THE IMPACTS OF THE T/V PUERTO RICAN OIL SPILL ON MARINE BIRD AND MAMMAL POPULATIONS IN THE GULF OF THE FARALLONES, 6-19 NOVEMBER 1984

A Special Scientific Report

BY

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OIL SPILL CHRONOLOGY

Oct 31: Dawn explosion and fire on T/V Puerto Rican 20 km outside the Golden Gate.

Nov 1: Tanker towed southwestward between mainland and the Farallones. Small oil slick released.

Nov 2: Severe storm during day and night. Strong winds from the southwest.

Nov 3: Vessel breaks up at 1:30 AM, releasing approximately 1,470,000 gallons of petrochemicals. Stern section sinks 17 km south of Farallon Islands, bow section is still under tow towards the southwest.

Nov 5: Slick spreading out. Five oiled birds show up on Marin County beaches. Winds increasing from the southwest with a new storm.

Nov 6: Oil touches SE Farallon Island from noon to 2:00 PM, recedes southward at 3:00 PM, passes northward by the island during the night. Some oiled birds seen on island. Fort Cronkhite cleaning facility set up by International Bird Rescue and California Department of Fish & Game.

Nov 7: Clean Bay vessel, Mr. Clean II, works all night at Farallones. 250-300 oiled birds sighted, 10 lifted off island by Clean Bay helicopter.

Nov 8: U.S. Coast Guard advises that an oil slick is 5 km south of Point Reyes Headlands. PRBO helps Point Reyes National Seashore organize collection of oiled birds on Point Reyes beaches. PRBO organizes airlift of more birds off SE Farallon by Clean Bay. Bow section maintained at sea 65 km south of Farallones, Coast Guard considering action plan with Keystone, NOAA, California Fish & Game, and others.

Nov 9: Oil in a sheen from Farallones to south end of Point Reyes; thicker oil in a patch 15 km long, 100 m wide lies offshore. Light oil touches Drake's Beach; boom put in place at Drake's Estero. Extensive collection of oiled birds in Marin County. Only one additional oiled Common Murre recoverable on SE Farallon.

Nov 10: Oil slick continues north to within 2 km of Bodega Head, touches Doran Beach, enters Bodega Harbor. Slick extends as far as the Russian River. Many oiled birds come ashore.

Nov 11: Booming and clean-up operations well under way at Bodega. Oil slick at 11:00 AM extends to the mouth of the Russian River, 3 km

offshore. Heavy lube oil in the surf zone of Bodega head. Slick hits Fort Ross at 6:00 PM.

Nov 12: Oil slick 9 km long extends 12 km west of Fort Ross--broken up, not continuous. Number of oiled birds found live at Bodega is 10.

Nov 13: PRBO crew still in Mendocino County, number of oiled birds very low. Only a few still being found on Marin County beaches. Slick is broken up and has moved offshore.

Nov 15: Coast Guard Port Captain for San Francisco decides to authorize return of the Puerto Rican's bow to San Francisco Bay.

Nov 18: Bow section of Puerto Rican safely reaches salvage dock at Hunter's Point. Oil slick drifting near site of sunken stern. PRBO continues aerial surveillance of pelagic bird and mammal populations. Coast Guard continues periodic aerial surveys for oil slicks.

PART 1. OVERVIEW AND ESTIMATE OF OVERALL IMPACT

Report Rationale. This report summarizes information we gathered concerning the impacts on marine birds and mammals in the Gulf of the Farallones from the T/V Puerto Rican oil spill. On 3 November 1984, the tanker broke in half, 17 km (11 miles) south of Southeast Farallon Island, releasing approximately 1,470,000 gallons of petrochemicals. The stern sank at that site (37° 31' N, 123° 02' W) taking approximately 357,500 gallons of petroleum products to the bottom (800 m). Many hundreds of gallons of chemicals were sprayed from aircraft on the initial slick in an attempt to disperse it. During the next 9 days, two different types of slicks moved northward through the Gulf (and beyond): a thin but extensive sheen of lighter products containing many aromatics, and a heavy, cohesive mass of lubricating oil that snaked northward in a line about 10 km long and 100 m wide (see photos in Part 5). Work by Dr. Michael Fry of UC Davis at a bird rehabilitation center set up in response to this incident, indicated that the lighter products were highly toxic to seabirds, causing marked physiological adjustment. The heavier material apparently was not toxic; it affected seabirds by destroying the insulating qualities of their plumage. As of this date, the sunken stern still slowly exudes a light sheen of oil with occasional interspersed globs of heavier material. Some of this oil apparently has come ashore subsequent to the primary oil spill (for example, on 28 November; see Part 2).

Since 1971, PRBO has conducted intensive ecological research on marine birds and mammals in the Gulf of the Farallones. In that first year, the

Fig. 1. Map of the Gulf of the Farallones providing a sketch of the trajectory of oil spilled from the T/V Puerto Rican in early November 1984. Bathymetry is given in fathoms. The dashed line represents the boundary of Point Reyes/Farallon Islands National Marine Sanctuary. The small star is the approximate location of the tanker's stern section when it sank. Shaded areas are approximate locations of slicks, patches, and sheens of oil products that drifted north. These are based on information from the U.S. Coast Guard:

Nov 3: Approx. 100,000 gallons within .7 km of 37° 31' N, 123° 01' W

Nov 4:
1) 3 km south of stern section
2) 37° 27' N, 123° 03' W
3) 37° 26' N, 122° 59' W

Nov 5: 37° 27' N, 123° 09' W ±

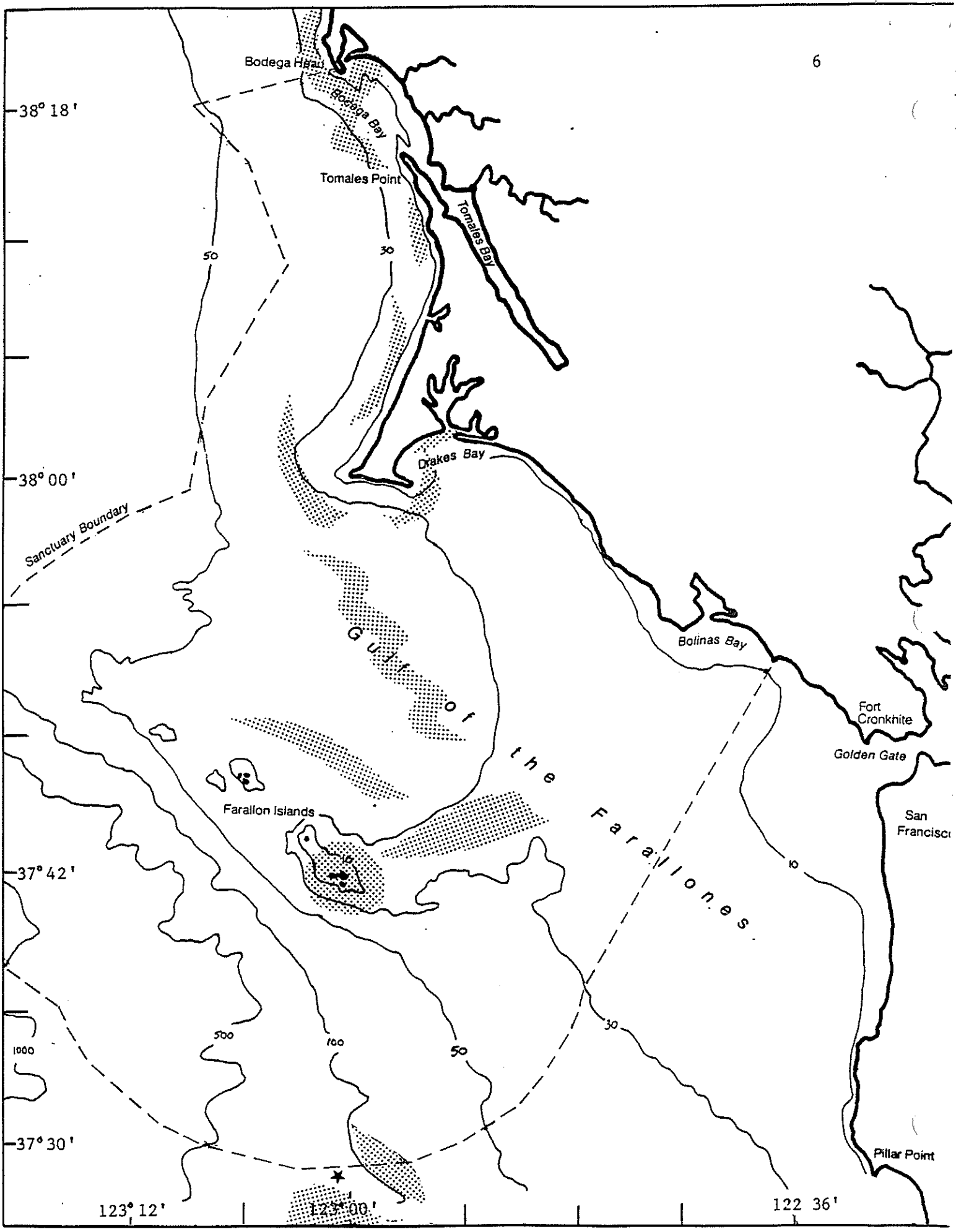
Nov 6:
1) 50 meters north of SE Farallon Island, 10:30 AM
2) Patches surrounding island extend NE to 37° 44' N, 122° 52' W

Nov 7: 8 km-long slick 4.5 km off Point Reyes

Nov 8:
1) 250 meter x 8 km slick 4.5 km off Point Reyes
2) Numerous sheen areas between Point Reyes and Farallon Islands

Nov 9:
1) sheen at McClure's Beach, Point Reyes National Seashore
2) black oil at Drakes Beach, Point Reyes National Seashore
3) .7 km band emulsified oil SW of Bodega Head
4) oil in Bodega Harbor, 11:30 PM

Nov 10:
1) on Doran Beach
2) in surf zone and on rocks, Bodega head north to Salmon Creek


Bodega Head
Bodega Bay
Tomales Point
Tomales Bay
Drakes Bay
Sanctuary Boundary
Bolinas Bay
Fort Cronkhite
Golden Gate
Gulf of the Farallones
Farallon Islands
San Francisco
Pillar Point
38° 18'
38° 00'
37° 42'
37° 30'
123° 12'
123° 00'
122 36'
50
30
10
500
100
1000

Observatory was involved in assessing the impact of the large oil spill which resulted from the collision of two tankers beneath the Golden Gate Bridge (Smail et al. 1972.)

From 1979 to 1981, PRBO also conducted research, under contract from the Department of Energy, on assessment of the impacts of oil spills on marine bird populations (Page et al. 1982). Given this background, PRBO personnel felt obligated to respond in earnest to the Puerto Rican incident, although Clean Bay, Inc., had lead responsibilities to clean up the spill and rehabilitate wildlife (through a subcontract with the International Bird Rescue Center), and the assessment of wildlife damages had been delegated to the California Department of Fish and Game. The expertise and knowledge of PRBO biologists about the birds and mammals of the Gulf of the Farallones is unequalled. In particular, we knew that we were in an optimal position to collect vital scientific data on the biological effects of the spill. Thus, we assembled an organization-wide team of our own to gather this information.

We assessed bird and mammal populations along beaches, at the Farallon Islands, and in the open waters of the Gulf of the Farallones. As part of our team, we intermittently enlisted researchers from UC Santa Cruz, who had collected baseline data on marine birds and mammals from aerial transect surveys in 1980-82.

Of all the organizations cooperating in the spill cleanup and impact assessment, only PRBO acted on the need to assess populations at risk (see Part 4), to complement the more commonly conducted body counts of dead organisms (Parts 2 and 3). The broadly based results of our work form the

substance for this report. We recommend that comprehensive efforts, such as the one which we undertook during the Puerto Rican incident, become integrated in responses to future spills.

Impact Assessment. There was surprise during the course of this incident that oil slicks moved northward from the site where the tanker broke up and the stern sank. A satellite photo taken 9 November (Fig. 2) helps explain the system of surface currents responsible for this northward movement. The image is infrared; in our black-and-white reproduction, the paler shades represent warmer surfaces. Clearly evident are inshore areas of relatively warm water that extend from Monterey Bay and hook around the Point Reyes Peninsula, with more widespread warm surface waters farther to the north. These represent northward movements of inshore water. Relatively warm, northerly currents are expected at this time of year in the Gulf of the Farallones. From one year to the next the only question is when such movement, associated with the annual resurgence of the Davidson Countercurrent near shore, will begin to manifest itself. Comparing the satellite photo with the aerial photos in Part 5 suggests that the elongate cohesive mass of heavy lubricating oil may even have tracked along the boundary of the warmer inshore water and the cooler offshore water. Another satellite photo taken six days later (but not reproduced for this report) reveals continued northward drift of surface water. These are the only satellite photos available for the period of the Puerto Rican oil spill incident, because skies were otherwise overcast on most days.

Indirect evidence of a northward trend of surface waters was also available. An analysis of long-term data by McLain and Thomas (1983)

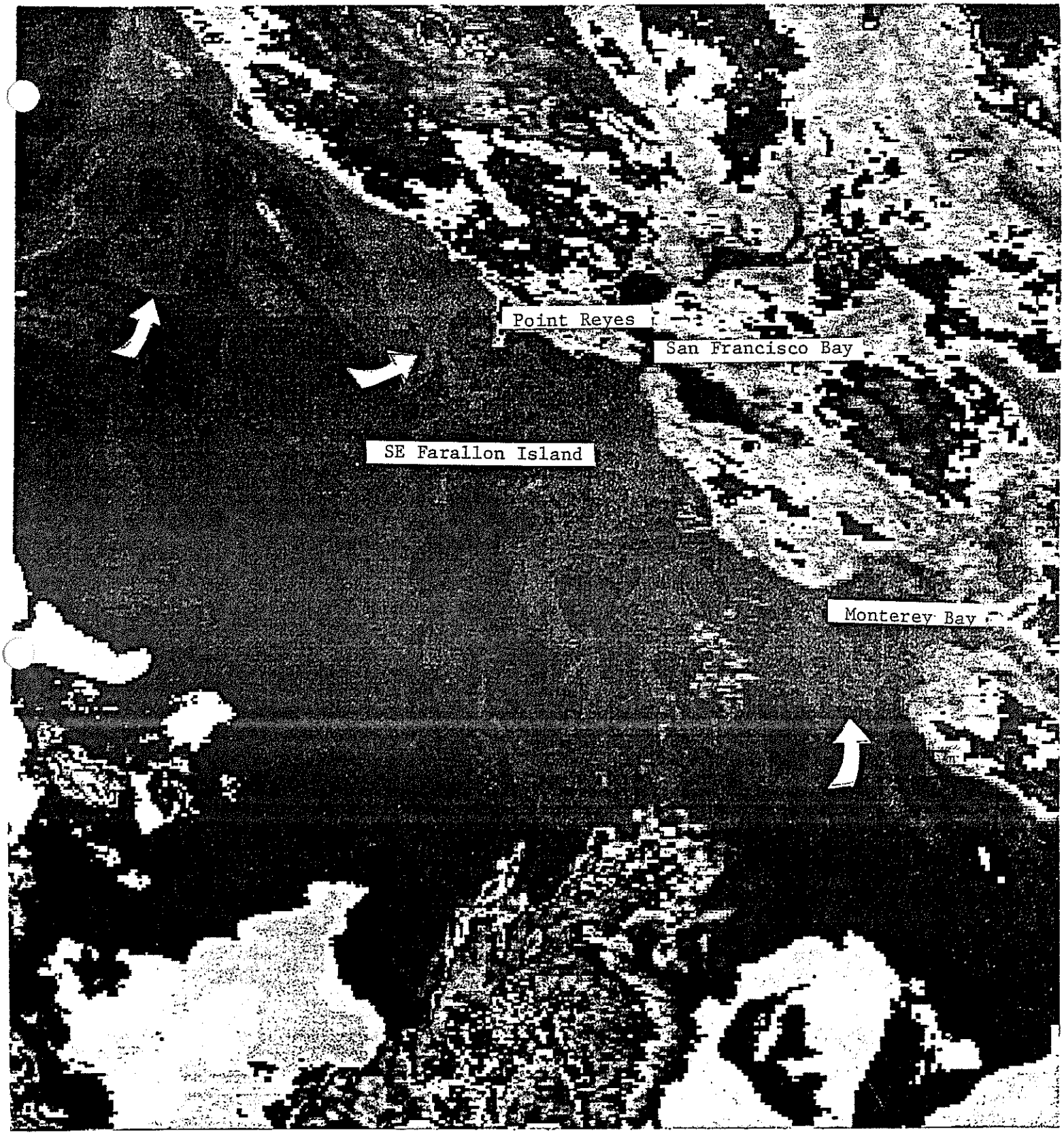


Figure 2. Infrared satellite photo, 9 November 1984. Paler shades in ocean surface represent warmer water. Large white shapes in bottom of frame are clouds. Arrows indicate three areas of warm water that represent northward movement of surface water.

showed that the movement of pelagic red crabs (Pleuroncedes planipes) northward into Monterey Bay and beyond is indicative of years when the northward movement of surface waters is particularly strong. Pelagic red crabs had been present in the vicinity of the Farallones for an extended period during the fall of 1983.

