STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
NONGAME BIRD AND MAMMAL SECTION

CAPTURE AND MONITORING OF FORAGING AND BREEDING OF THE MARBLED MURRELET IN CALIFORNIA DURING 1990

An Interim Report

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ABSTRACT

This report describes the results of an intensive research effort to determine the daily behavior at sea and onshore, to find nests, and determine the selection of habitat in forest stands by the Marbled Murrelet (Brachyramphus marmoratus) in California. This sea bird is, in large part, an inhabitant of the wet coastal redwood forests of the northern half of California, and little is known of its habits. Knowledge of this species is extremely important, as a review of the species for endangered status was begun in November 1988 by the U.S. Fish and Wildlife Service and in April 1990, by the California Department of Fish and Game. In addition, evidence is accumulating which indicates that the California populations are becoming increasingly isolated from the nearest population centers around Puget Sound in northern Washington and British Columbia.

The objective of this research was to augment our present study of intensive observations of the bird in coastal forests, in nearshore waters from land, and at sea from small boats. In the study described here, we attempted to determine the specific use of different configurations of redwood forests and to find nesting sites by the attachment of transmitters to birds captured at sea.

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INTRODUCTION

The Marbled Murrelet is a small seabird occurring along the Pacific coasts of Korea, north into Alaska, and south into central California. Only 16 of its nests have been found. These have been inland, and seven have been in trees, both quite unusual for seabirds. Previous research conducted on the Marbled Murrelet has included: distribution at sea (Sowls et al. 1980, Sealy and Carter 1984); breeding biology (Sealy 1975a, Simons 1980, Hirsch et al. 1983); and feeding ecology (Sealy 1975b, Carter 1984). This research indicated that the bird spends most of its time at sea in waters within 2 km of shore. While considered an oceanic species, Marbled Murrelets are known to use inland lakes year-round in the Pacific Northwest (Carter and Sealy 1986). There is a marked need for information on the bird's behavior and ecology in the southern portion of its range.

Previous studies

Little work has concentrated on inland habitat use by Marbled Murrelets, although some inference has been made on the basis of censuses (Paton and Ralph 1988; Ralph et al. 1990, Paton et al. in press). Nest and egg descriptions have included records from northern latitudes where the species nests on the ground (e.g. Johnston and Carter 1985), and in the southern parts of their range where nests have been found in trees (Kuzyakin 1963, Binford et al. 1975). On the west coast of North America, in the southern part of its range, the Marbled Murrelet is thought to nest only in old-growth forests (Sowls et al. 1980, Sealy and Carter 1984) which are being harvested at a rapid rate. In California, all evidence points to this species being almost entirely confined to redwood (Sequoia sempervirens) dominated old-growth forests (Paton and Ralph in press). Thus, the status and continued health of the California population is inextricably tied to these remnant forests. During 1988-89, a survey of the entire range of the species in California (Paton and Ralph 1988, Ralph and Paton 1990, Paton and Ralph in press) provided information linking the species to larger stands of old-growth forests, primarily redwood.

The California populations appear to be becoming more isolated from the rest of the species. The main population concentrations occur from Alaska through southern British Columbia and northern Washington in the Puget Sound area. South of this area the birds are found in small numbers in scattered pockets (K. Nelson and L. Leschner, pers. commun.) until the California border is reached. This increasing isolation may be of concern to the long term viability of the species.

In the past few years there has been greatly heightened interest in the species as research results have begun to accumulate which strongly indicate that the bird nests almost entirely in old-growth forests. Several timber sales and contracts have been postponed awaiting further information on the status of the species. The old-growth redwood forests outside of federal, state, and private protection are still considerable. However, recent developments, especially those concerning approximately 20,000 acres of the Pacific Lumber Company lands, indicate that much of the private holdings could disappear. Knowledge of the murrelets' use of forest stands and nearby offshore waters is urgently needed. Due to the murrelets' predominant use of nearshore waters, it is quite vulnerable to perturbations of the marine habitat. An oil spill off Humboldt and Del Norte counties and another off San Mateo and Santa

Cruz counties could severely decimate the population and cause virtual extinction of these southern population centers.

