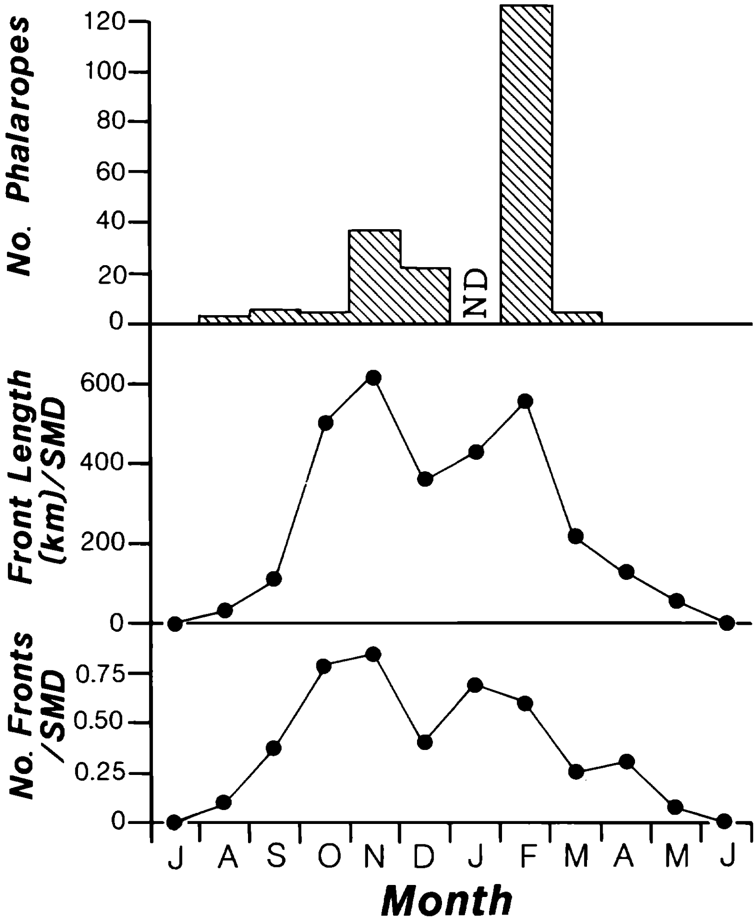


FIGURE 3. Comparison of monthly phalarope abundance to the incidence of oceanic fronts in the middle shelf (20–40 m depths) of the southeastern United States continental shelf. Total numbers of phalaropes observed in the middle shelf during 1983 cross-shelf cruises are shown in relation to indices of monthly front frequency and spatial extent. Front parameters were computed from thermal profiles of infrared satellite composites. (ND = no data available for January phalarope abundance).

ently realized. Although evidence suggests that phalaropes do aggregate along portions of fronts (Fig. 2; Briggs et al. 1984), it is unlikely that all of the 1800 km front is equally favorable as phalarope foraging habitat. Fronts are subject to short time-and small space-scale variation arising from durations of wind events, Gulf Stream water mass interactions, periodic tidal flow, diurnal atmospheric change, and intrinsic frontal instability (Allen et al. 1980, Bowman and Esaias 1978, Brooks 1978, Brooks and Bane 1981, Fearnhead 1975, Garvine 1974, Lee and Brooks

1979). This variance in the horizontal and vertical circulation at fronts can profoundly affect plankton accumulation (Bowman 1978, Holligan 1981). These additional sources of frontal variability may then in turn influence the optimal conditions that determine the suitability of the frontal habitat for foraging phalaropes.

Midshelf fronts exhibit additional types of variation. Fronts start forming in the fall and degrade last in the spring at higher latitudes off the Carolinas. Fronts are not static relative to the shelf and may move in a cross-shelf direction substantial distances throughout much of their length. Do phalaropes continue to occur at fronts during these shifts and do phalaropes respond in some manner to the seasonal, latitudinal variation in frontal occurrence? The effect of these dynamic frontal attributes on phalaropes is not entirely known. However, phalarope aggregations persist at fronts. On 8 February 1984 over 600 phalaropes were observed at the front after it had shifted 25 km seaward of the position on 1 February 1984 (Fig. 2).