The aerial census data (discussed more fully in Part 4) point out some fortunate aspects of the spill with regard to the direction of slick movement. First, had the slicks moved south and inshore, much heavier concentrations of vulnerable species (diving birds that do not roost on land and need loft to their plumage to insulate themselves against the cold sea) would have been in the spill path. Second, had the tanker been towed west of the Farallones before it broke up, and the oil then moved north, large concentrations of birds over the Cordell Banks would likely have been affected. Because that area is far offshore, their mortality might never have been detected. Finally, Cassin's Auklets, a vulnerable species and the one with the largest local breeding population, were unusually sparse in the region compared to other years.

In addition, there are fortunate aspects of the spill's timing, although since the loaded stern still poses a threat, they could eventually be negated. First, had the spill occurred after January, many thousands of birds of vulnerable species would have been concentrated in the area from where the stern sank north to Point Reyes; at that time they associate with breeding sites on the Farallones and at or near the Point. Second, had the spill occurred after December, many hundreds of fur seals could have been affected, because they occur then in the deep continental slope waters

where the tanker's stern sank. Like the plumage of birds, the fur of these seals insulates them from the cold water (other species of pinnipeds rely on blubber for insulation). Thus, fur seals, like diving seabirds, are particularly vulnerable to oiling. The northern fur seal has been proposed for inclusion on the list of "threatened species" under the Endangered Species Act.

Body counts of oiled birds is the most commonly used index of pollution impact on their populations. However, a growing body of scientific literature indicates that only 5 to 25% of birds that die at sea wash in or beach themselves on shore (e.g., Coulson et al. 1968, Hope Jones 1980). Clearly, the actual mortality resulting from a spill is much higher than the body counts indicate. Depending on the amount and toxicity of oil that adheres to a bird and how far from shore oiling takes place, death can easily occur in many birds long before they can reach a beach. When the air which birds trap in their plumage escapes, dead birds sink. This was graphically demonstrated to us in a recent series of 4 experiments (Page et al. 1982) in which the carcasses of marked diving birds (shearwaters, cormorants, murres, and auklets) were dropped between 250 m and 1500 m offshore. Overall, only 22% of 249 carcasses washed in.

In the Puerto Rican incident, it is likely that almost all affected species, excepting murres, auklets, and fulmars (offshore species) contacted oil within a few hundred meters of shore because of their preference for inshore habitats. Many were then able to swim ashore, and many that died beforehand likely washed in.

Of the offshore species, most fulmars probably died at sea as is

evident from two facts: 1) only 4 live fulmars were found on beaches (Table 2.3); and 2) most fulmar carcasses on shore were waterlogged. We have no information on the proportion of fulmar carcasses reaching shore. By contrast, experiments conducted at Bolinas Beach in 1981 indicate that many murres and auklets dying offshore likely sank and did not reach the beach. On 11 February 1981, 50% of 10 gull carcasses which we dropped 500 m offshore, and 40% of 10 carcasses dropped 1000 m offshore subsequently were found on adjacent beaches. No murre carcasses dropped in the same numbers and at the same locations were recovered on the beach. Results from 3 March 1981 were similar: 92% of 12 gull carcasses washed in from 500 m but none of 12 murres did. On 2 April 82% of 11 gulls, but 0% of 22 murres, and 0% of 9 Cassin's Auklets reached shore from 500 m (Page et al. 1982)

We attempted to estimate the number of Common Murres and Cassin's Auklets that died in the Puerto Rican incident by estimating the number that were within the path of the slicks. We confined our calculations to these two species because large populations nest locally in the Gulf of the Farallones, because they are highly vulnerable to oil pollution, and because they occur far enough offshore that many likely fail to reach shore after perishing. For this analysis, we assumed that the "effective" slicks covered a corridor only 3 km wide, a much narrower swath than that actually occupied by all the slicks (see photos, Part 6 and map coordinates from Fig. 1 and Table 1.1). An operative 3 km-wide corridor does allow for the more concentrated parts of the slick (including both types of product) to sweep through bird concentrations. We also assumed that all birds in that

swath were contacted by enough product that they became highly stressed and either died or made it to shore. We justify this assumption on the highly toxic nature of the light products and the adhesive nature of the lubricating oil. We then divided up the spill corridor relative to our census lines, calculated the area of ocean affected, and multiplied by the estimated bird densities in these areas (from Part 5). The result is an estimated 4464 murres and 79 auklets killed or disabled in the Gulf of the Farallones as a result of this incident (Table 1.1). The totals of individuals actually found on beaches is 11 and 20% of these figures for the two species respectively (see Part 2). These proportions are equivalent to those identified in previous studies on the proportion of dead seabirds that never wash into shore once they have died. These totals would bring the overall mortality during 6-19 November, to 5044 birds.

In absolute numbers, even the higher figure for mortality is not large compared to other oil pollution incidents. For example, an estimated 20,000 birds were killed in the 1971 San Francisco spill, and 40,000 in the 1967 Torrey Canyon spill in Britain. It is also not large compared to the mortality from gill netting in the Gulf of the Farallones. In 1983, the California Department of Fish and Game estimated that more than 20,000 seabirds were drowned in nets within the Gulf of the Farallones (the figures for 1984 are not yet available). As in this oil spill, the most heavily affected species was the Common Murre. However, the estimated mortality of 4464 murres in this spill is 5% of their estimated breeding population (90,000) in the Gulf during 1984. That figure is significant. It is equal to their annual rate of increase over the past 15

years (the population has been recovering from earlier decimation). Ironically, had it not been for recent population reductions due to gill netting (and to the 1983 El Nino climatological event), we expect that the absolute number of murres killed by this spill would have been much higher, because more murres would have been at risk. The estimated oil-induced mortality of auklets was 1% of their breeding population.

At present, with the tanker stern still leaking oil offshore near the Farallones and particularly with gill nets still allowed in the Gulf of the Farallones, the future of the Common Murre and other members of the seabird family alcidae (5 species of which breed on the Farallones) in central California waters is clouded. It must be emphasized that the populations of these species in the Gulf comprise a significant proportion of their populations statewide, and even for the entire West Coast. Some of these species have been re-established as breeders only recently. For example, only in 1974, after an absence of over 100 years, did the Rhinoceros Auklet re-establish a breeding population on the islands. Even a small slick near the Farallones between April and July could obliterate this emerging population of 300 birds, as well as significantly reduce the murre population. The leaking stern also poses a threat to the incipient breeding population of fur seals on the Farallones, a population beginning to re-establish itself after an absence of 175 years.

Table 1.1. An estimate of the number of Common Murres and Cassin's Auklets that likely became oiled in the Gulf of the Farallones as a result of the Puerto Rican incident.[a]

Portion of Slick Swath (sq km)[b]	Area Affected (sq km)[c]	Murre		Auklet	
		Density[d]	No. Oiled	Density[d]	No. Oiled
17	51	1.18	60	0	0
16	48	26.19	1257	1.16	56
10	30	56.05	1682	0	0
18	54	23.54	1271	0.42	23
20	60	3.23	194	0	0
Totals:	243		4464[e]		79[f]

[a] Based on the assumption that all birds contacted by oil died at sea or came ashore.

[b] From point of origin north to Point Arena as indicated in Fig. 1.

[c] Assuming that "effective" slick was 3 km wide.

[d] From Figs. 9 & 10 in Part 4 of this report.

[e] The number (488) recovered oiled on beaches, 6-19 November, is 11% of this total.

[f] The number (16) recovered oiled on beaches, 6-19 November, is 20% of this total.

PART 2: BEACHED BIRDS

We determined the numbers and species composition of marine birds that beached during the spill and the proportion that died as the result of oiling. Our coverage of San Francisco, Marin and Sonoma county beaches lasted from 6 to 19 November 1984 (Table 2.1). Whenever possible we relied on census methods used for PRBO's Beached Bird Surveys (1972-1984) when counting birds on beaches.

A Beached Bird Survey consists of one to two people walking on a beach and recording: (1) for the beach: date, section covered, and amount of oil; and (2) for each bird found: species, age and sex when possible, cause of death (if obvious), presence or absence of oil on plumage (and where on the plumage the oil occurred), and condition of bird. Bird condition is classed in one of four categories: alive but unhealthy; freshly dead (decay not evident); decomposing (smells or appears to be rotting); or decomposed (bones and feathers without flesh). Dead birds are either removed from the beach or marked (by cutting off outer primary tips) so they will not be recounted on a subsequent census.

Normally, live birds are not handled; however, during the 6-19 November period they were captured when possible and transported to a rehabilitation center. Also, during the Puerto Rican incident, we deviated from the standard procedures as regards type and intensity of beach coverage: Stinson Beach was covered by one to two persons in a four-wheel-drive vehicle after 6 November, part or all of Limantour was covered by two to three people in an all-terrain vehicle except on the final 19 November census, and the southernmost 6 km of Point Reyes Beach was covered by one

person in an all-terrain vehicle on 8 November.

When large numbers of birds beached at Bodega Bay on 10 November, systematic coverage broke down. Many people not formally coordinated by PRBO biologists or associates walked the beaches and harbor margins throughout the day, picking up birds and bringing them to either of two collection stations--Bodega Marine Laboratory or the ranger headquarters at Doran Regional Park. A few birds from small beaches as far north as Jenner were brought to the collection points and pooled with the Bodega Bay birds.

The noncoordinated involvement of members of the public at Bodega Bay resulted in the rapid rescue of stricken birds, but some data were lost. Most seriously, on 10 November, we were unable to learn the species composition of birds sent from the Bodega collection stations to the Fort Cronkhite rehabilitation center. Consequently, our totals for live birds on that date are based on Cronkhite rehabilitation center records of birds arriving from Bodega Bay. Our totals for dead oiled birds on 10 November, are based on counts at the Bodega collection centers. Some carcasses were removed from beaches and disposed of by members of the public before the censusers we had mobilized could cover the beaches. After 10 November, we asked people covering beaches at Bodega Bay to bring all birds to the collection centers (or center after 11 November), where experts in bird identification tabulated numbers. We turned over all oiled carcasses from Point Reyes and Bodega Bay to the California Department of Fish and Game.

Oiled birds also appeared on the Farallones (see Appendix). The rugged terrain and inaccessibility of some areas hampered efforts to tabulate numbers. On 7 November, we covered two-thirds to three-quarters of the

circumference of the island and saw about 300 oiled birds. Many were lightly coated gulls which probably survived. With the 7 November census data plus pooled additional observations on 8-9 November, (after which oiled birds stopped appearing on the island), we estimated the minimum number of oiled birds that beached themselves at the Farallones. A total of 21 live oiled birds were flown by helicopter from the islands to the mainland for rehabilitation.

We compared rehabilitation center records with ours for birds from 6 to 19 November. Some obvious differences occurred because the rehabilitation centers received some birds that we did not process. We added these birds to our regional totals in Table 2.2. Additions were for live oiled birds only: 1 each of Arctic Loon, Loon spp, Western Grebe, and Northern Fulmar for Ocean Beach; 1 Arctic Loon and 1 Common Loon for Stinson Beach; and 2 Arctic Loons for the Point Arena area.

Duration of the Beaching

Biologists reported oil on the shores of the Farallon Islands by 12:00 on 6 November 1984 (see Appendix). The first oiled birds appeared on Southeast Farallon Island that same afternoon, the first evidence that seabirds had been affected. On 6 November, we also conducted a beached bird census at Stinson Beach but no oiled birds were among the 16 carcasses found.

By 7 November at least 300 oiled birds were present at the Farallones. At least 200 gulls had small amounts of oil on their plumage. More severely oiled were the following: Eared Grebe (29), Common Murre (57), loons (5), Cassin's Auklet (1), Rhinoceros Auklet (1), Pigeon Guillemot

(1), Surf Scoter (1) and Pelagic Cormorant (1). On that date on the mainland we found 14 oiled murres (12 live and 2 dead) on preliminary checks of beaches between Bolinas and Drakes Estero.

By 8 November oiled birds were coming in to Cronkhite Beach, Stinson Beach, Limantour Beach, Drakes Beach and Point Reyes Beach, but numbers around the Farallones had dropped noticeably. The majority of the birds were found on Point Reyes Beach: 57 live and 36 dead; all but 7 were Common Murres.

The pattern on 9 November was similar to that of the previous day. Farallones biologists reported that only a few oiled birds were found and all were dead. One hundred twenty-seven (75 live and 52 dead) birds washed up on Point Reyes Beach. We covered Doran and Salmon Creek beaches at Bodega Bay but only two dead oiled murres were found.

On 10 November, the numbers of oiled birds on Bolinas, Palomarin and Point Reyes beaches were less than the previous day; in the last location a total of 18 oiled birds were found (8 live and 10 dead). However, the many oiled birds on Bodega Bay area beaches indicated the impact of the spill had yet to run its course. On 11 November, hundreds more oiled birds were recovered from Bodega area beaches, and a few still trickled in as far south as Bolinas.

On 12 November, the drop to only 20 live and 52 dead oiled birds in the Bodega area coincided with reports that the oil slick had moved northward. On 13 November, Bodega area casualties had dropped to 27 birds (7 live and 20 dead); small numbers of oiled birds were recovered as far north as Fort Bragg. On 14 and 15 November small numbers of oiled birds were also

collected in the Point Arena/Fort Bragg area, but the principal beaching of oiled birds appeared to be over.

Species Composition

Alcids (39.4%), scoters (31.6%), grebes (14.8%) and loons (7.7%) made up 93.4% of the combined totals of live and dead birds (Table 2.2). Common Murres made up 94.6% of the alcids found and nearly half of the murres (49.0%) were recovered alive. In contrast, all 16 Cassin's Auklets were dead when found. The Bodega Bay area produced 94.9% of all oiled scoters, and scoters accounted for 53.0% of all oiled birds from the Bodega Bay area. Of the total scoters recovered at Bodega Bay, 43.8% were alive. Both Surf and White-winged Scoters were affected, but the proportions are not separable because the species were not consistently differentiated by people recovering or reporting them (Table 2.2). Four species of grebes were affected, with Western Grebes making up 62.2%, Eared and Horned grebes 36.8%, and Red-necked Grebes 1.0% of the total. Live individuals accounted for 41.7% of the Western Grebes found. All but two of the Eared and Horned grebes came from either the Farallones or the Bodega Bay area (Table 2.2). Of the 30 Eared Grebes at the Farallones, 3 were found dead and 27 were reported so badly oiled that they would likely die. The latter had beached themselves on treacherous terrain and were not recoverable. Of the remaining small grebes, 70.7% were recovered alive. Oiled loons were recovered in all areas; 63% were alive when found. Exact proportions of Arctic, Common and Red-throated Loons, which occurred in that order of abundance, were obscured by numbers of unidentified loons (13% of the total).

At least 30 species of birds with oiled plumage were recovered from the beaches. The Bodega Bay area with 23 species contributed more than any other area. There is similarly extensive nearshore and estuarine habitat at Limantour and Drakes esteros. Had oil not entered Bodega Harbor, American Coots, Ruddy Ducks, scaups, and possibly Eared and Horned grebes would have likely escaped the spill's impact; many fewer scoters and Common Loons would have been affected.

Oil: Apparent versus Actual Cause of Mortality

Seabirds that have not been affected by oil die from a number of causes and their carcasses are common on beaches. PRBO's 13 years of systematically gathered beached bird data from central California supply ample evidence for this. During 7-19 November beach surveys, we found 262 dead birds without obvious oil on their plumage (see Table 2.3): 12 dead loons, 17 Western Grebes, 43 Northern Fulmars, 122 scoters, 52 Common Murres, 4 Cassin's Auklets and 12 gulls. Therefore, we raise three questions: (1) were some birds already dead when their plumage became oiled either in the ocean or after beaching; (2) were some birds unhealthy and likely to die anyway when they became oiled; and (3) were some birds affected by spilled substances that did not stain plumage, e.g. oil dispersants? Except for scoters, such high numbers of dead birds are highly uncharacteristic of natural mortality (as assessed by PRBO Beached Bird Surveys) for this time of year. Thus, something is amiss, and while the third question is no longer possible to answer, it should be given serious thought.