An urgent need exists to determine the nesting habitat requirements of the Marbled Murrelet in California. Though the murrelet is known to nest at inland forest sites in the Pacific Northwest (Sealy and Carter 1984, Binford et al. 1975, Sealy 1975a, Johnson and Carter 1985), little is known of the birds' specific habitat utilization.

While finding breeding birds on nests would be the most direct method of determining habitat use in forest stands, this has proved to be extremely difficult. To date, only 10 tree nests have been found in North America. Eight of these nests were located using ground search techniques in old-growth forest areas of known murrelet use. Perhaps, the best method of finding nests is to randomly capture the murrelets at sea, place transmitters on them, and follow them to their nests. However, in the past several years, using high-speed boats and small rifle-propelled nets, capture rate has been low, and transmitter life has been short on these birds. Recent improvements in methods for transmitter attachment were felt to reduce problems related to short transmitter life. In addition, some of the birds caught at sea may not be nesting, or may be nesting at some distance from the capture site. The effects of transmitters on behavior of the birds is presently unknown. We felt that capture at sea was the only method which can insure that a bird, rather than the investigator, will choose the habitat type.

We needed to determine specific habitat utilization of the murrelet because censuses, as done in the past (e.g. Paton et al. 1988), give only approximate location to within 2 km, and are not definite as to site. The use of transmitters and the finding of nests would provide information on structural components of actual stands at nest sites. Old-growth forest stands inland from Humboldt Bay and adjacent waters range in size from less than 100 acres to greater than 2000 acres. Logging activites within these stands also varies, ranging from residual cutting to no removal of trees in pristine stands. By following a sufficient number of birds inland, we felt we could determine habitat selection within this range of stand configurations and harvest prescriptions.

This research had three aspects: (1) capture and placing of transmitters on birds at sea; (2) monitoring the birds while they are at sea to determine foraging patterns and movements; and (3) following birds to inland sites to determine habitat needs for nesting.

In 1983 and 1984 Quinlan and Hughes (1984) captured 17 Marbled Murrelets in Alaska at sea using a net gun. Radio-tags were attached to the birds and one nest was located in a mountain hemlock by tracking the bird into the coastal forest. Varoujean et al. (1989) captured and radio-tagged four murrelets off the Oregon coast and though they did not locate the nest tree, they successfully tracked one bird inland to a forest stand where patterns of radio signals indicated incubation behavior. Capture at sea, radio-tagging and tracking the birds to nest sites have the potential to provide unbiased data on forest stand and nest site selection. Upon location of nest sites, information obtained on stand size, age, and structural components could be used to identify potential nesting areas and develop management strategies for these areas.

Objectives of this capture study include the location of 20 or more nests of murrelets captured offshore of Humboldt Bay and comparison of nest stand characteristics with available land to the east and south of Humboldt Bay.

METHODS

Capture efforts began 15 May and continued through 26 July (Table 1). Time of day for capture varied with weather and sea conditions, as well as capture method. Once at sea, capture crews continued attempts as long as conditions remained safe. Two boats were used for capture: a 13 foot inflatable Zodiac with a 40 hp engine and a 17 foot tri-hull Boston Whaler with a 90 hp engine. From 15 May through 26 June, the primary capture method utilized a net gun (Mechlin and Shaiffer 1980) modeled after those used in previous murrelet research (Quinlan and Hughes 1984, Varoujean et al. 1989). After launching at the Samoa boat ramp, at the north entrance to Humboldt Bay, crews travelled through areas of known murrelet use. When a murrelet was located, the crew approached at an angle from upwind, following a course directed 10 to 15 meters to one side of the bird. Immediately after passing downwind of the bird, the boat was turned sharply and accelerated towards the murrelet. A shot was then possible if the bird flushed and lifted off the water into the wind. Captured birds were taken to the ramp area for processing. Measurements and blood samples were taken, a U.S. Fish and Wildlife Service band placed on the leg, and the bird examined for the presence of a brood patch. A 2.5 gram radio transmitter (159-160 Mhz frequency) was attached to the contour feathers on the bird's back between the scapulars, using Titan #332 epoxy adhesive. Beginning 26 June, capture attempts were made at night using a spot light and dip net. This technique was used to successfully capture one murrelet in 1989 (Ralph et al. 1990).

Birds were tracked from land using a Telonics R-2 receiver and 2-element H-antenna until mid-June when we began using an AVM 3-element Yagi antenna on a 4 m telescoping pole. The birds were monitored after release until approximately one hour after sunset or the signal could no longer be located.

