# MARBLED MURRELET POPULATION MONITORING AT SEA IN CONSERVATION ZONE 4 DURING 2023. RESULTS FROM SOUTHERN OREGON AND NORTHERN CALIFORNIA

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## SUMMARY

Vessel transect surveys of seabirds in Marbled Murrelet Conservation Zones 4 were used to estimate populations of Marbled Murrelets during summer 2023. This is the 24th year of Marbled Murrelet population monitoring as a component of the Northwest Forest Plan (NWFP). Using a stratified-random sampling as designed by the NWFP, 32 Primary Sampling Unit (PSU) density samples were completed in Zone 4 during the summer sampling period. Zone 4 exends from Coos Bay, Oregon to the Humboldt-Mendocino county line, California, In total, 828.7 km of sampling transects were completed within 3 km of shore in the 15 May to 31 July survey period. In this effort, 767 murrelet detections were made comprising 1,340 birds, as well as counts of other seabirds, marine mammals, and vessels.

At sea abundance estimates generated by the NWFP at-sea monitoring group using line transect methods were of 6,562 Marbled Murrelets in Conservation Zone 4, with 95% confidence intervals from 4,042 to 9,082 birds. This estimate was lower than the mean of point estimates in the past 10 years, but well above the long term average since the implementation of the NWFP sampling program. Immigration, dispersal beyond sampled waters, and high inherent variability in the at-sea density of this patchily distributed species remain as uncertainties in assessing a long term trend in murrelet abundance for this region.

Marbled Murrelet distribution was comparable with other years, with peak densities occurring along sandy beaches offshore from Redwood National and State Parks. Productivity indices were slightly below average. There was indication of a late but strong spring transition in the northern California Current, and other seabirds in Zone 4 showed evidence of late but average nesting success. Bald Eagles impacted Common Murres at Castle Rock National Wildlife Refuge.

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## DISCLAIMER

The interpretation of data presented in this report are the product of Crescent Coastal Research and do not necessarily represent the views of the U.S. Fish and Wildlife Service, the U.S. Forest Service, the Northwest Forest Plan effectiveness monitoring group, or other government agencies.

## INTRODUCTION

### *Background*

The Marbled Murrelet (*Brachyramphus marmoratus*, hereafter murrelet) is a small diving seabird in the Alcid family which is on the Federally Threatened Species list, and is state listed as endangered in California. Marbled Murrelets have adapted to nesting on large branches high in old growth forests, and it is this unique nesting habitat that led to their decline and federal listing when most of the forests on the west coast were cut for timber in the latter 1800's and 1900's (Marshall 1988, Nelson 1977). As a component of the Northwest Forest Plan (NWFP; initiated by the Clinton administration in 1994), Murrelet abundance monitoring has been completed since 2000 as a means of testing the effectiveness of the NWFP in conserving remaining old-growth forest habitat on federal lands and maintaining populations of murrelets (Madsen et al. 1999, Miller et al. 2006). Because murrelet nests are disperse and difficult to locate high in trees of mature coastal forests, research on overall abundance is conducted at sea, where the birds are more easily seen and concentrated within a few km of shore on the open coast (Ralph and Miller 1995, Strong 2019). Murrelet population monitoring is structured using the Conservation Zones identified in the Marbled Murrelet Recovery Plan (USFWS 1997). The Effectiveness Monitoring component of the NWFP produced evidence of population decline from 2000 to 2010 throughout the 3 state region, with the greatest decline occurring in Washington (Miller et al. 2012). More recent estimates have indicated continuing decline in Washington, but with evidence of increase to the south (McIver et al. 2023), making it difficult to define an overall population trend during this century (Falxa et al. 2016, McIver et al. 2021). Surveys were completed in Zones 1 through 4 annually since 2000, but in 2014 the program has cut back to surveys of each Zone in alternating years; Zone 4 was not surveyed in 2014, 2016, 2018, or 2020.