The available evidence suggests that few birds became coated with oil

after death. Post-mortality oiling would have had to occur mostly in the ocean: (1) carcasses were removed from Stinson, Limantour, Drakes, Doran and Salmon Creek beaches before oiled carcasses appeared in number; (2) oiled carcasses occurred relatively frequently on beaches that themselves never showed any oil (for example, Stinson, Bolinas, Drakes and Limantour beaches); and (3) on Point Reyes Beach, where carcasses were not removed prior to the beaching of oiled birds, virtually no birds with oiled plumage showed evidence of decay. The only decaying or decayed oiled carcasses reported were one Northern Fulmar and one shearwater. Neither are included in Table 2.2. Other decaying carcasses excluded from Table 2.2 are one White-winged Scoter and one gull from Dillon Beach, where carcasses were not removed from the beach prior to the appearance of oiled birds, and 12 scoters, 1 Eared Grebe and 3 Common Murres from the Bodega Bay area.

Whether oiling occurred before or after death in the ocean is difficult to establish. Live and dead birds recovered with light to moderate amounts of oil on their plumage were oiled mostly on the ventral surface. Such a pattern would be expected most frequently if the bird encountered oil when still alive. Further evidence incompatible with the "in-ocean oiling after death" hypothesis comes from a comparison of the ratios of non-oiled to oiled carcasses of loons, Western Grebes, Northern Fulmars, and Common Murres. Of these species, we expect fulmar carcasses to occur at least as far offshore, be in the water as long, travel as far to reach shore, and be as likely to contact oil as the dead of the other species. (Fulmars are the least likely of these species to be seen nearshore.) Consequently, we suggest that if oiling of floating carcasses contributed greatly to the

totals of oiled carcasses found, the percentage of carcasses oiled this way should not exceed the 27.1% reported for the fulmar. Yet the percentage of oiled carcasses for the other three groups was much higher with oiled loon carcasses at 74.5%, Western Grebes at 80.5%, and Common Murres at 79.0% (from Table 2.3). This plus the similar distribution of oil on the plumage of dead and live individuals, suggests that a high proportion of the loons, grebes and murres found dead had oiled plumage before they died. Live loons, grebes and murres spend much more time on the water than fulmars, which are normally airborne. Consequently, live fulmars might be expected to be less likely to contact oil than the other species.

Possibly all oiled fulmar carcasses recovered were of birds that initially became oiled when alive. Oil can then be suggested as the cause of mortality. Alternatively, it could be argued that the birds were unhealthy already and would have died whether oiled or not. In fact, there were 2.7 non-oiled carcasses for each oiled one. Furthermore, fulmars do die from non-oil related causes particularly during the fall (PRBO unpubl. data). Similar circumstances may pertain to the gulls; of the 17 carcasses found, 12 showed negative and 5 positive evidence of oiling. The "would die regardless of oiling" hypothesis clearly applied to the scoters but again to an unknown proportion. Even before oiled birds came onshore there were reports of dying scoters at Abbott's Lagoon and Tomales Bay. During the study period, 17.1% of the live scoters recovered (Table 2.3) lacked oiled plumage and were emaciated. Much lower percentages of loons (3.6%), Western Grebes (0.0%), and Common Murres (1.4%) were recovered alive and without oil on the plumage. An unknown but not insignificant

proportion of the live and dead oiled scoters were emaciated and had poor chances of survival regardless of the oil. This should be reflected in the report on the rehabilitation success of the live birds.

The only means available to precisely estimate numbers of beached birds killed by the oil is to compare rates of carcass deposition during the spill period with baseline data collected during previous years at the same survey locations. These beached bird census data are filed at PRBO, but our resources have not yet permitted their compilation for an appropriate analysis.

Rehabilitation

The records from the Cronkhite and Marine Wildlife rehabilitation centers show that 624 live oiled birds came in for treatment (Table 2.2). The numbers are greater than the 610 we report by location because the rehabilitation centers received birds from sources other than the PRBO collection effort. We were unable to assign the 14 additional birds to a specific area. In addition, four oiled gulls we reported as sent in were apparently never received. In the preceding sections, we relied on the regional numbers rather than on rehabilitation center numbers. To assess mortality after the birds had been received by the rehabilitation center, only totals from the centers will be considered.

Those live oiled birds recovered from beaches and successfully released back into the marine environment, cannot be regarded as casualties of the spill because they have apparently regained their health (plumage free of the oil pollutant, birds float well, weight normal). The final results of the rescue effort will not be known for some time, but it is estimated that

a survival rate of about 50% is likely (Berkner unpubl. data). If the 50% rate holds, then approximately 1000 oiled birds died and were recovered during the spill period. Another 300 were recovered with oiled plumage and survived long enough to be reintroduced into the marine environment. An additional number died but were not recovered; these birds are considered elsewhere in this report (see Part 1).

Oiling of Birds After November 19

On 28 November there was a report of small amounts of a heavy oil and a number of oiled birds on Point Reyes Beach. We surveyed part of the beach on 29 November and about 75% of it on 30 November. Doran Beach was also covered on 29 and 30 November. No oiled birds were found at Doran. At Point Reyes Beach we found 6 live and 7 freshly dead oiled loons, 4 freshly dead oiled Western Grebes, 7 freshly dead oiled fulmars, 4 live and 3 freshly dead oiled Common Murres, 3 freshly dead oiled Cassin's Auklets and 1 freshly dead oiled Rhinoceros Auklet. Five decaying carcasses which must have become beached between 19 and 27 November were also found: 2 loons, 1 Western Grebe, and 2 fulmars. Freshly dead non-oiled carcasses of Western Grebes (1), fulmars (9), and Cassin's Auklet (2) were found, as well as decaying carcasses of loons (1), fulmars (2), and Cassin's Auklet (1). These data are not included in Tables 2.1, 2.2, or 2.3.

Table 2.1 Beaches covered by Point Reyes Bird Observatory biologists and volunteers for recovery of oiled birds between 6 and 19 November 1984.

Beach	Dates Covered
San Francisco County	
Ocean Beach	14 Nov
Marin County	
Cronkhite Beach	8-12, 16 Nov
Stinson Beach	6, 8-19 Nov
Bolinas/Palomarin	7-11, 16 Nov
Wildcat Beach	8 Nov
Limantour Beach	7-10, 19 Nov
Drakes Beach	7-8, 11, 19 Nov
Point Reyes Beach	8-10, 19 Nov
Sonoma County	
Dillon Beach	10-11 Nov
Doran Beach	9-14 Nov
Salmom Creek Beach	9-14 Nov

Table 2.2. Summary of (oiled) birds, tabulated by PRBO, and picked up on beaches 7-19 November. Excluded are sublethally oiled gulls, cormorants and pelicans from the Farallon Islands.

	Farallones 7-9 Nov		Ocean Beach to Cronkhite 8-16 Nov		Stinson Beach 8-19 Nov		Bolinas to Palomarin 7-16 Nov		Wildcat to Drakes 8-19 Nov		Pt. Reyes Beach 8-19 Nov	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Common Loon	2			1	3	4				1	3	
Arctic Loon	1	2	1		3	2	3		3	3	6	8
Red-throated Loon				1	1					1	1	1
Loon spp.			2						1			2
Western Grebe			1			7	3		3	2	1	5
Red-necked Grebe												
Horned Grebe												
Eared Grebe		30										
Grebe spp.												1
Northern Fulmar			1							1	2	8
Shearwater spp. (1)												
Cormorant spp. (2)									1			
Ruddy duck												
Scaup spp. (2)												
Black Scoter												
Surf Scoter		1					1					1
White-winged Scoter												
Scoter spp.						11						
American Coot												
Red Phalarope												
Gull spp. (3)					1		1				1	3
Common Murre	19	53		3	2	11	20	12	20	40	124	81
Pigeon Guillemot		1										
Cassin's Auklet		1										2
Marbled Murrelet												
Rhinoceros Auklet		1									2	1
Ancient Murrelet												1
Alcid spp.												
Other (2)												2
Totals	22	89	5	5	10	35	28	12	28	48	140	116

Table 2.2 (cont'd)

	Tomales Bay 10-14 Nov		Bodega Bay Area 9-14 Nov		Pt. Arena to Ft. Bragg 14-16 Nov		Regional Totals		Live Birds to Rehab. Centers
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	
Common Loon			12				20	6	24
Arctic Loon	1		5	11	5		28	26	37
Red-throated Loon					2		4	3	3
Loon spp.			8				11	2	10
Western Grebe	9	2	33	54			50	70	46
Red-necked Grebe	1			1			1	1	1
Horned Grebe			8	5			8	5	4
Eared Grebe			18	6	1		19	36	19
Grebe spp.			2				2	1	3
Northern Fulmar				7			3	16	4
Shearwater spp. (1)				1				1	
Cormorant spp. (2)			3	5			4	5	2
Ruddy Duck			2	3			2	3	4
Scaup spp. (2)			2	1			2	1	2
Black Scoter									1
Surf Scoter	5	1	75	171			81	174	75
White-winged Scoter	1		49	46			50	46	53
Scoter spp.			48	4			48	15	59
American Coot			29	6			29	6	31
Red Phalarope				3				3	
Gull spp.			1	2			4	5	
Common Murre	1		52	49	1		239	249	241
Pigeon Guillemot			2	1			2	2	2
Cassin's Auklet				13				16	
Marbled Murrelet				1				1	
Rhinoceros Auklet							2	2	2
Ancient Murrelet									1
Alcid spp.			1	2			1	2	1
Other (2)								2	2
Totals	18	3	350	392	9		610	700	624

Table 2.3. Number of live and dead, oiled and non-oiled birds reported picked up off beaches in Gulf of Farallones.

	Live		Dead	
	Oil	No Oil	Oil	No Oil
Loons	53	2	35	12
Western Grebe	50	0	70	17
Horned/Eared Grebe	28	0	12	0
Northern Fulmar	3	1	16	43
Scoters	179	37	235	122
Gulls	4	2	5	12
Common Murre	219	3	196	52
Cassin's Auklet	0	0	15	4
Totals	536	45	584	262

PART 3: AFFECTED MAMMALS

In spite of intensive coverage of ocean beaches in San Francisco, Marin and Sonoma Counties during the 6-28 November period (see Part 2), no oiled marine mammals, alive or dead, were found. Had the spill occurred a month or two later, as discussed more fully in Part 1, the story might have been different, because then large numbers of highly vulnerable fur seals would be expected to be in the area. The only fur seal we know of during this period was sighted off Cape Mendocino by a PRBO biologist on board NOAA ship Surveyor.

On the Farallones, 15 elephant seals became oiled, some heavily (see Appendix), but no deleterious effects were apparent. Many of these animals apparently became oiled as they hauled themselves across oiled shoreline. Only a few elephant seals were seen at sea in the area (Part 4); as far as known, most elephant seals in this area at this time of year (immatures) are hauled out on land for purposes of their annual molt.

On 13 November, we visited Drake's Estero and viewed Bodega Rock in order to determine if any harbor seals had become oiled. Seals were present at both sites in expected numbers, but none were oiled.

We encountered cetaceans at expected frequencies on various aerial censuses (Part 4). We have no evidence to indicate that they were affected by oil.

PART 4A: ASSESSMENT OF POPULATIONS AT RISK--PRELIMINARY OBSERVATIONS

While gathering financial support to conduct systematic censuses of threatened populations of birds and mammals, we conducted preliminary flights. On 4 November 1984, we flew fixed-wing aerial surveys using a Cessna 340 in the vicinity of the disabled tanker to determine the distribution and abundance of birds and marine mammals. On 8 November, observations were gathered from a Clean Bay, Inc. helicopter ferrying oiled birds from the island to the mainland.

On 4 November, we flew four east-west transect lines south of Southeast Farallon Island, starting 2 km south and finishing approximately 52 km south of the island. The transects crisscrossed the continental shelf break, beginning in shallow water on the continental shelf and finishing in deep water over the continental slope (Fig. 3). Our transect lines bracketed the area north and south of sunken the stern. We flew each transect line at an altitude of 61 m and a speed of 160 km/hr. One observer censused a transect approximately 50 m wide from the passenger side of the aircraft, while the other observer scanned a larger area on either side of the aircraft, paying particular attention to the presence of large flocks of birds and marine mammals. The data are grouped here by depth: 1) continental shelf, <200 m deep, and (2) continental slope, >200 m. The first transect began at 12:28 PST and the last transect was completed at 13:30 PST. Throughout the flight, weather conditions were partly cloudy with excellent visibility, with a northwesterly wind of about 19 to 35 km/hr. During the transects, we passed just north of the main oil spill at a position about 18 km south of Southeast Farallon Island (Fig.

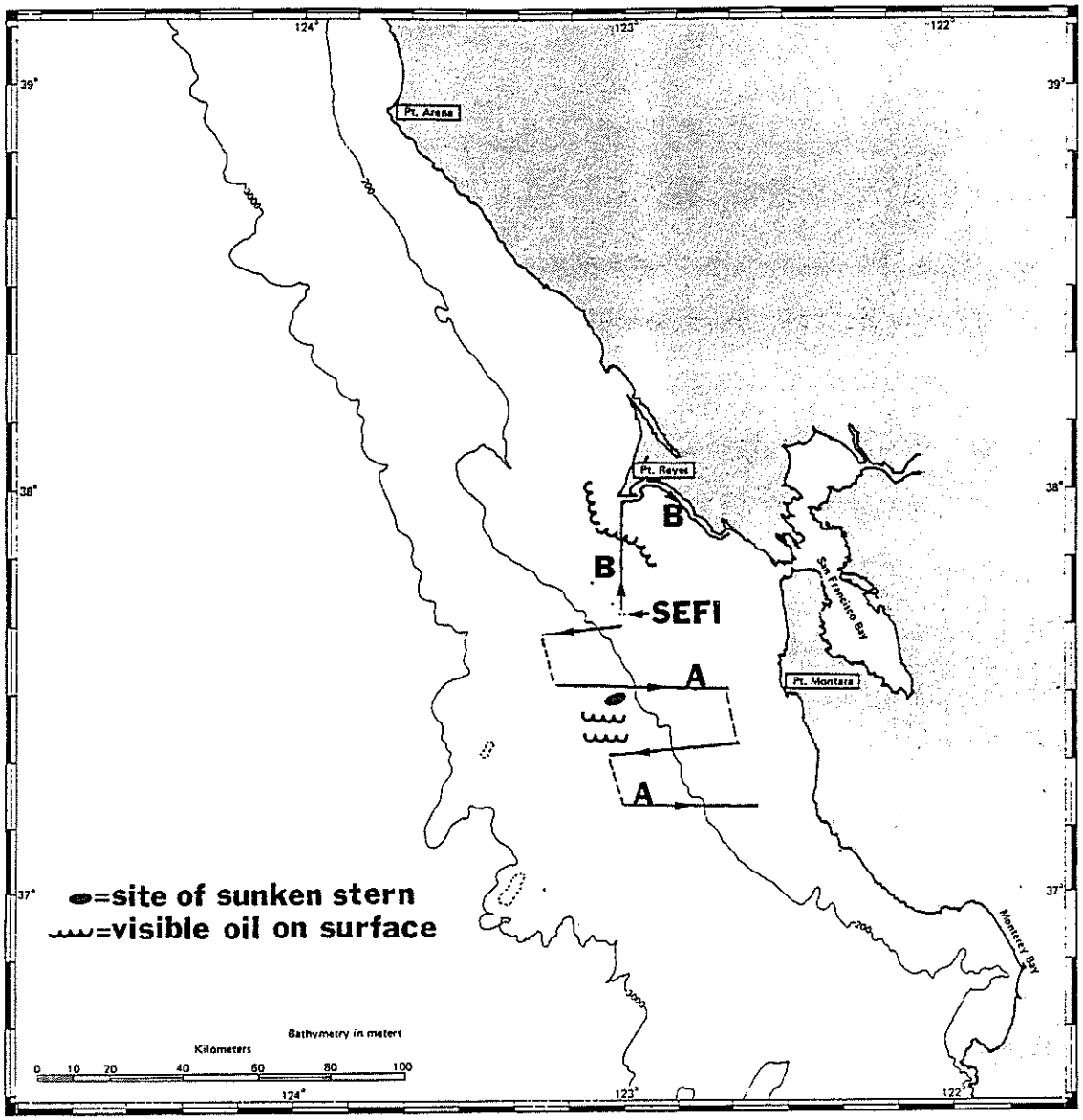


Figure 3. Map of aerial surveys flown on 4 November (A) and 8 November (B), 1984. SEFI = Southeast Farallon Island.

3). This oil appeared as a very cohesive, yellowish-brown, frothy slick about 50 to 100 m wide and 3 to 4 km long, drifting in a southwesterly direction. We also flew over several slicks comprised of much lighter oil, appearing as an oily sheen on the water's surface. Some of these lighter slicks covered several square kilometers.