Birds were tracked from a series of stations approximately 1-2 miles apart on the Samoa Peninsula, Humboldt Bay, and along the south spit of Humboldt Bay from Table Bluff to the south jetty at the bay's entrance. At each station, observers spent a minimum of 5 minutes monitoring each frequency. When a signal was located, a compass bearing to the bird's position was recorded. Monitoring continued until the signal was no longer heard. Birds were tracked daily until 20 June and periodically thereafter (Table 2).

Seven airplane flights were made to locate radio-tagged birds (Table 2). Flights were made in a Cessna 185, with a Yagi H-antenna mounted on each wing. Two observers monitored frequencies using the Telonics R-2 receivers. A transmitter was placed at the airport before each flight to test equipment and receiving distance for the day's weather conditions. Flight altitudes ranged from 500 to 5000 feet, adjusting for fog or cloud cover. During offshore flights we travelled 0.5 and 1.0-1.5 miles offshore, parallel to the shoreline as far as Punta Gorda to the south and Coos Bay to the north. We followed drainages inland from the coast. On 4 flights, a grid pattern was flown from Highway 36 at Fortuna to Old Kneeland and Mountain View roads. The grid consisted of north and south travel lines at one mile intervals from west (approximately Railroad Gulch) to east (approximately Bridgeville Road). Similar grids were flown over forested areas too large to be covered by a circle or single line flight pattern.

RESULTS

Capture.--We captured four murrelets using the net gun (Table 3), and no birds were captured using the spot-lighting technique. Capture attempts were made on 31 days using net guns and 12 nights using spot-lights. Capture efforts using the net gun totalled 145.3 hours (118.3 hours using the Zodiac and 27 hours with the Boston Whaler). Weather during the capture period made work impossible on many days. All four successful captures were made from the Zodiac.

As capture efforts progressed, the behavior of the murrelets appeared to change. The birds became more wary of the boats and it became increasingly difficult to approach within shooting range. The birds began to dive earlier upon the approach of the boat, and flew more readily than at the beginning of the season. Unfortunately, this occurred just as the capture crews were becoming more proficient at their task.

Following release into the waters of Humboldt Bay, captured birds dove repeatedly while moving away from the release point. Within a few minutes the birds began to preen between dives. The preening did not appear to be excessive and the frequency of dives slowed as the birds swam to areas of the bay normally used for foraging. The rapid diving may have been an attempt to regain normal body temperature after the period of processing. We were able to observe one bird continuously for approximately one hour after release. It returned to what appeared to be normal foraging behavior within 30 minutes.

Tracking.--Transmitters were attached to the four captured birds. Signals were located for a minimum of two days and a maximum of 24 days after capture (Tables 2 and 4). Offshore the birds were located from Centerville to the south to just north of LP Drive off the Samoa Peninsula, a total distance of approximately 26 km. One bird was located inland on one day from the airplane.

Each of the birds was named by the person capturing it, and the accounts of the birds are as follows:

(1) Frodo (159.380 megahertz).-- Captured at 13:00 on 23 May, 300 m west of the south jetty at the entrance to Humboldt Bay. The bird was located north and south of the Humboldt Bay entrance and inside of the bay for five of the first eight days following release. The signal was not heard for seven days and then was located for two days offshore of the Samoa Peninsula. For five days Frodo was not located. On the sixth day three signals were heard offshore of Centerville Beach during an airplane flight. On 16 June, Frodo was last located offshore of the Samoa Peninsula, 24 days after capture.

(2) Lucky (160.321 megahertz).-- Captured at 09:20 on 4 June, 1 km offshore, 1 km south of the south jetty at Humboldt Bay entrance. Lucky was located three of the four days following release, not heard for eight days, then located offshore of the Samoa Peninsula. The bird was heard last on 16 June, offshore of the south spit of Humboldt Bay, 12 days after capture.

(3) Sea Jay (160.336 megahertz).-- Captured at 09:40 on 5 June, 300 m offshore and 500 m north of the north jetty. Located on three days

following release, two of those days offshore of Samoa Peninsula. On 14 June, nine days after capture, three signals were heard, at approximately 08:00, in the Elk River drainage area (T4N, R1E, Sec 24) from an airplane. The signal was not relocated by either circling the plane over the area, or by ground search efforts that same day. This could have been a bird briefly visiting a nest with food provisions for a young, or possibly a signal anomaly.