Zone 4 extends from Coos Bay, Oregon, to the Mendocino County border, California (near Shelter Cove). This region is quite heterogeneous both geographically and oceanographically, and includes two major upwelling centers off Cape Blanco, Oregon, and Cape Mendocino, California. The majority of high quality nesting habitat for murrelets is contained in state and national parks in the middle of the Zone, though patches of old growth forest habitat exist in southern Oregon and along the Eel River in California (Lorenz et al. 2021).

Crescent Coastal Research (CCR) has contributed to population monitoring in the Oregon portion of Conservation Zone 4 since 1992, before the inception of standardized NWFP monitoring in 2000, and has completed all population monitoring in this Zone since 2010. Redwood Sciences Laboratories (U.S.Forest Service, PSW Station, Arcata) completed earlier NWFP surveys (years 2000-2009) of the rest of Zone 4 in coordination with CCR.

This report summarizes the 2023 survey results for this region, and compares distribution and abundance patterns of Marbled Murrelets with prior years. Also included here are data summaries for some other nesting seabirds and assessments of marine conditions for seabirds during 2023. Depredation on Common Murres at Castle Rock National Wildlife Area is also described.

## METHODS

### *Vessel Survey Methods*

Vessel surveys were made from a 21 foot Boston Whaler 'revenge' fitted with a Global Positioning System receiver (GPS), and sonar depth finder, which also relayed sea surface temperature (SST). Other equipment included binoculars, and digital micro recorders for each observer, maps covering planned transect lines, and a laser range finder. The deck of the boat is level with the waterline; so standing observer viewing height was about 1.8 m above water. The GPS was loaded with the randomly selected transect routes prior to each survey.

Two observers and a vessel driver were on board for all transects. Each observer scanned a 90$^{o}$ arc between the bow and the beam continuously, using binoculars only to confirm identification or to observe plumage or behavior of murrelets. Search effort was directed primarily towards the bow quarters and within 100m of the vessel, so that density estimates based on distance sampling from line transects would be at their most accurate (Buckland et al. 1993). Observers stood side by side and verbally checked each other that all detections were recorded and none were duplicated. All Marbled Murrelet detections were recorded with information on group size, side of vessel, estimated perpendicular distance from the transect line, behavior, and age. All seabirds within 50 m of the transect line and on the water were recorded (ie; using strip transect methods). Flying birds other than murrelets were not recorded except for the aerial foragers (pelicans, terns, Osprey). Marine mammals and boats were recorded using line transect methods, with an approximate 1.2 km truncation distance in reporting boats. Observer distance estimates were checked weekly and calibrated by running 5 to 30 replicates of estimated distance to small floating targets while running at low speed in calm waters near the launch port. Observers would estimate the perpendicular distance from the transect line to the target, and then the 'true' distance was measured with the lazer rangefinder when perpendicular to the target. If any observer estimates differed from laser readings by over 15% for any of 5 trials, the exercise was repeated until adequate precision was obtained. Weather, depth, SST were recorded on each survey segment. Observing conditions were quantified into 5 categories based on estimates of swell height and period, wind force and direction, Beaufort sea state, percent of obscuring glare, and visibility restriction due to fog or reflection from shore. Data were recorded on digital recorders and later transcribed to data forms and entered on computer using DBase software.

The vessel driver maintained a speed of 10 knots (11 knots in excellent conditions, and down to 6 knots in compromised conditions or at high bird densities), followed the transect route, and watched for navigational hazards. The driver participated in searching for murrelets when not otherwise occupied. Detections made by the driver that would otherwise have been missed by observers were noted as 'driver detection'. Transects were paused sometimes to rest, make observations, or for equipment reasons, and resumed at the same location where they left off. A break from duties was taken at least every 3 hours. Observers and driver rotated positions between subunits of each PSU (see below) and between PSU samples when more than one sample was done in one day.