We calculated a total density of 33.4 birds per square kilometer for all bird species in all habitats. Densities differed, however, between the continental shelf (density 50.0 birds/sq km) and slope (11.3 birds/sq km; Table 4.1). Densities also varied within these two habitats, with coefficients of variation (standard deviation/mean x 100) ranging from 60 to 200% for most species. This high variation is attributable to the natural flocking of birds into relatively few localities while they are completely absent in others.

Gulls, primarily Western Gulls, were the most prevalent group, followed by Common Murres and Cassin's Auklets/other small alcid types. At this time of year, these three groups are comprised chiefly of resident breeders from the Farallon Islands and Point Reyes. Other groups seen in lower densities were all migrants. Between transects we also sighted an Ashy Storm-Petrel, a small seabird whose population on the Farallones comprises approximately 70% of this species' world population.

Two marine mammals were sighted during the flight. We observed a Dall's porpoise approximately 21 km E of the main oil spill, in shallow water on the continental shelf. Dall's porpoises typically travel in groups, so more animals were probably in the vicinity. An unidentified medium-sized whale was sighted 3 km W of the main oil spill, in deeper

water on the continental slope.

We did not see any oiled birds from the air, but we did see significant numbers of birds within 2 km of the main slick. Again, gulls were the most abundant group, including some individuals sitting on the water and possibly feeding immediately adjacent to the slick. Common Murres and Cassin's Auklets were both present on transects near the slick. Both are highly vulnerable to oiling due to their habit of sitting for long periods of time on the surface of the water.

On 8 November 1984, we were able to conduct another survey in the Gulf of the Farallones. The flight path was straight north from SE Farallon Island to Point Reyes (water depth 10-60 m), then southeast along the shoreline to Bolinas Bay (water depth <10 m). The coastal section of this flight was 300 m offshore, just beyond the breakers. The helicopter maintained a speed of 160 km/hr at an altitude of 61 m throughout the flight.

On this flight we encountered a large oil slick lying between 6 and 12 km SW of Pt. Reyes (Fig. 3). The western edge of this slick contained brown frothy lubricating oil, but most of it was composed of a light sheen, apparently drifting inshore with the southwesterly winds. The slick was at least 30 km long, snaking in broken sections from about 15 km NE of SE Farallon Island to northwest of Pt. Reyes (see also aerial photos in Part 5).

The species composition and densities observed between SE Farallon and Pt. Reyes were similar to those observed on 4 November south of SE Farallon (Table 4.2). The coastal transect showed much higher densities

than those offshore, particularly of coastal species vulnerable to oiling such as Western Grebes and scoters.

During the 8 November flight, we observed several birds within the main oil slick, including 2 Common Murres, 3 Cassin's Auklets, 2 loons, and 1 Northern Fulmar. Considering the drift of the slick, it had already passed through a huge area in the western Gulf of the Farallones.

Table 4.1 Densities of birds observed on 4 November 1984 during aerial surveys near the wrecked tanker Puerto Rican south of the Farallon Islands.

	Continental Shelf[a]			Continental Slope[b]		
Species	Mean[c]	S.D.	Transects[d]	Mean[c]	S.D.	Transects[d]
Loon spp.			0	0.8	1.7	1
Fulmar/Dark Shearwater	1.2	1.8	2			0
Buller's Shearwater	2.6	1.5	4	1.0	1.2	2
Brown Pelican	0.2	0.5	1			0
Phalarope spp.	4.3	8.7	1			0
Gull spp.	23.5	16.1	4	4.9	5.5	3
Tern spp.	0.2	0.5	1	0.2	0.4	1
Common Murre	17.9	26.0	3	1.3	2.5	1
Cassin Auklet/Small Alcid	6.0	10.2	3	3.8	7.6	1
Totals	56.1	46.5	4	12.0	15.0	4

[a] These are waters <200 m deep but >10 m deep; total area sampled 3.56 sq km.

[b] These are waters >200 m deep; total area sampled 2.67 sq km.

[c] Mean = mean number of birds per sq km.

[d] Transects = the number of transects (4 total) on which each species group was observed.

Table 4.2. Densities of birds observed on 8 November 1984 during flight from SE Farallon Island to Point Reyes and along shore from Drake's Bay to Bolinas Bay.

Species	SE Farallon[a] to Point Reyes		Drake's Bay[b] to Bolinas Bay	
	Total Counted	Density (#/sq km)	Total Counted	Density (#/sq km)
Loon spp.	4	2.6	5	3.0
Western Grebe	0	0	65	39.0
Fulmar	2	1.3	0	0
Cormorant spp.	0	0	13	7.8
Brown Pelican	0	0	7	4.2
Scoter spp.	0	0	171	102.6
Phalarope spp.	2	1.3	0	0
Gull spp.	11	7.2	79	47.4
Common Murre	26	17.0	5	3.0
Cassin's Auklet	3	2.0	0	0
Totals	48	31.4	345	207.0

[a] This area is equivalent to the continental shelf habitat of Table 4.1; total area sampled, 1.53 sq km.

[b] This area included waters <10 m deep and within 300 m of shore; total area sampled, 1.67 sq km.

PART 4B: ASSESSMENT OF POPULATIONS AT RISK--SYSTEMATIC FLIGHTS

We report here results of four systematic aerial surveys of seabirds and marine mammals conducted on 11, 14, 17, and 20 November 1984 in the Gulf of the Farallones and vicinity. The purpose of these surveys was to assess the at-sea distribution, abundance, and species composition of the mammal and bird fauna in the region, and to determine the relationship between these animals and floating oil produced by the T/V Puerto Rican. Our purposes were thus the same as those for preliminary flights (Part 4A), but with a better-equipped aircraft we could be more systematic in our coverage. We covered a larger area than in the earlier flights, and flew the same tracks each time.

As in the previous section, seabird results are presented as densities, i.e., the number of birds per square kilometer. In many instances the data are presented as average density within each of three habitat zones based on water depth: inner shelf (depth <100 m), outer shelf (depth 100-200 m), and continental slope, (depth >200 m). The fewer sightings of marine mammals are presented in tabular form. Locations of oil slicks encountered during the surveys are also presented.

Results of these surveys are compared briefly with results of similar surveys conducted by UC Santa Cruz for the Minerals Management Service during November 1980, 1981, and 1982 (Briggs et al. 1983). Given the high degree of annual variation exhibited by these populations of marine animals, however, inter-year comparisons should be considered with caution.

We used a high-wing, twin engine Aero-Commander 500A for all surveys except the first (11 November) when a low-wing Cessna 310 was used. On

each flight we surveyed 6-8 track lines from the shoreline to beyond the 2000 m isobath, concentrating our efforts between Pigeon Point and Bodega Bay (Figs. 4-7). Track lines were chosen from a master list of east-west transects used by Briggs et al. (1983). As in the preliminary flights (Part 4A), surveys were flown at 65 m altitude at 185 km/hr using the strip transect protocols of the MMS-funded studies of the Southern California Bight and central and northern California outer continental shelf. Observers working only on the shaded side of the aircraft scanned a 50 meter-wide corridor and recorded all sightings on tape. Eacn sighting included identity to lowest possible taxon, numbers of each species, associations, and behavior. Aircraft position was determined by Loran-C (nominally accurate to within 20 m).

Of the four surveys, two (14 and 17 November) were flown during fair-weather conditions which optimized our observational capabilities (Figs. 5 and 6). The surveys of 11 and 20 November were flown in relatively rough weather, where sea state at times exceeded 29 km/hr (Figs. 4 and 7). Surveys conducted during rough weather usually report lower observed densities than during fair-weather flights. Whether these lower densities are the result of changes in the behavior of the birds (e.g. increased tendency to remain ashore) or the decreased detection capabilities of the observers is not yet clear for all species. Species distributed narrowly along the coast (e.g., grebes and scoters) may not be sampled adequately by this survey technique.

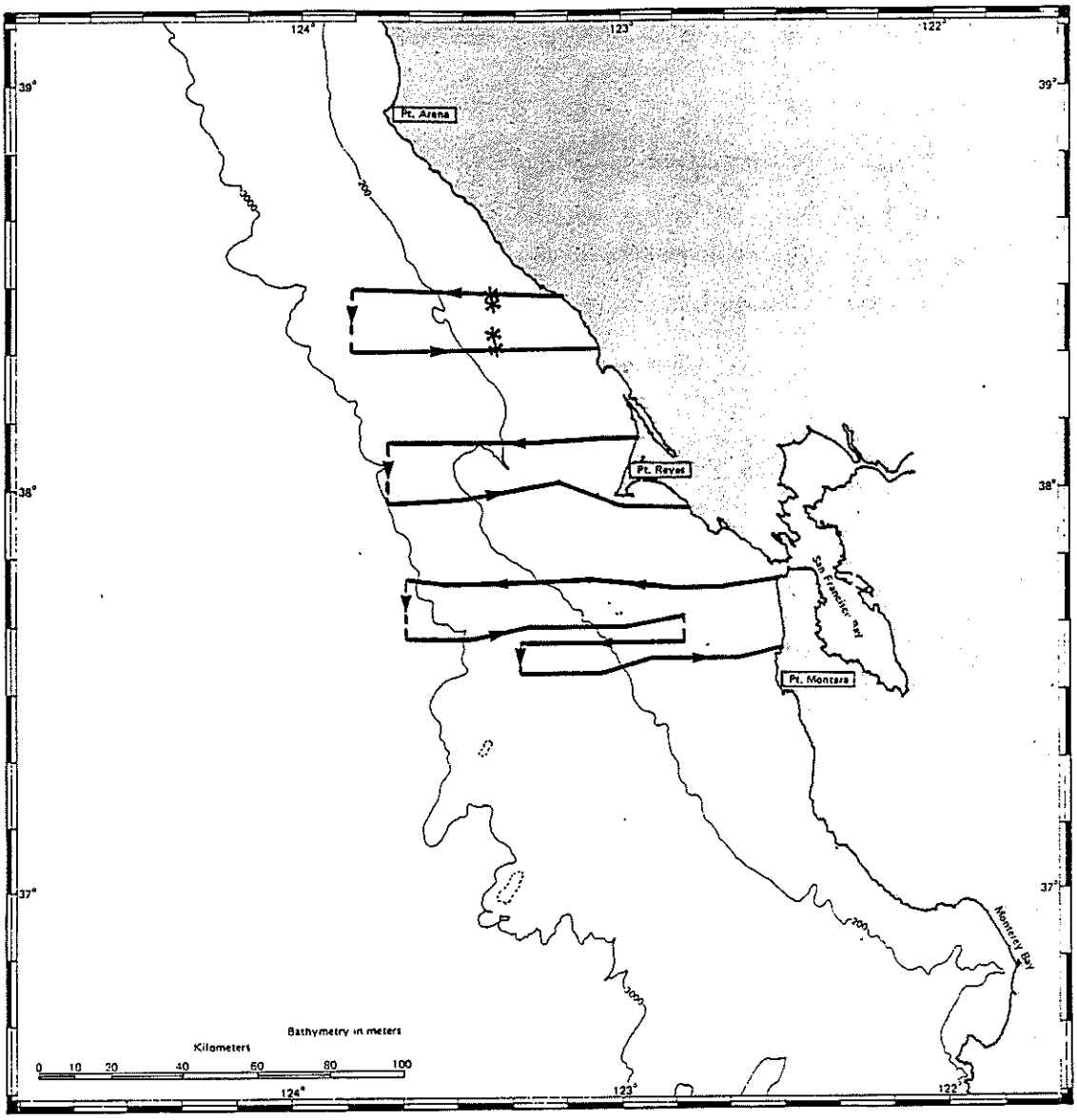


Figure 4. Aerial survey track of 11 November 1984, showing locations of any floating oil encountered (*).

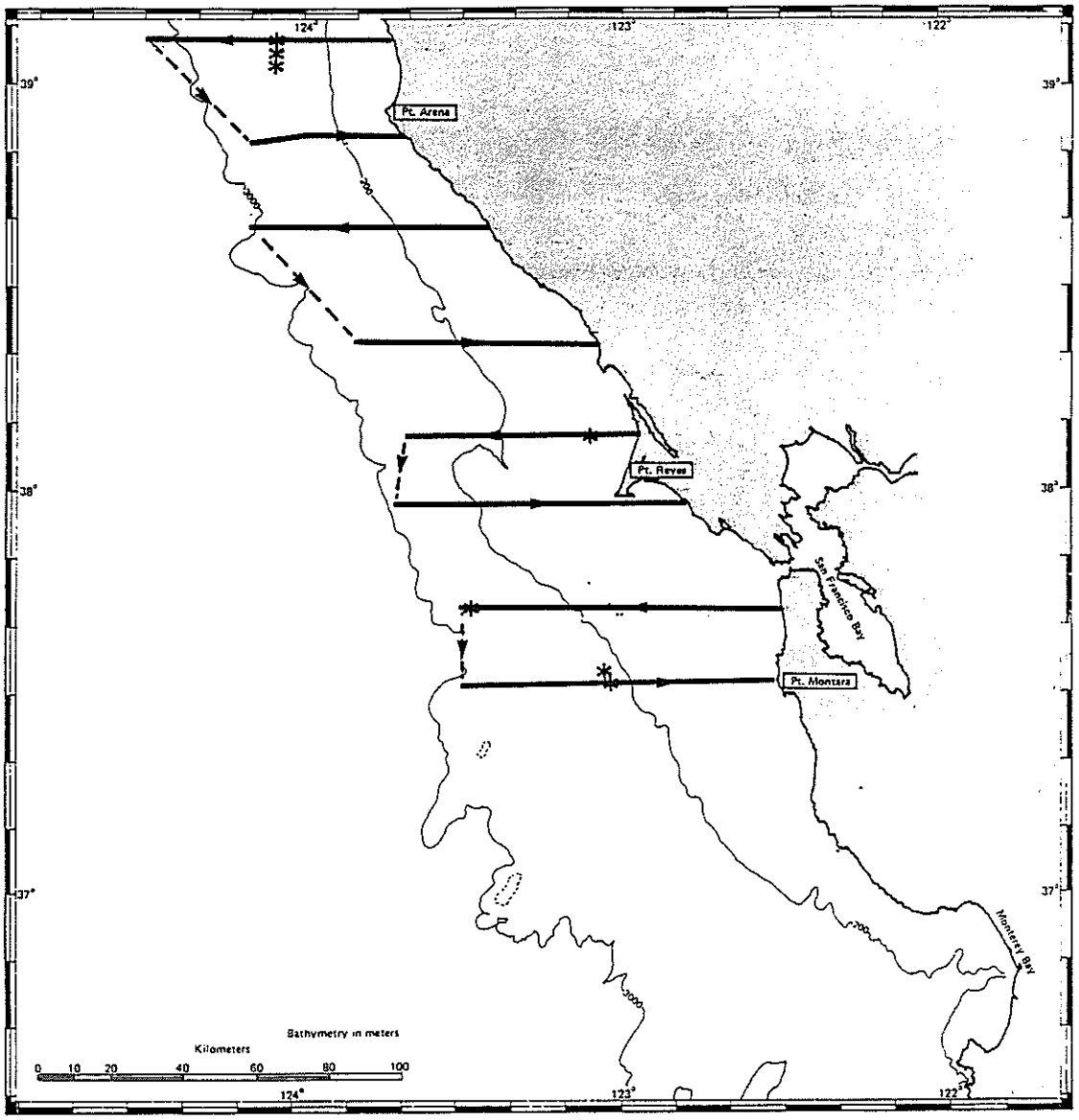


Figure 5. Aerial survey track of 14 November 1984, showing locations of any floating oil encountered (*).