Phalaropes may associate with shelf fronts elsewhere off the southeastern U.S. coast, where large numbers of phalaropes are observed occasionally in winter (Table 3). The northeast Gulf of Mexico is oceanographically-similar to the South Atlantic Bight. The continental shelf is similarly broad and shallow, but it is the Loop Current rather than the Gulf Stream that contributes to strong sea surface temperature gradients (and thus thermal fronts) between nearshore and offshore waters during midwinter. The winter statuses of phalaropes in the northern Gulf of Mexico are unclear, primarily from lack of seabird surveys in that region (Clapp et al. 1983, Duncan and Havard 1980). Duncan and Havard reported that commercial fishermen observed large numbers of "phalarope-like" birds in the Gulf during winter. Weston (1953) reported flocks of Red Phalaropes numbering into the thousands from late December through late February off northwestern Florida. Most of his sightings were 50–80 km offshore, a region of the shelf where fronts are also prevalent during midwinter (Fig. 4). The correlations of both recent and past records of phalaropes with regions of frontal activity strongly imply that these oceanographic features are important factors governing winter phalarope distribution and seasonal occurrence off the southeastern United States.

Concluding remarks.—The application of remote sensing hydrographic data to seabird studies lends several advantages to marine ornithologists. Surveys of seabirds are usually made opportunely, often from vessels that are not conducting oceanographic research. Using remote sensing data can give the investigator qualitative and quantitative information about the water masses in the study area. Because satellites give more extended temporal and spatial coverage, more information about meso-scale water mass properties can be derived compared to ship-board measurements (Briggs et al. 1984). Perhaps the greatest utility of remote sensing data, once ground truth correlations have been established between seabirds and oceanographic features, lies in the hypotheses that are generated by

TABLE 3. Winter records (December–February) of phalaropes from the southeastern United States (from Clapp et al. 1983). All records came from offshore or marine sightings.

Species	Date	Number	Region	Location
Red-necked Phalarope	11 February 1979	3	Atlantic	off Jekyll Island, GA
	16 December 1962	16	Atlantic	off Juno Beach, FL
	23 January 1977	36	Atlantic	20–30 km off Canaveral, FL
Red Phalarope	26 January 1975	28	Atlantic	off Wrightsville Beach, NC
	29 December 1977	100–1000	Atlantic	off Oregon Inlet, NC
	5 December 1978	100–1000	Atlantic	off Oregon Inlet, NC
	30 December 1978	100–1000	Atlantic	off Oregon Inlet, NC
	6 December 1972	200	Atlantic	10 km off Charleston, SC
	7 February 1959	7	Atlantic	20 km off Miami, FL
	16 February 1967	22	Atlantic	off Jacksonville Beach, FL
	22 January 1972	100	Atlantic	off Jacksonville, FL
	21 January 1973	19	Atlantic	off Mayport, FL
	23 January 1977	400	Atlantic	off Cape Canaveral, FL
	Dec–Feb 1946–1954	200–600	Gulf	off Pensacola, FL

examination of long-term, satellite-derived hydrography. Although we are beginning to understand which physical oceanographic features affect seabirds, we know almost nothing about the influence of variations in these features, and the role variability plays in shaping seabird ecological patterns. Prediction is an important component of any scientific discipline and has not been extensively used in seabird studies. Remote sensing data add a heuristic tool to observational studies of seabirds and could eventually tell us much about how, when, and where marine birds interact with their habitats in pelagic and shelf ecosystems.

SUMMARY

Phalarope relationships to oceanographic features in the South Atlantic Bight were studied during 1983 and 1984 using ship-board counts, on-board physical measurements, and satellite-derived composite maps that delineated thermal boundaries of surface waters. Red-necked and Red phalaropes occur in winter 40–80 km offshore on portions of the southeastern United States continental shelf. Infrared satellite imagery revealed this middle shelf zone (20–40 m depths) to be a region of intense frontal activity during fall and winter. The seasonal abundance and small-scale distribution of phalaropes corresponded to the incidence of these oceanic fronts. The extent of frontal habitat in southeastern U.S. shelf waters, and the correlation of both past and present phalarope records with fronts, suggest more widespread wintering in this region than is currently recognized. Suggestions are given whereby remote sensing data can by applied to other studies that seek to relate seabird distribution and abundance to different water masses.