### *Personnel*

The field team was led by Craig Strong, with primary crew members Darell Warnock and Kelly DeForest through the first half of the season. Kelly had proven her exceptional observer and murrelet detection skills in 2022 in Zone 3, and Darell has been on the CCR murrelet survey team for over two decades and is familiar with all aspects of the field work as well as being an excellent observer, boat operator, and photographer. Kelly's replacement took another job at the

last minute, and so Darell and Craig completed the remainder of the season with experienced local observers Rob Fowler, Teresa Bird and Deborah Jaques. When a third observer was not available, we got vessel driving assistance from Jeff Jacobsen, Dawn Barlow, Mark Marks, Alexandra Cook, and Joseph Godla (1 day each for these drivers).

Darell, and Deborah participated in survey training in mid-May, which included discussion of all methodological details, distance estimation trials, on-water practice in observing birds and conducting trial surveys. Teresa and Rob Fowler did not attend training, but each had over 10 days experience over 2 + prior years on the crew. Drivers Jeff, Dawn, and Mark had prior experience driving surveys; Alex and Joey were new but performed adequately.

***Sampling Design***

A thorough description of the population monitoring sampling design can be found in Raphael et al. (2007). In short, the coast was divided into 20 km long Primary Sampling Units (PSU, see Figures 1 and 2) and a transect was conducted through each PSU following a randomized transect route between 400 and 3,000 m out to sea. Each PSU sample included an inshore subunit made up of four 5 km long transect segments running parallel with the coast at 4 randomly-selected distances from shore, and an offshore subunit where transects were conducted on a diagonal relative to shore from the inshore 2,000 m boundary out to 3,000 m, with a randomized starting point. A PSU density sample consisted of approximately 20 km of transect effort in the inshore subunit and 6 km of transect effort in the offshore subunit (based on the lower density of murrelets in the offshore, see Bentivoglio et al. 2002). The outer boundary of sampled waters and the inshore/offshore subunit boundary for Zones 4 were designated by C.J. Ralph and Sherri Miller of the USFS Redwood Sciences Laboratories at the inception of the NWFP sampling implementation in 2000 (Bentivoglio et al. 2002).

Strata within Zones were designated as regions with distinctly different murrelet abundance, and low abundance strata received less sampling effort in the overall design (Raphael et al. 2007). In Zone 4 the higher abundance stratum 1 runs from Coos Bay to Patrick's Point (now Sue Meg Point, PSU 1 – 14), and Stratum 2 extends from Sue Meg Point to the Mendocino county line south of Shelter Cove (see Fig. 1).

The goal in population monitoring under the NWFP is to complete 30 PSU samples within each Conservation Zone during the middle of the Marbled Murrelet nesting season, between 15 May and 31 July (Hamer and Nelson 1995, Raphael et al. 2007). More sampling in any Zone is desirable for improved accuracy and higher precision, but budgetary and logistic constraints have limited sampling to the present program goals.

***Other Seabird Observations***

Data on all other species and on murrelet productivity that were collected during transects are contained in Crescent Coastal Research databases. Castle Rock National Wildlife Refuge in Del Norte County ($41.75692^0$ N, $124.2397^0$ W) was visited from shore in early morning hours on 20 occasions between April and August 2023, where observations were made with a spotting scope from the road or from the point closest to the island (1 km away). Counts of Pelagic Cormorant (*Phalacrocorax pelagicus*) nests on Castle Rock National Wildlife Refuge (NWR) were made by boat circumnavigating the island in calm conditions on 9 July and on 3 August 2023. Pelagic Cormorant productivity data were collected at two subcolony locations in Del Norte County using methods adapted from the Alaska Maritime National Wildlife Refuge's Wildlife Inventory Plan (see Strong 2020). The Tolowa Rock colony is located at the south end of Pebble Beach in

Crescent City at 41.75671$^{o}$ N, 124.22144$^{o}$ W, and the Hunter Island colony is located 500 m north of the Smith River mouth at 41.95423$^{o}$ N, 124.20839$^{o}$ W.