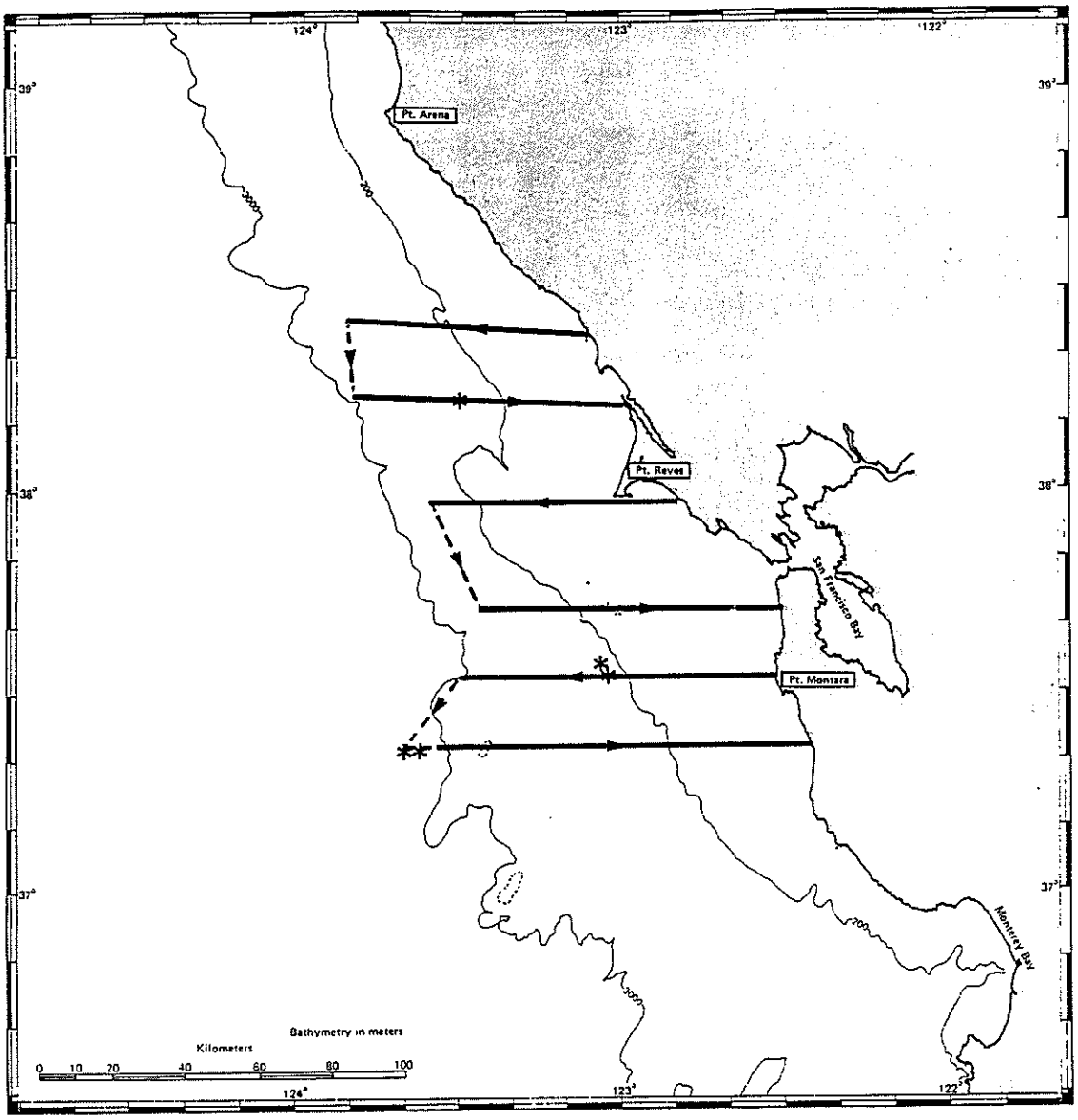


Figure 6. Aerial survey track of 17 November 1984, showing locations of any floating oil encountered (*).

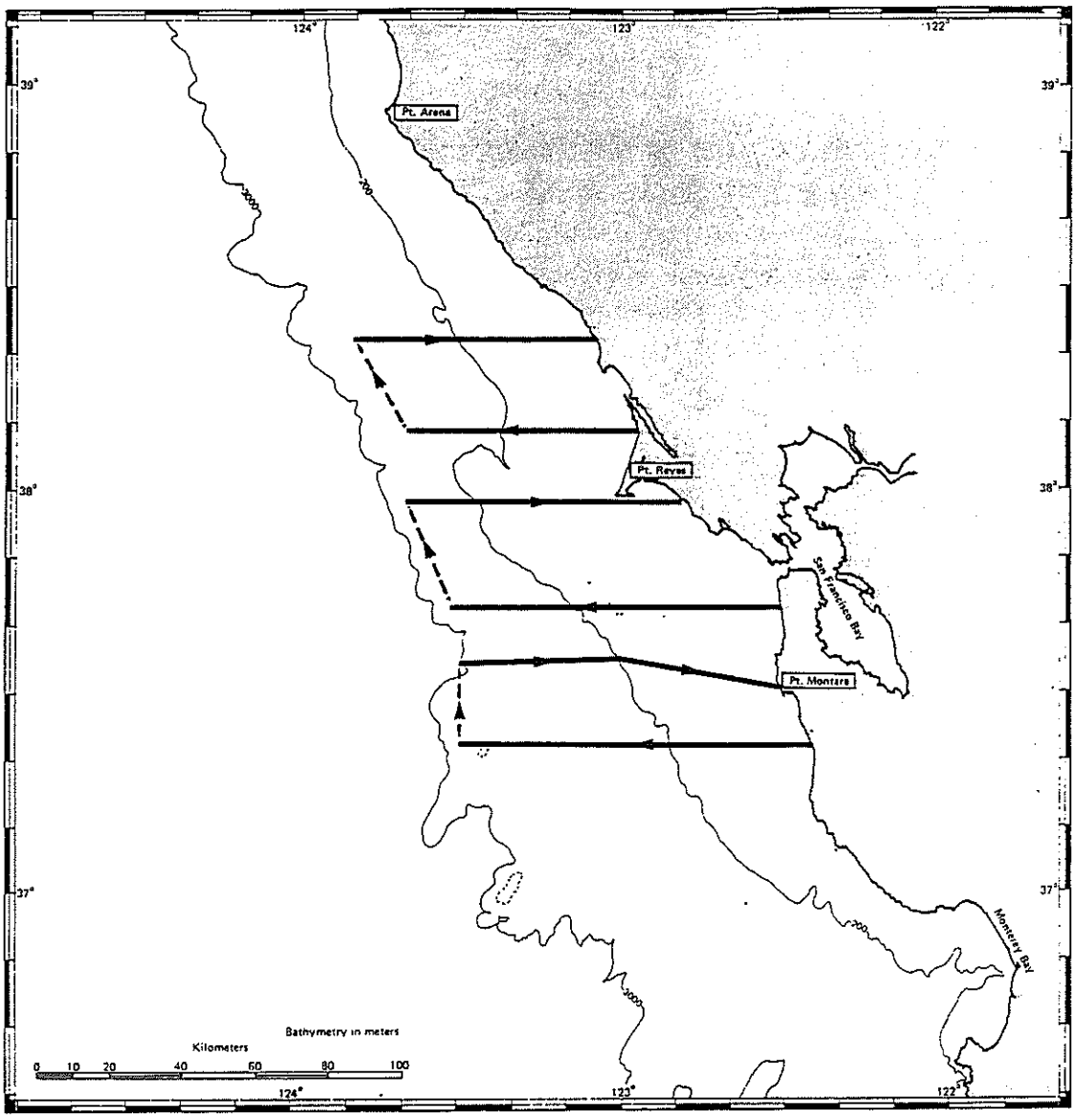


Figure 7. Aerial survey track of 20 November 1984, showing locations of any floating oil encountered (*).

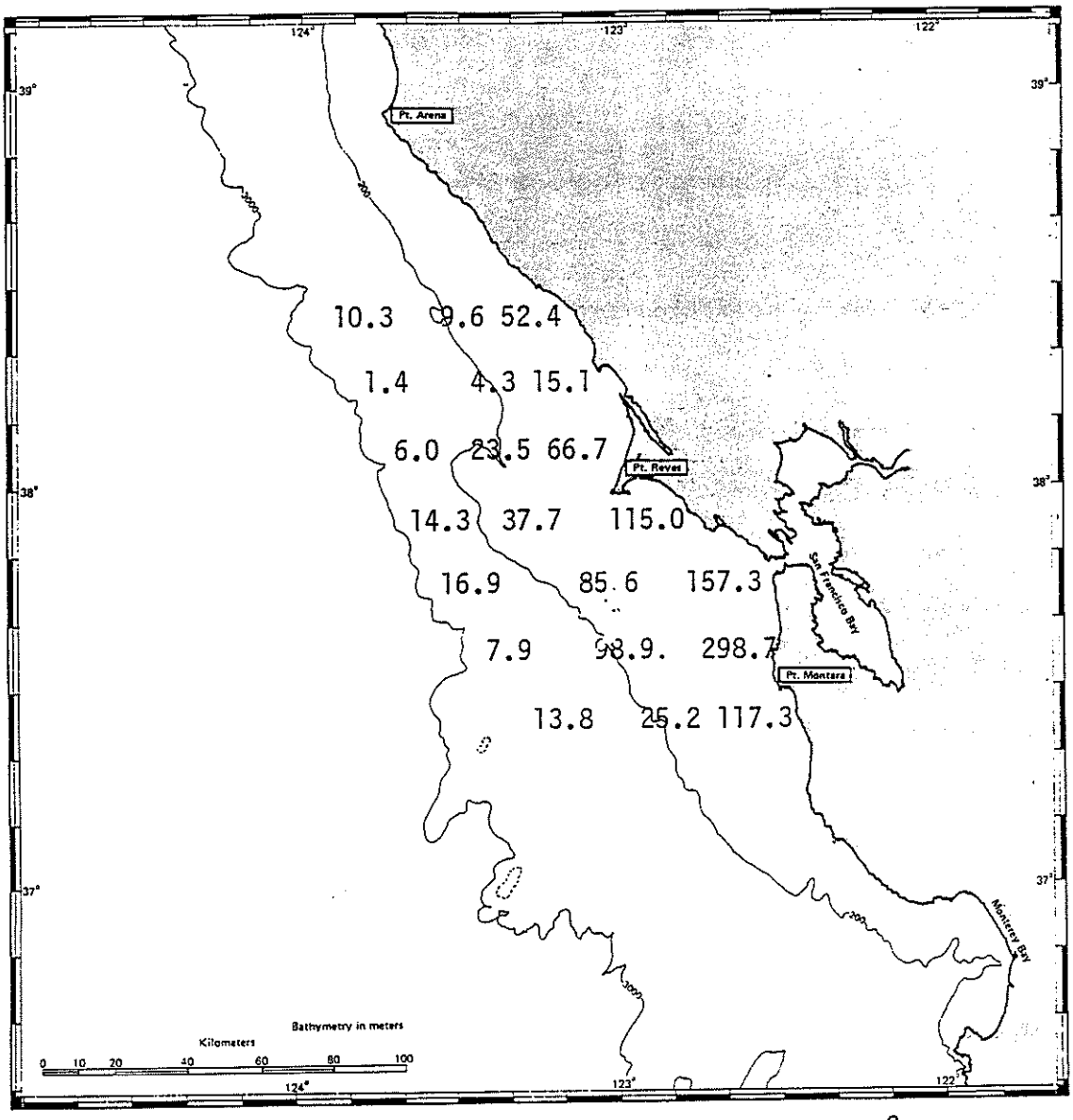


Figure 8. Total seabirds distribution ($\bar{x}$ birds per km^2) in the Gulf of the Farallones region, 11-20 November 1984.

SEABIRDS

We identified 30 species of marine birds during this flight series (Table 4.3). The density of all species combined averaged approximately 140 birds per sq km on waters of the inner shelf, 50 per sq km on the outer shelf, and 10 per sq km over slope waters. Thus, results for these habitats were similar to those obtained during preliminary flights (Part 4A). During the two fair-weather surveys (14 and 17 November) density was 33% higher on the shelf and 11.5% higher in slope waters than during the two rough-weather surveys. Overall, highest concentrations of seabirds were found over the inner shelf from Pillar Point to Point Reyes; average density near Point Montara was nearly 300 birds per sq km. Density over slope waters showed less latitudinal variation than that over the shelf (Fig. 8). The average density of each major seabird group within each depth zone is presented in Table 4.4.

On the inner shelf, gulls (primarily California, Western, and Bonaparte's) accounted for 62% of all birds seen. Alcids (almost exclusively Common Murres) were also numerous, comprising 28% of the total of all seabirds in that depth zone. Other vulnerable species present in low to moderate numbers were loons (primarily Arctic), Western Grebes, Surf and White-winged Scoters, phalaropes, cormorants, and Brown Pelicans.

Gulls (74% of the total birds) were also numerically predominant on outer shelf waters. Alcids, mostly Common Murres and Cassin's Auklets, comprised 14%. Arctic Loons, phalaropes (most presumed Red Phalaropes), Brandt's Cormorants, and Northern Fulmars were occasionally numerous in this depth zone.

Over slope waters, gulls were outnumbered by shearwaters 47% to 42%. The Northern Fulmar was the most abundant procellariiform in this depth zone, although flocks of Sooty and Buller's Shearwaters were also seen. Among the gulls, Herring Gulls, Black-legged Kittiwakes (17 November only), Bonaparte's Gulls, and California Gulls accounted for most sightings (although the latter two species were absent offshore during rough weather). Also present in this zone were three species of vulnerable alcids: moderate numbers of Cassin's Auklets, low numbers of Rhinoceros Auklets, and a few Tufted Puffins.

For comparison, area-wide densities of numerically important species recorded on November surveys in three prior years (1980-1982) are presented in Table 4.5. The years with highest average density, 1980 and 1981, were accompanied by slightly cooler sea surface temperatures (SST's) than were found in autumn 1982 and this year (Aver 1981, 1982; Bell 1984; Briggs et al. 1983; Sund 1984). The extremely low densities recorded during the 1982 surveys were coincident with the onset of the recent well-publicized El Nino event. That year the large populations of northern breeding gulls, phalaropes, and alcids did not move south into the study area until quite late, and then only in diminished numbers (Briggs et al. 1983). This year, regional SST's are at or slightly below normal for November (Bell 1984); but note the continued presence of the pelagic red crab, Black-vented Shearwaters, and other "warm water" creatures (see Part 1). The punctual appearance of near-normal numbers of most northern breeding species (present densities are more comparable to those of 1980 and 1981 than to 1982) are consistent with slightly lower SST's. The large densities of

1980 and 1981 reflected the presence of increased numbers of migratory phalaropes and Bonaparte's Gulls whose numbers can fluctuate widely from year to year.

Loons and Grebes. We identified two species of loons and one species of grebe. Average density was low for these species (together they comprised less than 5% of all birds seen in each zone), but occasionally large flocks (over 500 birds) were seen on inshore waters. Migrating Arctic Loons were widespread over shelf waters (Mean = 1.64/sq km) and a few were recorded beyond the shelf break (Mean = 0.13/sq km). Western Grebes and Red-throated Loons were restricted to the inner shelf. At least moderate numbers of these species were concentrated in the immediate Gulf of the Farallones area (Point Reyes to Point Montara). One flock seen near Point Arena on 14 November comprised at least 1000 loons, primarily Arctics.

Densities of Arctic Loons calculated from these surveys fall within the range reported from prior surveys (Table 4.5). Western Grebe numbers were substantially lower than those found during previous Novembers (Briggs et al., unpubl. data), suggesting that the winter influx of this species was delayed this year.

Procellariiformes. We recorded seven tubenoses accounting for nearly half of all birds over slope waters (Mean = 5.09/sq km) but less than 5% on shelf waters (Mean = 1.69/sq km). Within this group the Northern Fulmar was the predominant species over the slope (Mean = 3.11/sq km) and outer shelf (Mean = 1.93/sq km). We identified four shearwater species--Sooty, Buller's Black-vented, and Pink-footed, all in low densities (<1.0/sq km).

Sooty Shearwaters (in flocks of up to 150 birds) and Buller's Shearwaters were more numerous than the other shearwater species. Small numbers of Black-footed Albatross were present over slope waters. A single Ashy Storm-Petrel seen beyond the shelf break north of the Farallones represented the only storm-petrel sighting of these surveys. In general, during the course of the survey period, numbers of fulmars increased while numbers of other shearwater species declined.

The patterns described above are generally consistent with those recorded during previous November surveys. Black-vented and Pink-footed Shearwaters are more apt to be seen in this region during warm-water years. Sightings of storm-petrels (especially Ashy Storm-Petrels) were somewhat more frequent during prior November surveys (Briggs et al., unpubl. data).

Other waterfowl sightings (all off-transect) included flying flocks of 25 Canada Geese near shore north of Bodega Head on 14 November, and 20-25 unidentified ducks approximately 10 km west of the North Farallones on 11 November.

Phalaropes. Phalaropes (probably mostly Red Phalaropes) occurred in moderate numbers on shelf waters, and low numbers offshore. Densities averaged 2.65 per sq km on the outer shelf and 1.05 per sq km on the inner shelf. On several occasions we saw large numbers concentrated in the immediate vicinity of oil slicks. Phalaropes are known to forage at naturally occurring slicks, of biological origin, associated with local upwellings and convergences.

Phalarope densities were substantially lower during the 1984 surveys than in 1980 and 1981 (Table 4.5) when flocks of thousands of birds were

observed in the Gulf of the Farallones. Phalaropes are highly migratory, and both time of arrival and duration of stay within this region can vary greatly among years. Phalaropes are one of the few "shorebirds" that are highly vulnerable to mortality as a result of oiling.