(4) Finally (159.542 megahertz).-- Captured at 10:35 on 15 June, just offshore of the south jetty. Following release, this bird was located for only two days in the vicinity of the Humboldt Bay entrance. Finally's signal was last heard 17 June offshore of the Samoa Peninsula.

DISCUSSION

The north coast of California experienced unseasonable weather conditions and storms during the period of our capture efforts. Unsafe sea conditions created by this weather pattern forced the capture crews to remain ashore or abandon efforts on many days during this period (Table 1). We feel the decrease of capture hours affected the number of birds captured.

The population of Marbled Murrelets offshore of Humboldt Bay appeared to be more dispersed in 1990, perhaps due to unusual weather conditions. When compared with 1989 results, fewer birds were seen on our offshore boat censuses, as well as during from-shore observations from the south spit census area. To locate the birds we made several reconnaissance surveys and found murrelets as far as 5000 m offshore. This is farther offshore than in previous years (Ralph et al. 1990). In our 1989 work, most birds were seen within 2000 m of shore, and very few as far as 3000 m. We have extended our regular survey areas farther offshore to transects at 5000 m, and also to the north and south during 1990, and will be comparing bird distribution in these areas.

This dispersed behavior may be related to a general breeding collapse of most species of seabirds in 1990 that was well-documented by the Point Reyes Bird Observatory on the Farallon Islands, 300 km to the south (D. Ainley et al., pers. commun.). This was apparently due to unusual warming of offshore water, resulting in an "El Niño" type event. The more dispersed murrelets could have been searching for food in short supply. These conditions made capture more difficult, and may have affected the breeding biology of the murrelets as well.

According to previous studies (Quinlan and Hughes 1984, Ralph et al. 1990), when Marbled Murrelet pairs are incubating, the incubation exchange occurs once per day before dawn. Each bird, therefore, should be found offshore and inland in alternating 24-hour periods. Following hatching and a short period of brooding, the adults fly inland with fish and remain only long enough to feed the chick, presumably, then returning to the sea to forage. Tracking radio-tagged birds to inland sites would be extremely difficult if the birds are not spending time at a nest site. Each murrelet captured during our 1990 field season was located offshore the day following release (Tables 2 and 4), indicating these birds were either non-breeding birds or were feeding young at the time of capture.

The birds appeared to move extensively. During the four day period between 4 June and 7 June, Lucky and Sea Jay were captured and relocated by radio

signals (Table 2). Frodo was also located during this time, though it had been seven days since the signal was last heard. Over the next five days only one of the three birds was heard (Sea Jay). Between 13 June and 17 June, Frodo and Lucky were located offshore. Finally was caught on 15 June and tracked for three consecutive days. No signals were heard from any of the birds after 17 June. Observations of groups of murrelets during censusing indicate the birds may congregate at available food resources. These four and five day periods in which at least three of the birds could be located may indicate the birds were moving in and out of our tracking range in search of food.

Antennae configuration appears to be an important factor in the ability to track the birds on the ocean from shore. Topography in the area available for tracking stations was limited. Only two of our approximately 15 stations were greater than 10 m elevation. The remaining stations were positioned on low sand dunes and man-made structures. The 2-element Yagi "H" antennae used early in the study did not pick up signals heard with a 3-element Yagi at the same station and time. Using the 3-element antennae mounted on a 4 m telescoping pole, with seas of approximately 1.7 m, we were able to locate a signal from a 9.6 km segment of dune. It was not known if the bird was moving during this period, nor was it possible to determine the bird's distance offshore.

Before each airplane flight a transmitter was placed on the ground at the airport. Maximum distance for receiving the signal ranged from 3 to 6.5 km. On one occasion (during high pressure conditions) the signal could be located for 13 km. One bird, located offshore using the airplane, was tracked from varied heights in concentric circles. Fog ceiling was at 1800 m. The signal could be heard for a maximum of 0.8 km at 4800 ft. elevation. The relatively short distance at which a signal can be heard over water requires grid patterns over water to be no more than 1.6 km apart.