### *Analysis*

Population estimates for strata and Zones were generated by Jim Baldwin (USFS, PSW Research Sta., NWFP at-sea working group, retired) using line transect distance sampling analysis with each PSU as a density sample (replicate samples of a PSU were averaged). Annual murrelet densities at the PSU and subunit level were also provided in the R statistical program that Jim developed. Further analysis details for the NWFP population monitoring effort are contained in Raphael et al. (2007).

## RESULTS

### *Effort*

We attempted at-sea sampling surveys on 21 days in Zone 4 during the 15 May to 31 July study season, and were successful in completing surveys each day (Tables 1 and 2). This high success rate was due to a cautious approach and to better short term computer forecast models than were available in the past.

In Zone 4 we completed 32 PSU sampling surveys which included 857.3 km of transects (Table 1). Sampling was distributed through time and geographically, but with gaps in sampling in early June and for two weeks at the end of June - early July due to northwest windy conditions (Table 1). There was a persistent 'wind shadow' in the middle of the Zone (PSU 9 – 14) which allowed for sampling there when other areas were blown out. Most sampling effort was in Stratum 1 where most of the murrelets occur (Table 1, Fig. 1). We waited for an opportunity to sample the southern 4 PSU in one trip, but due to nearly continuous wind >Beaufort 2 throughout the season around Cape Mendocino (PSU 19 and 20) this was not possible, and by the time we prioritized sampling PSU 21 and 22 along 'lost coast' area at the south end of the Zone in July, winds never abated enough to attempt this. Thus the southern 4 PSU were never sampled in 2023 (Table 1).

### *NWFP Population Estimates and Trend*

The population estimate for Zone 4 in 2023 was of 6,562 birds, with 95% confidence intervals from 4,024 to 9,082 birds (Table 2). The 2023 estimate was above the mean for the entire NWFP sampling since 2000, but close to average since 2013 (data in Table 3). The mean group size in 2023 was comparable to other years, and this parameter has shown little variability across years (Table 2). The detection rate (number of groups seen per km of transect) has generally been the main driver of population estimates.

An adjustment to these summary statistics was made to account for the missing data from the 4 southernmost PSU in 2023. Simply put, the mean density of those PSU from prior years in which all 4 PSU were sampled (years 2012, 2013, 2015, 2017, 2019, and 2021) was used in the 2023 estimate. This essentially made for a separate substratum of Stratum 2, and the two substrata pieces were added (and weighted by area) to obtain a stratum 2 estimate. This was necessary because the unsampled PSU at the south end have consistently had very few murrelet detections (see Fig. 1) and samples from farther north in Stratum 2 (PSU 15 – 18) are not representative of the southern area. Using this technique, the northern substrata contributed 637 birds and the southern substrata contributed 150 birds to the Stratum estimate of 787 birds seen in Table 2.

There has been an overall increasing trend in Zone 4 murrelet abundance at sea over time, but examination of the annual estimates show that it has not been linear (Fig. 2). No clear trend in population was seen from 2000 to 2010 in Zone 4 (Miller et al. 2012, Fig. 2), but estimates in 2015, 2017, and 2019 were much higher and gave a positive linear trend (Table 2, Fig. 2). The 2023 estimate was close to the mean since 2013 (6,976 birds) but considerably higher than in the first decade of this monitoring program.

***Distribution along the Coast***

While on population sampling transects, we had 767 murrelet detections in Zone 4 (Table 1), in which a total of 1,340 murrelets were counted. Murrelet distribution was similar to prior years from a large scale, regional perspective as shown in Figure 1. The area offshore from the Redwood National and State Parks (PSU 10 - 14) has usually held the highest numbers of murrelets, and this was again the case in 2023. Specifically, PSU 13 and 14 from Redwood Creek to Su Meg Point have held the highest densities in the past, and this year both PSU were well above the long term average. PSU samples in Oregon and in the sampled portion of Stratum 2 were generally at or below average densities (Fig. 1), thus the high estimate of this year was largely driven by samples from PSU 13 and 14. The unsampled waters around Cape Mendocino and along the Lost Coast have had zero to very low densities in the past (except for the anomalous immigration event in 2017, Strong 2018).