Jaegers, Gulls, and Terns. Low numbers of Pomarine Jaegers and a single Parasitic Jaeger were seen at scattered locations over the slope during these surveys. This is consistent with the densities observed in November 1980-1982; in those years the peak of jaeger migration occurred during October (Briggs et al. unpubl. data).

We recorded eight species of gulls; these comprised 68% of all birds seen on shelf waters and 42% of all birds seen over the slope. Throughout the survey area, the California Gull predominated in all depth zones, averaging about 25 birds per sq km over the outer shelf and almost 50 per sq km nearer shore (density was lower, especially offshore during rough weather).

Western Gulls (Mean = 7.27/sq km) and Herring Gulls (Mean = 1.76/sq km) were also important elements of the shelf avifauna. These larger species were less affected by inclement weather, and Herring Gulls were sometimes the most numerous gulls over the slope (Mean = 0.45/sq km).

Bonaparte's Gull distribution was generally quite patchy, but during the two fair-weather surveys they averaged 7.30 per sq km over the shelf and 1.28 per sq km over the slope; during rough weather they were virtually absent at sea.

Other gull species seen in low number were Black-legged Kittiwakes offshore, and Glaucous-winged, Heermann's, and Mew gulls inshore.

We saw substantially more gulls during these flights than during any prior November surveys. Overall gull densities for November 1984 averaged 63.5 per sq km vs. 21.5 in 1980, 16.3 in 1981, and a very low 6.87 in 1982 (Briggs et al. unpubl. data). The bulk of this increase is comprised of California and unidentified (probably mostly California) gulls (Table 4.5).

The overall pattern of gull occurrence during these surveys is consistent with that observed during November 1980 and 1981. Bonaparte's Gull migration is usually of short duration with a sharp peak sometime during November; California Gull migration is more protracted and the peak often falls during October (Briggs et al. 1983). Perhaps the abundance of an unusual food source, pelagic red crabs, has induced this gull species to linger in the region this year. Kittiwakes usually arrive in central California in November, as they did this year.

Alcids. We recorded four species of alcids. They comprised 24% of all birds on shelf waters and 7% of all birds over the slope. Common Murres were the predominant alcid of shelf waters, especially the inner shelf where their average density was over 39 per sq km and they accounted for 99.8% of the alcids. Cassin's Auklets, nearly absent from inner shelf waters, averaged 2.45 birds per sq km on the outer shelf where they comprised 33% of the alcids seen. They averaged only 0.71 per sq km over the slope, but were the predominant alcid there, accounting for 70% of the total. A few Rhinoceros Auklets and Tufted Puffins also were sighted, mostly over the slope.

Alcids, in general, are particularly vulnerable to oiling at sea, and the Gulf of the Farallones supports one of the two largest concentrations

of breeding alcids in California waters (Sowls et al. 1980; Briggs et al. 1983). Figures 9 and 10 show observed distribution of Common Murres and Cassin's Auklets within each depth zone per each 10' of latitude surveyed. Common Murres attained highest densities on inner shelf waters from Point Montara to Point Reyes; peak average density (75/sq km) occurred near Point Montara. Murres were numerous in outer shelf waters only in the vicinity of the Farallon Islands, where densities reached 26 per sq km. No murres were seen beyond the shelf break.

Observed densities of Common Murres were substantially lower during the survey of 20 November which was flown in stormy weather. It is possible that poor survey conditions lowered our counts, although murres are known to stay ashore during rough weather (Blake 1984). Observed densities of the less-easily detected Cassin's Auklet were not lower during this survey, which suggests that fewer murres actually were at sea.

Cassin's Auklets reached peak densities (about 5.5/sq km) in the outer shelf area north of the Farallones and west of Point Reyes, including Cordell Bank. We also found moderate numbers (4.81/sq km) over the slope west of Half Moon Bay. Elsewhere, Cassin's Auklets were scattered in low densities over the slope and outer shelf.

Data from previous November surveys show that Common Murres and Cassin's Auklets were extremely abundant during 1980 and 1981, but nearly absent in 1982, at the outset of El Nino (Briggs et al. 1983). Murre densities in shelf waters averaged about 50 birds per sq km during 1980 and 1981, compared to 22 per sq km this year, and only 2 per sq km in 1980 (Table 4.5). Cassin's Auklet densities during 1980 (Mean = 15.2/sq km over

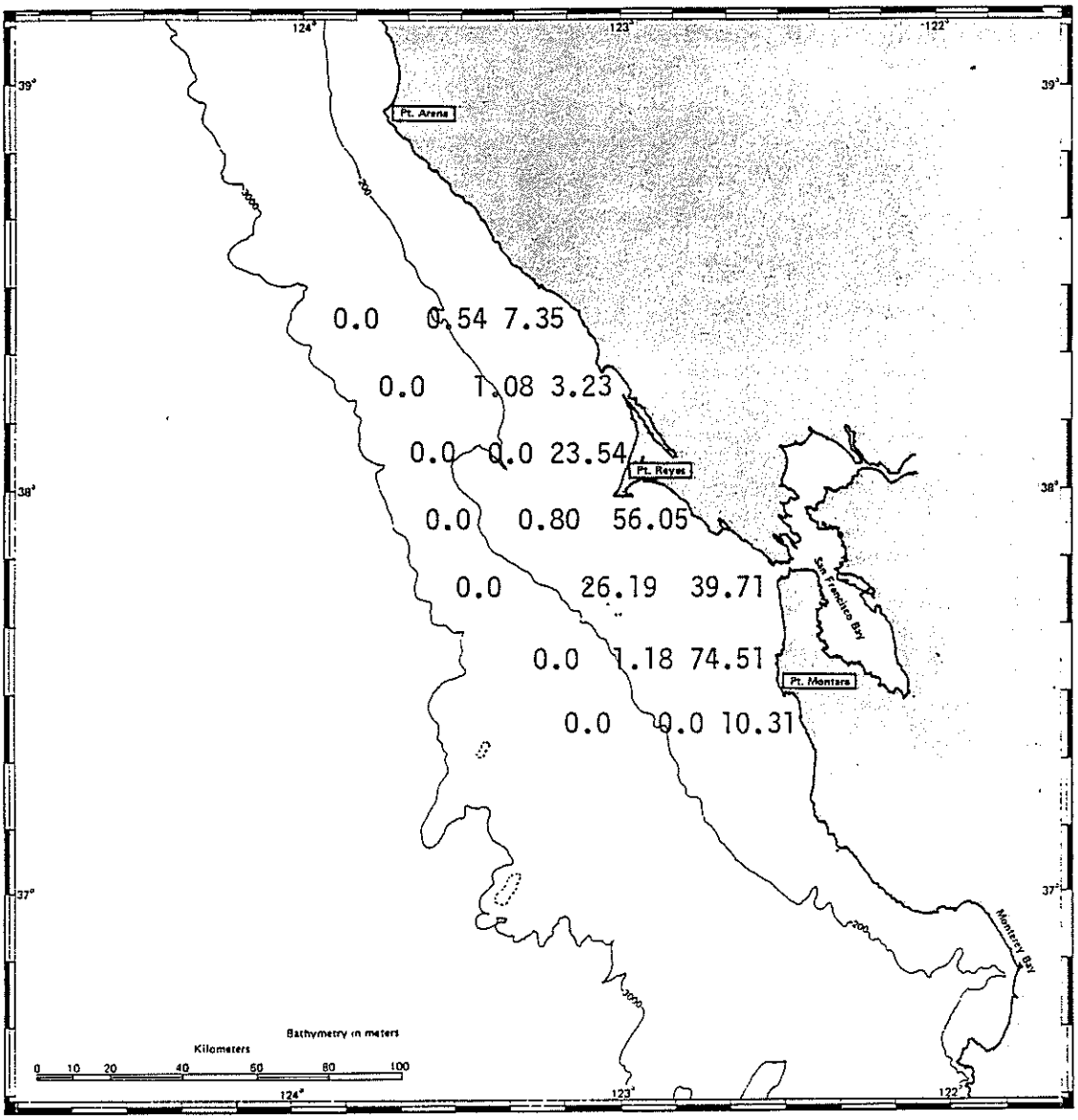


Figure 9. Common Murre distribution ($\bar{x}$ birds per km^2) in the Gulf of the Farallones region, 11-20 November 1984.

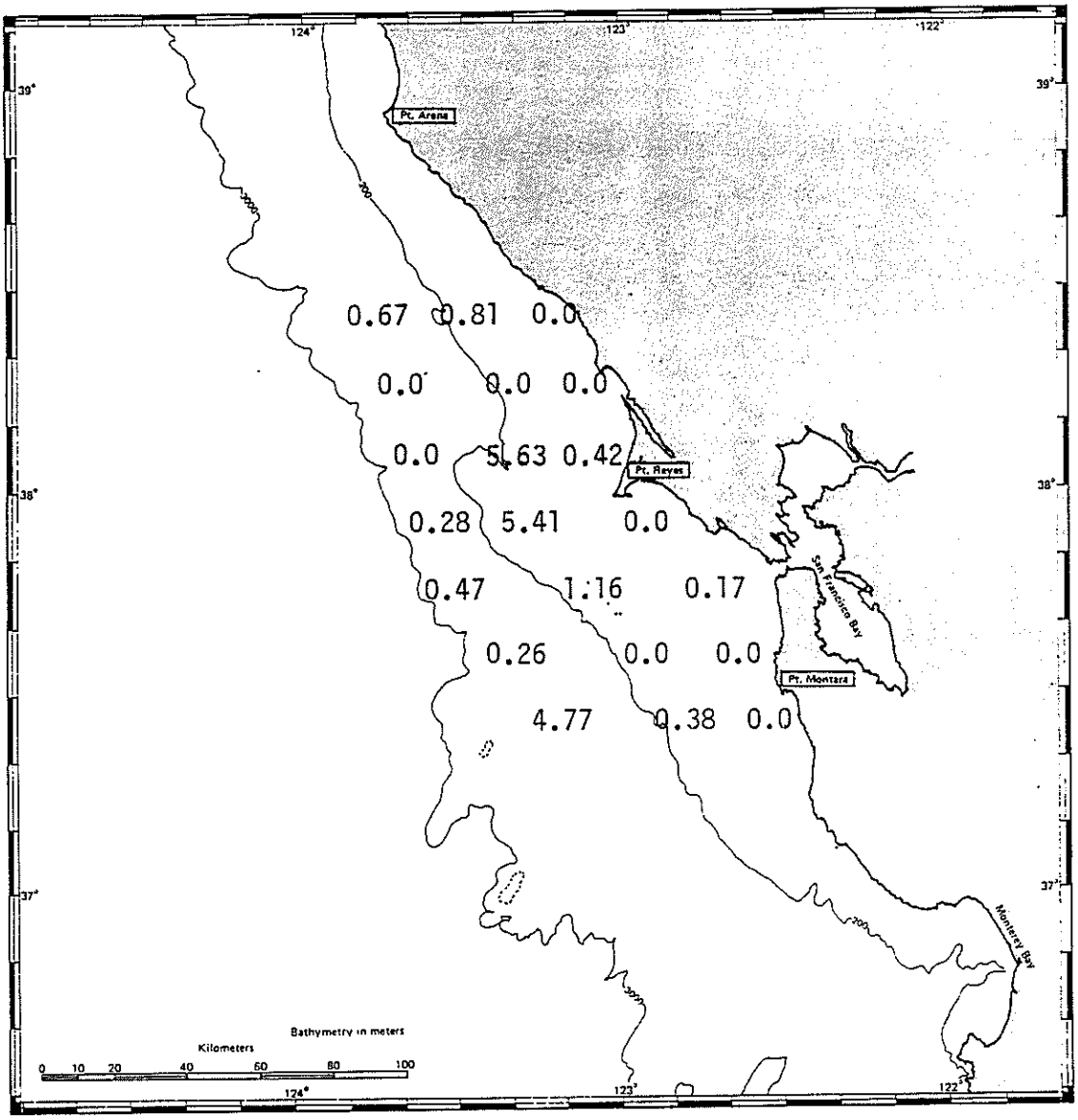


Figure 10. Cassin's Auklet distribution ($\bar{x}$ birds per km^2) in the Gulf of the Farallones region, 11-20 November 1984.

the shelf) and 1981 (Mean = 7.8/sq km over the slope) were much higher than those reported this year (Table 4.5). During 1982 no Cassin's were seen in shelf waters, and slope densities averaged only 0.5 per sq km. The fact that the primary oil slick from the Puerto Rican passed directly over an area of traditionally heavy use by Cassin's Auklets (Cordell Bank and vicinity) may at least partly explain the low densities observed during the November 1984 surveys.

MARINE MAMMALS

We recorded six species of cetaceans and two species of pinnipeds during this flight series; sighting locations are presented in Table 4.6. Four solitary sperm whales seen near the shelf break were the only big whales sighted. In contrast, surveys in November 1981 and 1982 reported only solitary gray whales, although other large whales (especially humpback whales) frequently occur in this region during autumn. Among the five species of small cetaceans, only the Pacific white-sided dolphin and northern right whale dolphin were observed in herds larger than 5 animals.

Three sightings of California sea lions and one of a female northern elephant seal comprised all the pinniped records. No northern fur seals were seen, although small numbers were reported during November surveys in 1981 and 1982. Fur seals are expected to begin arriving in the region during December, gradually leading to peak numbers in February and March.

OIL SLICKS

We observed significant patches of floating oil on each of the four surveys; the positions of these slicks are presented in Figures 4 through 7. Slicks varied in size but the largest covered about 10 sq km. Slicks generally appeared as thin iridescent sheens, but sometimes we saw thicker (denser), more opaque layers near the center. On some occasions the sheen was bordered by brownish foam.

Although we observed no birds actually in contact with floating oil, the slicks did appear to be a source of attraction on some occasions. In these instances, larger than average numbers of birds, especially gulls and phalaropes, were aligned just outside the edge of the slick. Other species (including Arctic Loons, Cassin's Auklets, and Northern Fulmars) seen near the slicks in increased numbers may have been lured to the area by the actions of the gulls.

Table 4.3. Summary list of all marine bird species sighted.

Species	Inner Shelf	Outer Shelf	Slope
Arctic Loon	x	x	+
Red-throated Loon	+	-	-
Western Grebe	x	-	-
Black-footed Albatross	-	+	+
Northern Fulmar	+	x	x
Pink-footed Shearwater	+	-	+
Sooty Shearwater	+	+	x
Short-tailed Shearwater	-	?	-
Buller's Shearwater	+	+	x
Black-vented Shearwater	+	-	+
Ashy Storm-Petrel	-	-	+
Brown Pelican	+	+	-
Brandt's Cormorant	+	+	-
Canada Goose	+	-	-
White-winged Scoter	x	-	-
Surf Scoter	x	-	-
Red Phalarope	x	x	+
Parasitic Jaeger	-	+	-
Pomarine Jaeger	-	+	x
Glaucous-winged Gull	+	+	-
Western Gull	x	x	+
Herring Gull	+	+	+

Table 4.3. (cont'd)

Species	Inner Shelf	Outer Shelf	Slope
California Gull	x	x	x
Mew Gull	+	-	-
Heermann's Gull	+	+	-
Black-legged Kittiwake	-	+	-
Bonaparte's Gull	x	x	+
Common Murre	x	+	-
Tufted Puffin	-	+	+
Rhinoceros Auklet	-	+	+
Cassin's Auklet	+	x	+

x = relatively numerous; + = relatively uncommon; - = not seen.

Inner shelf (depth <100 m); outer shelf (depth 100-200 m); slope (depth >200 m).

Table 4.4. Composition of seabird fauna by group (Mean density = #/sq km).

Species	Inner Shelf	Outer Shelf	Slope
Loons	2.65	1.08	0.13
Grebes	0.80	0	0
Albatrosses	0	0	0.03
Shearwaters and Fulmars	0.98	2.40	5.09
Storm-Petrels	0	0	0.07
Pelicans	0.18	0.11	0
Cormorants	0.47	0.21	0
Scoters	6.35	0	0
Phalaropes	1.05	2.65	0.09
Jaegers	0.06	0.02	0.21
Gulls	88.92	38.14	4.58
Terns	0	0	0
Alcids	39.45	7.47	1.01
Other	1.38	0	0
Totals	142.29	52.08	11.21

Table 4.5. Comparison of area-wide mean densities (Mean/sq km) of numerically predominant species for the years 1980-1982 and 1984.