PLANNED FURTHER WORK

We felt that the ability of murrelets to avoid the boat, coupled with apparent lack of breeding this year, greatly hampered our efforts. We plan to continue this work during the 1991 breeding season. We also plan to involve Daniel Varoujean of the University of Oregon, who has had good experience using a net gun for capture. We feel that this will maximize the possibility of success.

The results would allow us to determine between several alternatives, assuming sufficient number of birds are captured and followed inland. We could determine if small (<100 acres) or residual stands are being used at all. If they are not, then small stands would be unimportant to the murrelet. If large stands are not being used preferentially, then the birds do not need large stands for successful nesting. This method is the only one which will give land managers the ability to know actual nesting habitat requirements of the species. Results should be applicable to areas outside of specific timber harvest areas.

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Table 1. Summary of 1990 capture effort offshore from and inside of Humboldt Bay and offshore of Crescent City using 13 foot inflatable and 17 foot tri-hull boats and a net gun.

Date	Boat[1]	Time	Hours[2]	No. of Shots	No. of Captures	Capture Location
15 May	Z	0800-1800	10.0	~3	0	
16 May	Z	0600-1200	6.0	~3	0	
	BW	1800-2100	3.0	~3	0	
17 May	Z	0900-1200	3.0	~3	0	
	BW	1800-2145	3.75	2	0	
18 May	Z	0600-1100	5.0	~3	0	
	Z	1700-2100	4.0	~3	0	
	BW	0600-1100	5.0	3	0	
19 May	Z	0700-1400	7.0	~3	0	
21 May	BW	0830-1100	2.5	1	0	
23 May	Z	0930-1300	3.5	~3	1	300 m offshore of so. jetty
	Z	1700-2045	3.75	~3	0	
25 May	Z	1000-1400	4.0	3	0	
	Z	1600-2030	4.5	10	0	
27 May	Z	1300-1630	3.5	1	0	
28 May	Z	1630-1930	3.0	3	0	
1 June	Z	1015-1345	3.5	3	0	
2 June	Z	0900-1100	2.0	0	0	
4 June	Z	0800-1130	3.5	3	1	1 km so. of so. jetty 1 km offshore
	BW	0700-1200	5.0	8	0	
5 June	Z	0800-1230	2.5	5	1	500 m no. of no. jetty 300 m offshore
	BW	0600-0700	1.0	3	0	
7 June	Z	0720-1045	3.25	0	0	
	Z	1930-2100	1.5	3	0	
8 June	Z	0715-1200	4.75	9	0	
9 June	Z	0830-1400	5.5	~3	0	
11 June	Z	0700-1130	4.5	4	0	
12 June	Z	0700-1015	3.25	0	0	
	Z	1115-1145	0.5	0	0	
	BW	0700-1045	3.75	3	0	
13 June	Z	0700-1100	3.0	8	0	
14 June	Z	0900-1000	1.0	3	0	
	Z	1200-1400	2.0	4	0	
15 June	Z	0745-1045	3.0	8	1	In Humboldt Bay, east of no. jetty
	Z	1145-1515	3.5	3	0	
16 June	Z	0745-1200	4.25	3	0	
20 June	Z	0700-0900	2.0	2	0	
21 June	Z	0645-1045	4.0	5	0	
22 June	Z	0700-0930	2.5	2	0	
23 June	Z	0945-1300	3.25	2	0	
	Z	1400-1615	2.25	2	0	
26 June	Z	0730-0830	1.0	0	0	
	BW	2030-2330	3.0	Spot-lighting		
28 June	BW	0900-1315	4.25	10	0	
	BW	2000-0100	5.0	Spot-lighting		
3 July	BW	2000-0200	6.0	Spot-lighting		
5 July	BW	2000-2400	4.0	Spot-lighting		
6 July	BW	1930-2430	5.0	Spot-lighting		Crescent City[3]
10 July	BW	2030-2400	3.5	Spot-lighting		Crescent City

11 July	Z	1200-1600	4.0	0	0	Crescent City
	BW	1830-2130	3.0	Spot-lighting		Crescent City
	BW	2400-0300	3.0	Spot-lighting		Crescent City
12 July	Z	1900-2030	2.5	0	0	Crescent City
13 July	BW	2100-2400	3.0	Spot-lighting		Crescent City
14 July	BW	2400-0100	1.0	Spot-lighting		Crescent City
26 July	BW	0100-0500	4.0	Spot-lighting		Crescent City
	BW	1800-2000	2.0	Spot-lighting		Crescent City

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[1] Z = Zodiac, 13 foot inflatable, BW = Boston Whaler, 17 foot tri-hull

[2] Each capture trip includes approximately 20 minutes of travel to and from potential capture areas.