***Distribution Relative to Shore***

Murrelets are a very near-shore species, although there is geographic variation in this (exemplified in Table 3 and in Strong 2022). In 2023 the center of peak abundance was shifted offshore relative to prior years, with highest detection rates occurring between 1 and 1.8 km from shore (Table 3), whereas it is typically 0.6 to 0.9 km (Fig. 3). This observation does not show up by comparing densities in the near-shore and offshore subunits of the PSU since the subunit boundary is at 2 km offshore,

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PSU 10, just within the California border, had many murrelets at 3 km out on our offshore subunit sample on 21 July. In |Zone 4, murrelet detections out to the limit of sampled waters has occurred often in prior years for any of the PSU from 9 to 15.

***Seabird Productivity***

In 2023 we recorded the first murrelet fledgling on 9 July. While on PSU sampling transects a total of 11 fledgling (HY) Marbled Murrelets were seen in Zone 4, and 2 more were noted while off transect in PSU 9 (1) and 1 (2). Using all aged murrelet data from transects after 10 July as an index of productivity, the ratio of HY to AHY was 11:312 (0.0353), or 3.4% HY. This is an indication of average productivity for the murrelet, slightly below the long term mean (Table 4).

The detection rate of HY at sea independent of adult numbers serves as a second index of productivity that is not reliant on the assumption of equal distribution between HY and older birds. HY detections per km for Common Murres (*Uria aalge*) were average in Zone 4 during July 2023, and slightly below average for murrelets (Table 4). However, due to the late nesting season, many murres had not yet fledged by the end of July (pers. obs. and see below), so the indices of Table 4 are likely an underestimate of murre productivity. We do not know the chronology of murrelet productivity, and this program was not designed to sample murrelet productivity, so the indices are only a relative indicator.

Nesting seabirds in general had average to good but very late nesting success through Zone 4. This assessment was based on observations of 'full' Common Murre colonies at Castle Rock NWR (but see eagle notes below). Brandt's Cormorant (*Phalacrocorax penicillatus*) colonies expanded to the largest size recorded on Castle Rock, and most appeared to fledge 2 or more chicks in late July and August. Aerial photographic data are collected by the USFWS' San Francisco Bay NWR in early June at Castle Rock NWR which may verify this statement, but the images are not yet counted for murre and cormorant numbers (G. McChesney pers. comm.).

Pelagic Cormorants had variable but overall average productivity at 3 colonies in Del Norte County, northern California in 2023 (Table 5). The Castle Rock nest count of 188 productive nests on 9 July was above average, and likely a good representation of maximum numbers of nest attempts in this late season. A count in similar calm conditions on 3 August was of 170 productive nests on Castle Rock NWR, indicating some nest failures before fledging.

***Bald Eagle depredation on Common Murres***

Common Murre colonies on Castle Rock NWR were impacted by Bald Eagle (*Haliaeetus leucocephalus*) predation in April, May, and June, with up to 5 eagles on the island in April and May (2 adults and 3 immatures). Essentially all eagle activity was seen in the morning hours, mostly very early. Where eagles were at various locations early in the season, they seemed to occur less frequently on the island in June and were not seen in July. Witnessed predation events (5) were concentrated at one sub-colony of murres on the northwest side of the island. In spite of persistent eagle presence, murres attended all subcolonies, and some were incubating by the end of May (as evidenced by Western Gulls and Ravens eating eggs from murres displaced by the eagles). Murres had lower attendance at the most affected sub-colony, and fledged chicks later than other parts of the island, but they still did fledge some chicks.