	Nov 1984	Nov 1982	Nov 1981	Nov 1980
All Birds				
Shelf	97.03	18.75	100.62	149.05
Slope	10.85	5.62	22.16	13.92
Arctic Loon				
Shelf	1.64	0	1.39	7.62
Slope	0.07	0	0.20	0
Northern Fulmar				
Shelf	1.84	6.05	8.32	1.75
Slope	5.12	2.35	6.62	1.56
Phalaropes				
Shelf	1.85	0.53	5.04	39.77
Slope	0.09	0.12	0.17	0.49
California Gull				
Shelf	28.00	1.48	2.65	6.13
Slope	1.94	0.23	1.65	3.66
Western Gull				
Shelf	6.49	2.77	3.34	13.09
Slope	0.60	0.32	0.81	1.82
Common Murre				
Shelf	22.11	2.06	46.35	50.45
Slope	0	0	0.26	0.19
Cassin's Auklet				
Shelf	1.31	0	1.04	15.19
Slope	0.71	0.45	7.76	1.43

1980-82 data are from a U.C. Santa Cruz study conducted for the Minerals Management Survice.

Table 4.6. Sightings of Marine Mammals.

Species	Number	Position
11 November		
Harbor Porpoise	1	38°17.5'N x 123°07'W
Risso's Dolphin	4	38°07.5'N x 123°30'W
Elephant Seals (female)	1	37°57.5'N x 123°20'W
14 November		
Pacific White-sided Dolphin	30	39°07.5'N x 124°10'W
Northern Right Whale Dolphin	20	38°52.5'N x 124°05'W
Sperm Whale	1	38°37.5'N x 123°40'W
Sperm Whale	1	38°57.5'N x 123°40'W
California Sea Lion	1	37°57.5'N x 123°10'W
17 November		
Sperm Whale	1	38°13.5'N x 123°40'W
Sperm Whale	1	37°42.5'N x 123°10'W
Dall's Porpoise	2	37°17.5'N x 122°30'W
20 November		
Northern Right Whale Dolphin	4	37°42.5'N x 123°10'W
California Sea Lion (juv.)	1	37°22.5'N x 122°40'W
California Sea Lion	1	37°42.5'N x 122°45'W
Dall's Porpoise	4	37°42.5'N x 122°55'W
Risso's Dolphin	1+	38°27.5'N x 123°27.5'W

PART 5: DESCRIPTIVE NARRATIVE FOR AERIAL PHOTOS TAKEN ON 9 NOVEMBER 1984: SLICKS FROM THE T/V PUERTO RICAN

The following aerial photos, selected from a set of prints obtained by the Marine Mammal Commission, document the large expanse of ocean affected by oil slicks subsequent to the Puerto Rican spill. These photos are dated November 9, 1984. The numbers in parentheses refer to the file numbers on the prints. A set of the original color prints is on file at Point Reyes Bird Observatory, and others are in the possession of the Marine Mammal Commission in Washington, D. C.

Photo 1 (005). Looking northwest, the main slick of heavy lubricating oil(a) is about 8 km off the Point Reyes Headland. The slick is moving linearly westward parallel to the coast, around the Headland, and along the interface between warm inshore waters and cooler offshore waters. This interface is also visible in infrared photos taken by satellite on the same day. On this day about 70 oiled birds were picked up from beaches on both sides of the Peninsula, but it was not until the following day that of oil came ashore on the beaches here.

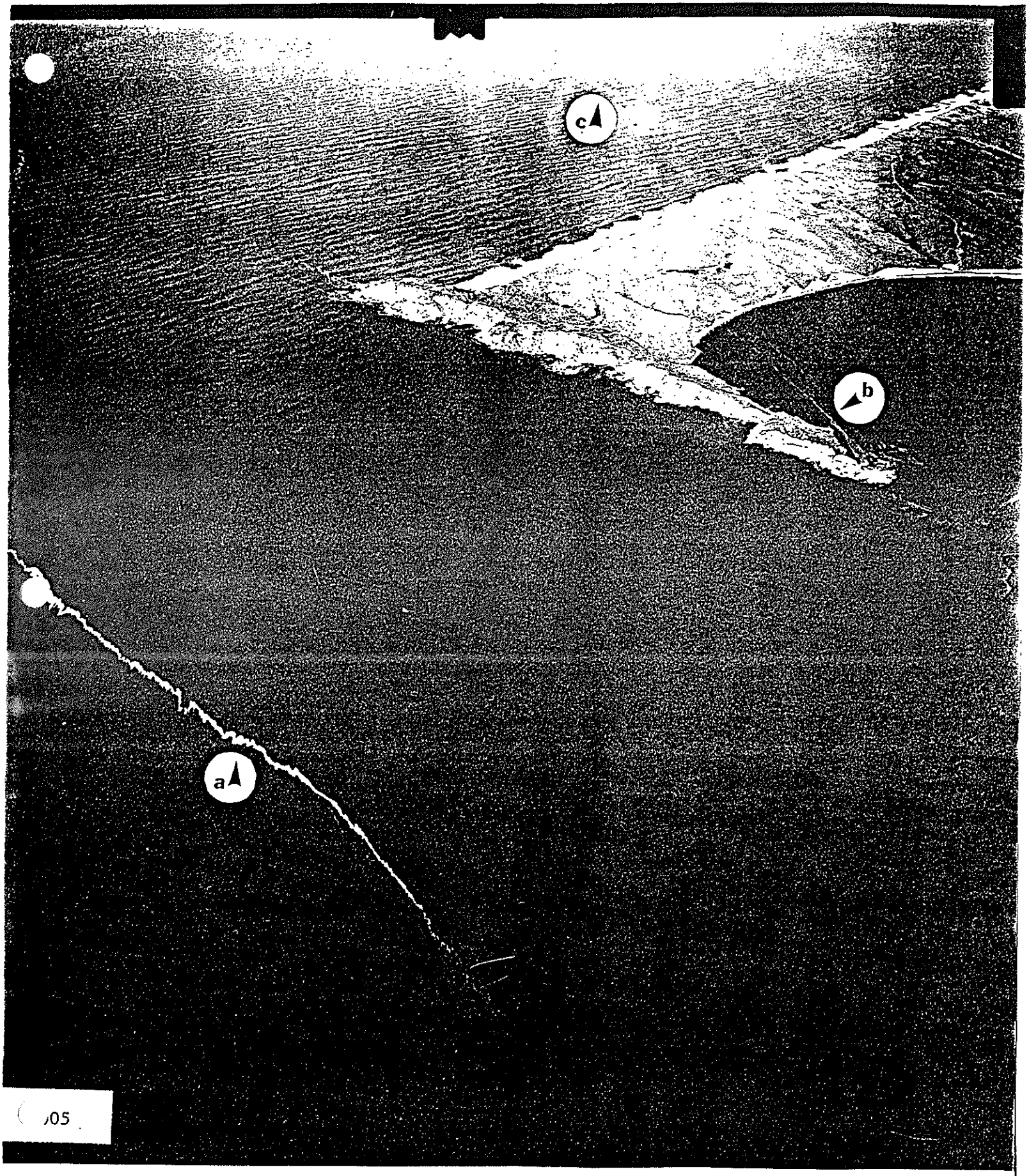
Streaks of oil of a somewhat lighter composition are visible extending from Chimney Rock (southern tip of the headlands) toward Drake's Beach(b). Also visible at the middle of the top margin of the photo is the tip of a slick approaching the northern shore of the Peninsula(c). This movement was apparently the main source of oil on the Peninsula. As is also obvious in the satellite photos, this tail of the slick is curling around the Peninsula with the flow of warm inshore water.

Photo 2(018). Looking north, the entire Point Reyes peninsula is shown, as well as the slick of heavy oil offshore(a), the lighter oil heading from Chimney Rock toward Drake's Beach(b), and, to the upper left corner of the photo, the lighter oil that had curled around to head toward the western shore (12-Mile Beach) of the peninsula(c). A similar type of curling movement brought oil again to this section of the beach on 28 November.

Photo 3(028). Looking northwest, the Point Reyes headland is shown with the line of heavy oil offshore(a) and slicks (sheens) of lighter oil heading northwest toward the horizon(b) as well as curling around the Point back toward the east(c). The slick and oily froth moving from Chimney Rock toward Drake's Beach is also visible(d).

Photos 4(032) and 5(030). An overview and closeup of the entrance to Drake's Estero, on the southeast shore of the Point Reyes peninsula. It appears that some lighter oily froth has already entered the estuary(a). No boom has been placed across the mouth of Limantour Estero, which is to the right of the main estero entrance in Photo 032. The oily froth in Drake's Estero is precisely over the sand bar where the large population of Drake's Bay harbor seals hauls out at low tide. In these photos the tide is high.

Photo 6(059). Looking to the northeast, a closer view of the oil headed along shore in the vicinity of the Bodega headland(a). No boom has yet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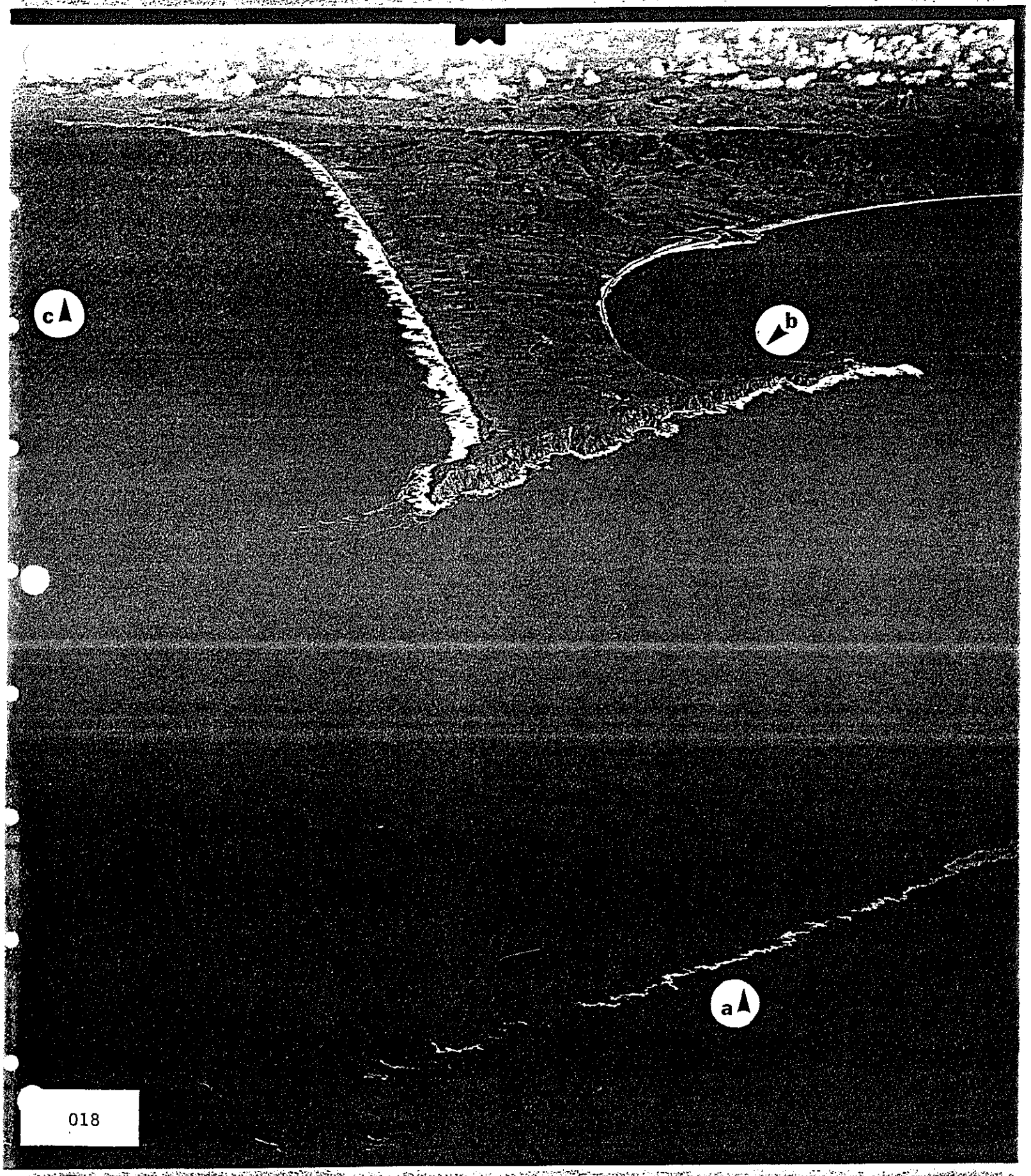
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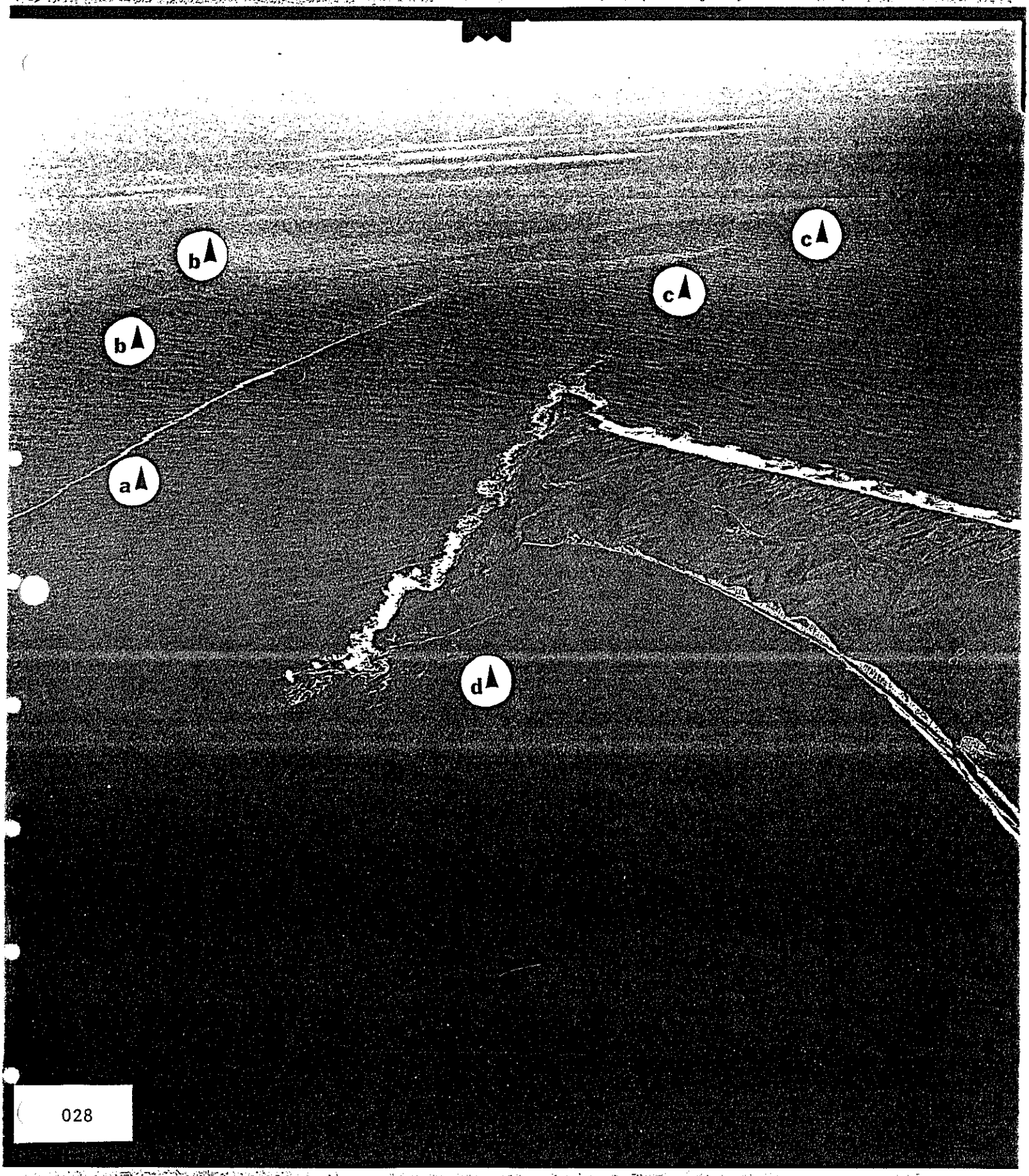