[3] Capture effort in Crescent City

Table 2. Results of tracking radio-tagged Marbled Murrelets caught in Humboldt Bay and offshore of Humboldt County, California, using a net gun from May through July 1990.

Date	Tracking time	Tracking area	Results: Frequency	Bird location	Time located
23 May	1400-1500	Humb. Bay	**159.380**[1]	Humb. Bay, no. of PG&E	1400
	1600-1904	Samoa Pen.	159.380	Humb. Bay, no. of PG&E	1600
	1930-2130	So. Spit[2]	No response		
24 May	1500-1710	So. Spit	No response		
	1745-2030	Samoa Pen.	159.380	Offshore of Samoa Peninsula	1815
25 May	1730-2130	Samoa Pen.	No response		
26 May	0640-0804	Samoa Pen.	159.380	Offshore of Samoa Peninsula	0640
	1800-2130	Samoa Pen.	No response		
27 May	0530-0830	Samoa Pen.	No response		
	1815-2035	So. Spit	159.380	Offshore of So. Spit	1845
	1400-1720	Samoa Pen.	No response		
28 May	0510-0855	So. Spit	No response		
	1830-2140	Samoa Pen.	No response		
29 May	0800-0925	Samoa Pen.	No response		
	1745-2135	Samoa Pen.	No response		
30 May	0940-1200	Samoa Pen.	159.380	Offshore of Samoa Peninsula	0940
	0518-1038	So. Spit	No response		
	1645-2048	So. Spit	No response		
31 May	1040-1145	Samoa Pen.	No response		
1 June	0450-0746	Samoa Pen.	No response		
	0812-1055	So. Spit	No response		
4 June	0520-2030	Samoa Pen.	**160.321**	Offshore of Samoa Peninsula	1755
	0742-0846	So. Spit	No response		
5 June	0458-0652	Samoa Pen.	160.321	Humb. Bay, no. of PG&E	0556
	1648-1952	Samoa Pen.	**160.336**	Humb. Bay, no. of PG&E	1706
	2059-2141	So. Spit	160.336	Offshore of Samoa Peninsula	2107
6 June	0450-0635	Samoa Pen.	159.380	Humb. Bay, no. of PG&E	0455
			160.336	Offshore of Samoa Peninsula	0555
7 June	0450-0931	Samoa Pen.	159.380	Offshore of Samoa Peninsula	0600
			160.321	Offshore of So. Spit	0826
8 June	0458-0820	Samoa Pen.	No response		
9 June	0828-1110	Samoa Pen.	No response		
	1900-2100	Samoa Penn.	No response		
10 June	0830-1306	Samoa Pen.	160.336	Offshore of Samoa Peninsula	0906
11 June	1150-1330	Airplane	No response		
		Inland: Elk River drainage, Lawrence Cr., Salmon Cr. grid Mattole River, mouth to 5.0 mi inland			
		Offshore: Big Lagoon to Cape Mendocino, 1.0 mi and 0.5 mi offshore			
12 June	1735-1920	So. Spit	No response		
13 June	0730-1030	Airplane	159.380	Offshore of Centerville	0830
		Inland: Elk River drainage, Lawrence Cr., Salmon Cr. grid Grizzly Crk. grid, SW of Scotia			
		Offshore: Samoa to Bear River, 1.0 and 0.5 mi offshore			