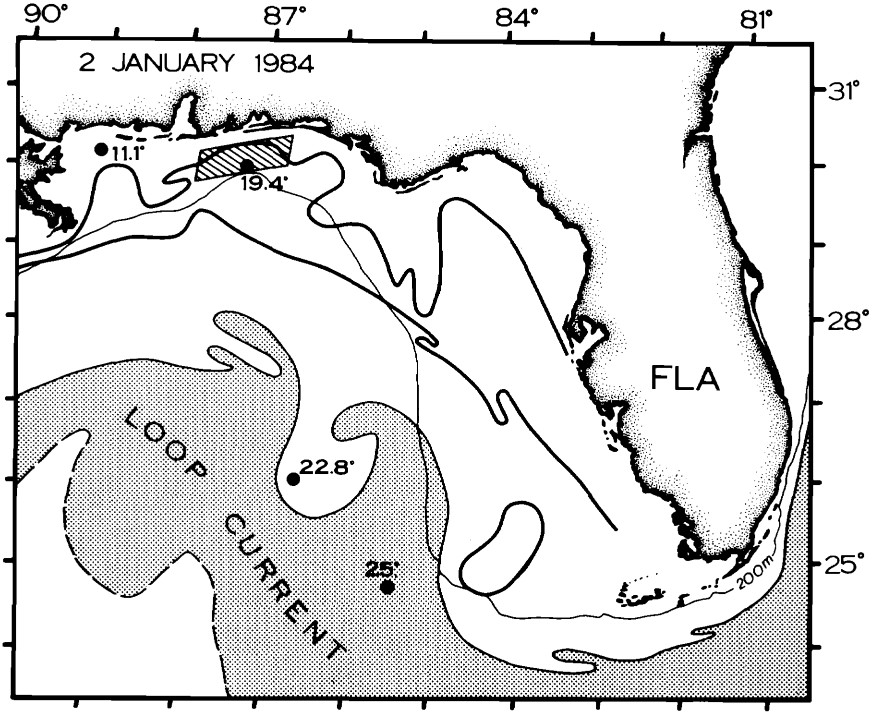


FIGURE 4. Typical thermal boundaries and principal water masses of the northeast Gulf of Mexico during midwinter. Shelf fronts are shown as solid lines and temperatures of surface waters indicated in °C. Approximate locations of Weston's (1953) phalarope sightings are shown by cross-hatching. Hydrographic data are derived from satellite composites.

ACKNOWLEDGMENTS

I thank the captains and crews of the research vessels "Bluefin," "Bulldog," "Cape Hatteras," "Delaware II," and "Oregon I" for the assistance they rendered in the course of this study. G. Grossman, D. W. Menzel, G.-A. Paffenhofer, L. R. Pomeroy, M. Rawson, T. E. Targett, G. Ulrich, and H. Windom provided access to facilities. P. Christian, M. Harris, D. Kearns, R. Manns, P. McGillivary, D. Oakley, G. Rogers, and P. Stangel assisted in various capacities in the field or in data analyses. Direct and indirect financial support was provided by the University of Georgia Department of Zoology and Marine Extension Service, South Carolina Department of Wildlife and Marine Resources, Burleigh-Stoddard Fund, Skidaway Institute of Oceanography, and NSF grants OCE81-10707 to L. R. Pomeroy and OCE81-17761 to G.-A. Paffenhofer. S. Baig (NOAA, Miami, Florida) furnished some of the Gulf Stream Flow Charts and A. Boyette drafted the figures. I thank J.

Yoder and G. Paffenhofer for access to their unpublished data on zooplankton at fronts. J. A. Jackson and two anonymous reviewers gave valuable advice on improving earlier drafts of the manuscript.

LITERATURE CITED

AINLEY, D. G., AND G. S. SANGER. 1979. Trophic relationships in the northeastern Pacific Ocean and Bering Sea. Pp. 95–122, *in* J. C. Bartonek and D. N. Nettleship, eds. Conservation of Marine Birds of Northern North America. U.S. Fish Wildl. Serv. Wildl. Res. Rep. 11.

ALLEN, C. M., J. H. SIMPSON, AND R. M. CARSON. 1980. The structure and variability of shelf sea fronts as observed by an undulating CTD system. Oceanol. Acta 3:59–68.

AMERICAN ORNITHOLOGISTS' UNION. 1983. Checklist of North American birds. 6th edition. Allen Press, Inc., Lawrence, Kansas.

ATKINSON, L. P., T. N. LEE, J. O. BLANTON, AND W. S. CHANDLER. 1983. Climatology of the southeastern United States continental shelf waters. J. Geophys. Res. 88:4705–4718.

BLANTON, J. O. 1981. Ocean currents along a nearshore frontal zone on the continental shelf of the southeastern United States. J. Phys. Oceanogr. 11:1627–1637.

BOWMAN, M. J. 1978. Introductions and proceedings. Pp. 2–15, *in* M. J. Bowman and W. E. Esaias, eds. Oceanic Fronts in Coastal Processes. Springer-Verlag, New York.

———, AND W. E. ESAIS. 1978. Oceanic fronts in coastal processes. Springer-Verlag, New York.

BRIGGS, K. T., K. F. DETTMAN, D. B. LEWIS, AND W. B. TYLER. 1984. Phalarope feeding in relation to autumn upwelling off California. Pp. 51–62, *in* D. N. Nettleship, G. A. Sanger, P. F. Springer, eds. Marine Birds: Their Feeding Ecology and Commercial Fisheries Relationships. Can. Wildl. Serv. Proc. of the Pacific Seabird Group Symp.