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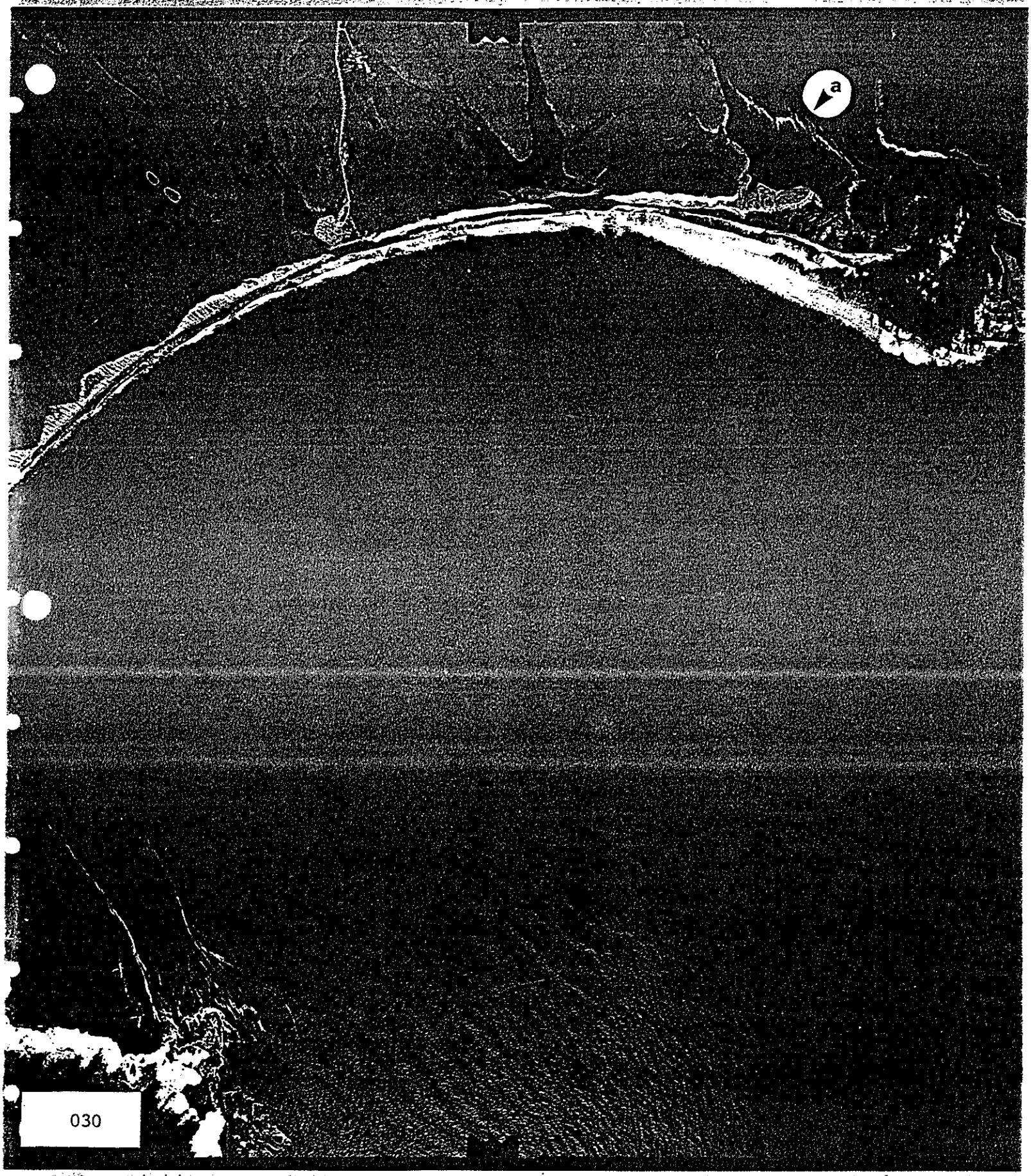
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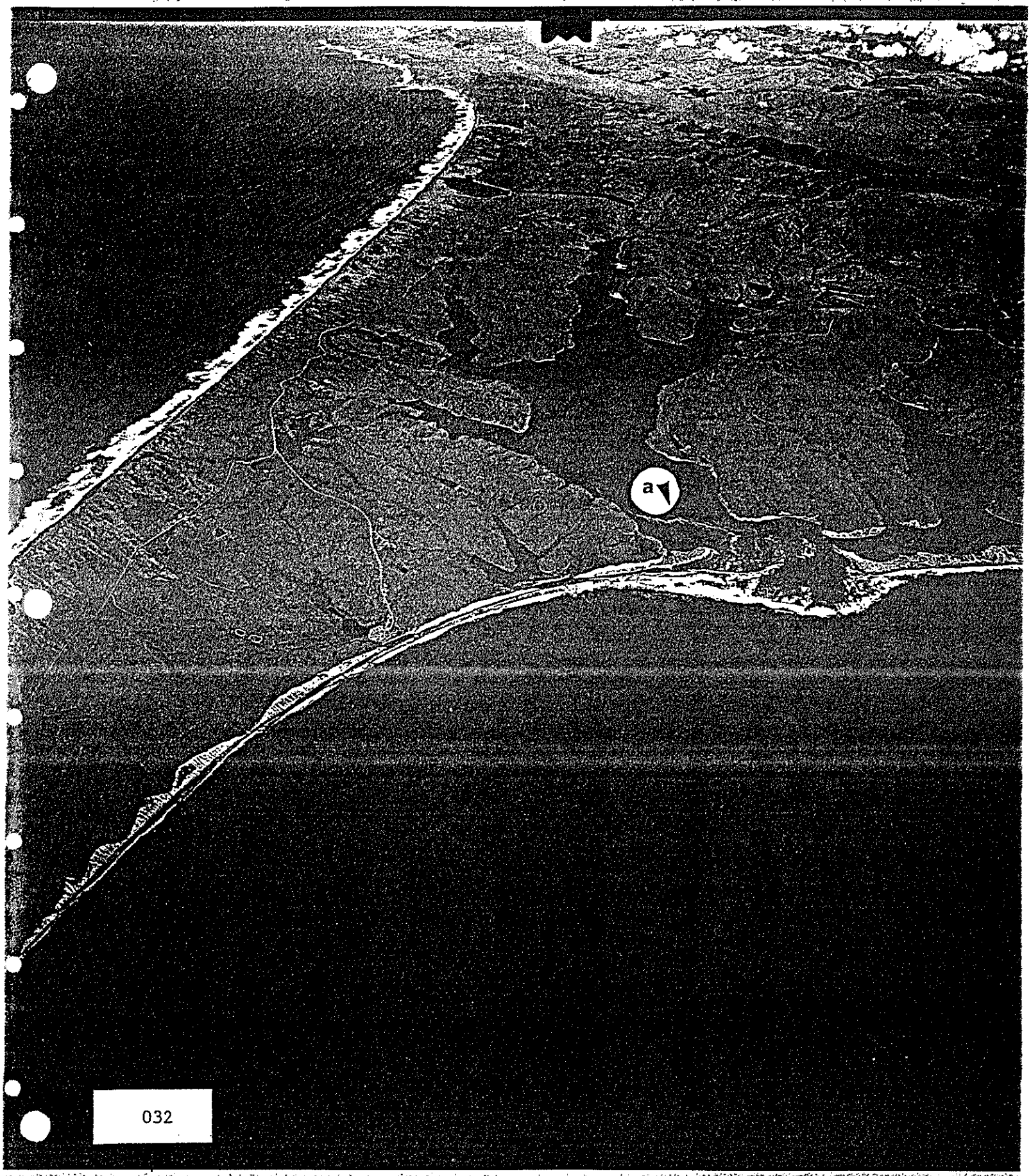

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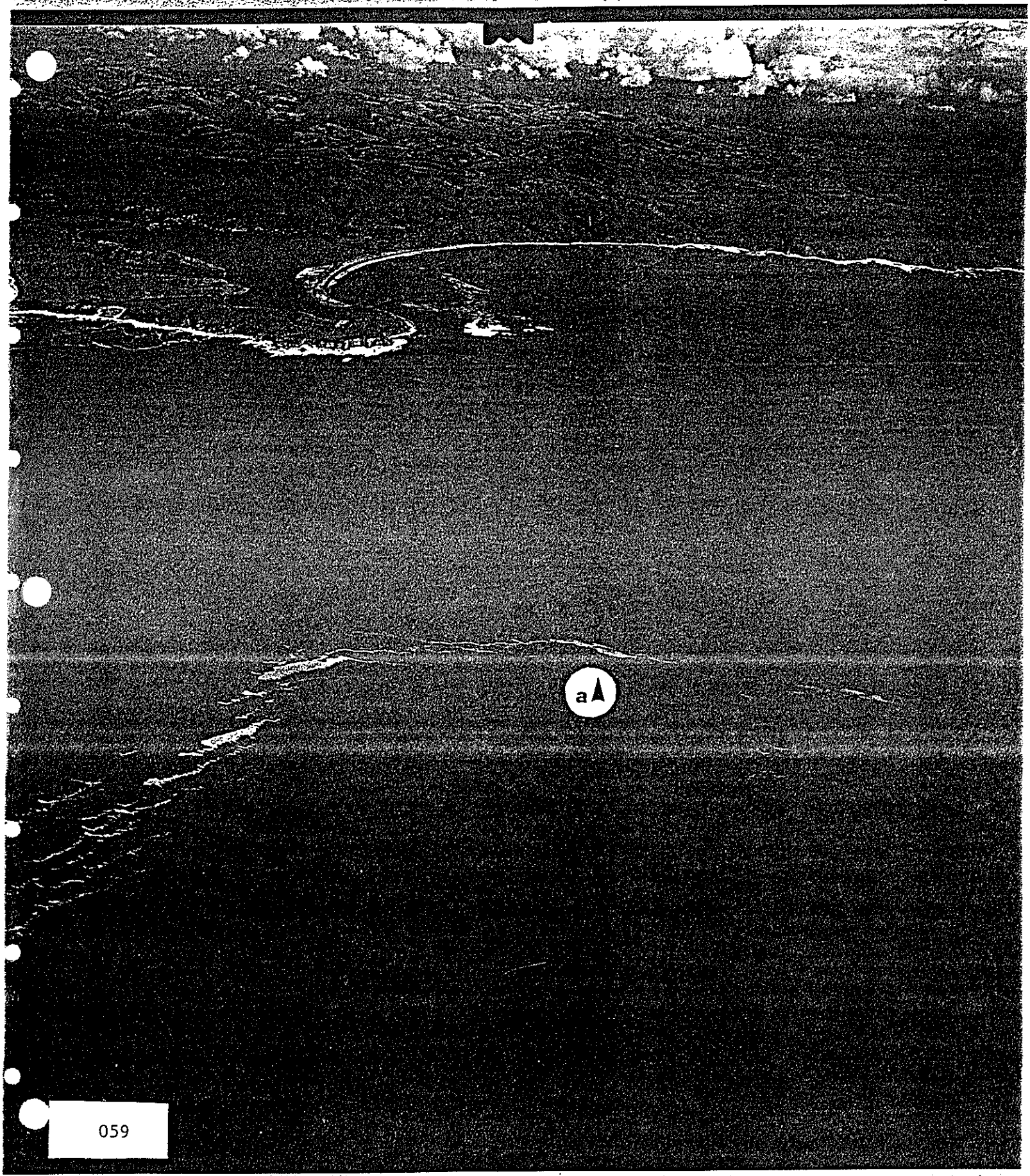

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APPENDIX: OBSERVATIONS OF THE SPILL FROM THE FARALLONES

A chronology and assessment of the impact of the spill on the Farallon Islands is presented below. The account is based upon excerpts from the Farallon Station log and the recollections of the biologists on the island at the time. While less formal, the impressions thus recorded may prove a useful adjunct to the more empirical work constituting the bulk of this report.

Nov 5. The wind shifted from the NW to S by dawn and had built to 19-27 km/hr by the afternoon. There was still no evidence at the island of any oil product from the tanker. Our augmented weather monitoring for NOAA continues with hourly updates sent by radio during daylight hours.

Nov 6. We requested a Coast Guard helicopter to bring PRBO personnel and cargo to the island. The helo departed Crissy Field with Phil Henderson and supplies. Two-thirds of the way to the island, at approximately 0900 hours, we observed a slick of tan-orange substance about 200 m long and 5 m wide on the surface of the sea. A little closer to the island we approached a circular patch of slightly darker and more opaque substance, perhaps 15 m across. This patch confirmed suspicions of oil, for its appearance was nothing like a bloom of plankton that the first patch might have been.

Once on the island, Henderson joined other island personnel in a survey of the shore and nearby ocean. At 0930 hours, an oil slick forming a thin strip off the northern perimeter of the island was less than a kilometer offshore. Stretching from west to east, the slick appeared to be somewhat

more than 1.6 km in length and a few meters wide. The wind had been calm since before dawn with only a slight (5 km/hr) breeze developing in the afternoon.

By 1030 the slick had rapidly approached the island, and it was following this that oil appeared to make the greatest contact with the island (at least during daylight hours). From the lighthouse we could still see a strip extending 400 to 800 m east from Shubrick Point on the island's NE extremity. Maintop Bay and Fisherman's Bay which are large, north-facing bays, were filled with patches of malt-colored oil. Because the island had basically acted as a barrier to the slight southern movement of the slick, the two bays had scooped and trapped a portion of the oil.

Other than what was within the two bays, the oil remained in a cohesive strip exactly following the contours of the island but remaining about 20-30 m away from the intertidal zone. As the strip made its way south, more oil became trapped in the two bays and the rest passed around the island, staying just off shore, and eventually reforming into a ragged strip extending off the south end of the island.

The percussion of the large surf seemed to be the factor that kept the oil off the island, except for the two bays. These sea conditions are quite unusual in our observations -- calm and near windless seas, yet large swells -- and may have minimized this oil slick's impact on the island. The exact locations of definite contact with the island are not certain, because patches of oil would disintegrate in the frothy surf. Most of the shorelines in the two bays probably experienced at least some contact with the oil. Late in the day, after oil immediately around the island had

vanished, we inspected the intertidal in the area of Driftwood Cove at the base of Maintop Bay. This cove collects much of what is trapped in Maintop Bay by the prevailing NW winds. The intertidal appeared normal except for a very slight odor of oil and a very thin surface film on one of the few tide pools.

By the afternoon, the oil still visible from the island seemed to break up and disperse, covering considerably more surface area. USCG and CDFG vessels, among others, had arrived at the slick for investigation, and by dark the "Mr Clean II" was on scene. By 1200 hours, island personnel began to see a few oiled birds beaching and also noticed that some of the elephant seals had encountered black viscous oil on Mirounga Beach in Mirounga Bay on the island's south side. The discovery of this oil suggested that a slick passed by the island during the night and moved north, buoyed by the south winds of the previous night, leaving the oil on south-facing coves and intertidal areas much the same way it was trapped in Maintop and Mirounga Bays by winds from the north.

Nov 7. By first light this morning only one small (approx. 9 sq m) patch of malt-colored oil floated about 50 m off the south end of the marine terrace and the smell of oil had dissipated. All other traces of oil had disappeared, at least from our vantage point. Alice Berkner, from International Bird Rescue, arrived by helicopter and gave instructions in "first aid" for oiled birds to island personnel.

We estimate a minimum of 193 oiled birds on Southeast Farallon I.; thirteen of these were captured, treated, and returned to the mainland for rehabilitation; many others were inaccessible for rescue because of the

island's steep terrain. Though the oil was not in evidence from the island, there were reports from various overflights of vast patches of oil almost all the way back to the S. F. Bay Entrance Buoy.

Nov 8. Nine more oiled murres were taken to the mainland for rehabilitation. There were many fewer oiled birds around the island compared to Nov 7.

Nov 9. Only a few dead birds and practically no live oiled birds were noticed today.

A tally of oiled birds resulting from our observations to date yielded the following:

Common Loon	2 oiled (2 rescued)
Arctic Loon	3 oiled (1 dead, 1 rescued)
Eared Grebe	30 oiled (3 dead)
Brown Pelican	2 oiled
Brandt's Cormorant	8 oiled
Pelagic Cormorant	10 oiled (1 dead)
Surf Scoter	1 oiled (1 dead)
Western Gull	60 oiled
California Gull	2 oiled
Common Murre	72 oiled (25 dead, 19 rescued)
Pigeon Guillemot	1 oiled
Cassin's Auklet	1 oiled (1 dead)
Rhinoceros Auklet	1 oiled (1 dead)

These figures are the result of an actual count of perhaps 50-75% of

the island covered by foot and with the aid of telescopes in some areas inaccessible by foot. The actual toll to the wildlife is certainly higher than our tally, because so much of the island is impossible to survey. We estimate the actual toll on most species impacted at the island to be at least twice the figures tallied and possibly 3 times as high for Western Gulls, strong fliers that do not necessarily show up at the island when oiled.

A total of 15 elephant seals were heavily spotted with the viscous black oil. Another 3 were smeared on 40-60% of their surfaces.

Nov 29. A Herring Gull with black-oiled undertail coverts and a Canvasback slightly oiled on head and neck were observed today. After an interval of nearly three weeks, the recent storm appears to have sent a fresh batch of black oil to the island.