14 June	0645-0902	Airplane	160.336	Elk River drainage, T4N,R1E,Sec24, not relocated by ground search	0800
		Inland: Elk River drainage, Lawrence Cr., Salmon Cr. grid Bear River, mouth to 6.0 mi inland Eel River from Scotia to Pepperwood			
		Offshore: Mad River to Bear River, 1.0 and 0.5 mi offshore			
	1750-2009	Samoa Pen.	No response		
15 June	0710-0955	Samoa Pen.	160.321	Offshore of Samoa Peninsula	0955
	0830-1020	So. Spit	No response		
	1700-2030	Samoa Pen.	159.542	Offshore, just so. of south jetty	1700
16 June	0747-1120	So. Spit	160.321	Offshore of So. Spit	0851
			159.542	Offshore of Samoa Peninsula	0932
	1215-1557	Samoa Pen.	159.542	Offshore of Samoa Peninsula	1324
			159.380	Offshore of Samoa Peninsula	1433
	1333-1440	Airplane	159.542	300m offshore so. jetty	1333
		Offshore: low fog, jetty area and bay only			
17 June	0900-1135	Samoa Pen.	159.542	Offshore of Samoa Peninsula	1000
18 June	0640-0800	Samoa Pen.	No response		
	0910-1055	So. Spit	No response		
	1846-2034	Samoa Pen.	No response		
19 June	0705-0810	Samoa Pen.	No response		
	0858-1048	So. Spit	No response		
20 June	1515-1715	Airplane	No response		
		Offshore: Pt. St. George to Punta Gorda, 0.5 and 1.5 mi offshore			
23 June	0510-1035	Samoa Pen.	No response		
	1730-2045	So. Spit	No response		
25 June	1010-1145	Samoa Pen.	No response		
	1215-1310	So. Spit	No response		
26 June	0840-1130	Samoa Pen.	No response		
	1300-1440	So. Spit	No response		
5 July	0958-1145	Samoa Pen.	No response		
	1235-1415	So. Spit	No response		
6 July	1530-1755	Samoa Pen.	No response		
	1159-1430	Airplane	No response		
		Inland: Elk River drainage, Grizzly Cr. grid			
		Offshore: Pt. St. George to Punta Gorda, 0.5 and 1.5 mi offshore			
11 July	1150-1350	Samoa Pen.	No response		
	1425-1600	So. Spit	No response		
12 July	0500-0947	Samoa Pen.	No response		
15 July	0745-1058	Samoa Pen.	No response		
	1127-1324	So. Spit	No response		
16 July	1300-1600	Airplane	No response		
		Offshore: Coos Bay, Oregon to Punta Gorda, 0.5 and 1.5 mi offshore			
2 Aug	0848-1145	Samoa Pen.	No response		
	1210-1400	So. Spit	No response		
3 Aug	1058-1150	So. Spit	No response		
	1300-1518	Samoa Pen.	No response		
13 Aug	0805-1035	Samoa Pen.	No response		
	1140-1255	So. Spit	No response		
14 Aug	1822-1947	Samoa Pen.	No response		
	2012-2136	So. Spit	No response		
15 Aug	1243-1531	Samoa Pen.	No response		
	1600-1740	So. Spit	No response		

16 Aug	1280-1510	Samoa Pen.	No response
	1545-1600	So. Spit	No response
17 Aug	0835-1150	So. Spit	No response
18 Aug	0730-0942	Samoa Pen.	No response
	1025-1216	So. Spit	No response

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[1] Bold type indicates first signals heard on the day of capture
[2] So. Spit is the sand spit on the west side of Humboldt Bay which runs from Table Bluff to the south jetty of the bay entrance

Table 3. Summary of Marbled Murrelets captured offshore of Humboldt County and in Humboldt Bay from 15 May to 15 July 1990.

Bird's name	Capture Date	Time	Location	Frequency	Date signal last heard
Frodo	23 May	1300	300 m offshore of south jetty	159.380	16 June
Lucky	4 June	0920	1 km so. of so. jetty 1 km offshore	160.321	16 June
Sea Jay[1]	5 June	0940	500 m no. of no. jetty 300 m offshore	160.336	14 June
Finally	15 June	1035	In Humboldt Bay, east of no. jetty	159.542	17 June

[1]Brood patch on Sea Jay only

Table 4. Summary table of radio-tagged Marbled Murrelets located, from May through June 1990, offshore of Humboldt County, Californa.

			May									June																			
Name	Frequency (mhz)	Date captured	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Frodo	159.380	23 May	Δ	Δ		Δ	Δ			Δ							Δ	Δ						Δ			Δ				
Lucky	160.321	4 June													●	●		●								●	●				
Sea Jay	160.336	5 June														◊	◊				◊				◊[1]						
Finally	159.542	15 June																								‡	‡	‡			

[1] Inland location
No signals heard after 17 June