BROOKS, D. A. 1978. Subtidal sea level fluctuations and their relation to atmospheric forcing along the North Carolina coast. J. Phys. Oceanogr. 8:481–493.

———, AND J. M. BANE, JR. 1981. Gulf Stream fluctuations and meanders over the Onslow Bay upper continental slope. J. Phys. Oceanogr. 11:257–265.

BROWN, R. G. B. 1979. Seabirds of the Senegal upwelling and adjacent waters. Ibis 121: 283–292.

———. 1980a. Seabirds as marine animals. Pp. 1–39, *in* J. Burger, B. Olla, and H. E. Winn, eds. Behavior of Marine Animals. Vol. 4. Plenum Press, New York.

———. 1980b. The pelagic ecology of seabirds. Trans. Linn. Soc. N.Y. 9:15–22.

CLAPP, R. B., D. MORGAN-JACOBS, AND R. C. BANKS. 1983. Marine birds of the southeastern United States and Gulf of Mexico. Part III. Charadriiformes. U.S. Fish & Wildl. Serv., Div. Biol. Services, Washington, D.C. FWS/OBS-83/30.

DODSON, S. I., AND D. L. EGGER. 1980. Selective feeding of Red Phalaropes on zooplankton of arctic ponds. Ecology 61:755–763.

DUNCAN, C. D., AND R. W. HAVARD. 1980. Pelagic birds of the northern Gulf of Mexico. Am. Birds 34:122–132.

FEARNHEAD, P. G. 1975. On the formation of fronts by tidal mixing around the British Isles. Deep-Sea Res. 22:311–321.

GARVINE, R. W. 1974. Dynamics of small-scale oceanic fronts. J. Phys. Oceanogr. 4:557–569.

HANEY, J. C., AND P. A. MCGILLIVARY. 1985a. Aggregations of Cory's Shearwaters (*Calonectris diomedea*) at Gulf Stream fronts. Wilson Bull. 97:191–200.

———, AND ———. 1985b. Midshelf fronts in the South Atlantic Bight and their influence on seabird distribution and seasonal abundance. Biol. Oceanogr. 3:401–430.

HEINEMANN, D. 1981. A rangefinder for pelagic bird censusing. J. Wildl. Manage. 45: 489–494.

HOLLIGAN, P. M. 1981. Biological implications of fronts on the northwest European continental shelf. Phil. Trans. Roy. Soc. London A302:547–562.

IVERSON, R. L., L. K. COACHMAN, R. T. COONEY, T. S. ENGLISH, J. J. GOERING, G. L. HUNT, JR., M. C. MACCAULEY, C. P. MCROY, W. S. REEBURG, AND T. E. WHITLEDGE. 1979. Ecological significance of fronts in the southeastern Bering Sea. Pp. 437–465, *in* R. L. Livingston, ed. Ecological Processes in Coastal and Marine Systems. Plenum Press, New York.

LAMB, K. D. A. 1964. Seabirds at the confluence of the Gulf Stream and the Labrador Current east of New York. Sea Swallow 16:65.

LEE, T. N., AND D. A. BROOKS. 1979. Initial observations of current, temperature and coastal sea level response to atmospheric and Gulf Stream forcing on the Georgia shelf. Geophys. Res. Lett. 6:321–324.

———, L. P. ATKINSON, AND R. LEGECKIS. 1981. Observations of a Gulf Stream frontal eddy on the Georgia continental shelf, April 1977. Deep-Sea Res. 28:347–378.

MARTIN, P. W., AND M. T. MYRES. 1969. Observations on the distribution and migration of some seabirds off the outer coasts of British Columbia and Washington State, 1946–1949. Syesis 2:241–256.

PINGREE, R. D., G. R. FORSTER, AND G. K. MARRISON. 1974. Turbulent convergent tidal fronts. J. Mar. Biol. Assoc. U. K. 54:4615–4622.

STANFORD, W. P. 1953. Winter distribution of the Grey Phalarope *Phalaropus fulicarius*. Ibis 95:483–492.

TANING, A. V. 1933. The winter quarters of the phalaropes. Ibis 3:132–133.

TASKER, M. L., P. HOPE-JONES, T. DIXON, AND B. F. BLAKE. 1984. Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101:567–577.

WEBER, A. H., AND J. O. BLANTON. 1980. Monthly mean wind fields for the South Atlantic Bight. J. Phys. Oceanogr. 10:1256–1263.

WESTON, F. M. 1953. Red Phalarope (*Phalaropus fulicarius*) wintering near Pensacola, Florida. Auk 70:491–492.

Skidaway Institute of Oceanography, P.O. Box 13687, Savannah, Georgia 31416, and Department of Zoology, University of Georgia, Athens, Georgia 30602. Received 15 Jan. 1985; accepted 3 Oct. 1985.