Eagle presence at Common Murre colonies was also noted at other Zone 4 colonies; False Klamath rock ($41^0$ 35' 42"N.) and Flatiron Rock ( $41^0$ 04' 36" N).

***Oceanographic conditions and seabirds***

A review of Sea Surface Temperature (SST) anomaly images in https://www.nnvl.noaa.gov/view/globaldata.html show the California Current System in the Zones 4 region to have had cool SST anomaly values from January to May 2023, but without strong northwest winds (https://www.ndbc.noaa.gov/station_history.php?station=46027) or significant upwelling (https://www.cencoos.org/cuti-and-beuti-upwelling-indices-post). Then on 20 May a strong bout of northwesterlies caused a major upwelling event (Fig. 5), which marked a very late but distinct spring transition. Seabirds at Castle Rock NWR responded with a surge of nesting activity. Forage fish shoaling at the surface were a common sight through the season. Large silver fish were the most common fish held by Common Murres, and were tentatively identified as adult herring (*Clupea harangus*).

There were few sightings of unusual biota during surveys, other than a thresher shark eating juvenile herring on 9 July. More notable was the nearly complete lack of phalaropes or Shearwaters through the season (Table 6). Cassin's Auklets were also entirely absent in our observations until late July, and then were super-abundant on our last survey south of Bandon (Table 6).

## DISCUSSION

### *Population Estimates and Distribution*

The Zone 4 Marbled Murrelet population estimate of 6,560 birds in the region in 2023 was close to average for the past 10 years of sampling, but well above average for the 23 year span since 2000 (5,283 birds). Distribution beyond the sampled waters remains a problem in our certainty of Zone 4 estimates, since distribution beyond the 3 km outer limit is evident in certain PSU samples in most years Strong (2011, 2013a, 2022, Table 3, Fig. 3). Samples with murrelet detections to the 3 km limit of sampling have occurred in the areas of higher abundance, from Brookings to Patrick's Point (PSU 9 – 14), where the bathymetry is shallower and murrelets distribute farther offshore.

The seaward distribution shift in abundance to farther offshore as shown in and Fig. 3 was notable throughout the season while on survey. One interpretation of this is that osmerid smelt species were not available in the very near-shore this year, and murrelets were instead targeting juvenile herring or other prey not associated with the near surf zone. Herring (*Clupea harengus*) appeared to be in great abundance in 2023 judging from the frequent sightings of murres holding adult herring. Adult herring are beyond the size range for easy consumption by murrelets.

The 4 missing samples at the south end of Stratum 2 in Zone 4 presented special consideration in developing the Stratum point estimate, since this situation had not been encountered in any prior years. Because murrelet density in these 4 PSU have been extremely low in the past, it was not justifiable to apply the densities of northern Stratum 2 to the missing area. The solution of using the mean of prior surveys was clearly the best alternative, as discussed in the at-sea working group meetings in fall 2023.

Where Zone 4 has had variable but increasing estimates over the NWFP sampling period, Zones 1 and particularly 2 have shown a consistent declining trend (McIver et al. 2021, Pearson et al. 2023). Thus it is tempting to suggest that there has been a shift in at-sea abundance to the south withing the NWFP area. Nesting habitat has decreased slightly in Washington and possibly increased slightly in Oregon and California (Lorenz et al. 2021), but not to the extent that at sea abundance has changed. Additional years of data may shed some light on these trends.

### *Seabird and Marine Productivity*

Marbled Murrelets and Common Murres both had near average measures of productivity in 2021 (Table 5). This corresponds with other indicators of average to above average marine productivity for seabirds in Zone 4.

Because murrelet fledgling detections at-sea are a rare event (zero to 16 per year, Table 5), simple stochastic events of where and when sampling occurs can have a large effect on chances of detection and overall numbers of fledglings detected. The NWFP sampling effort was not designed to estimated productivity As described by Kuletz and Piatt (1999) and Strong (2013b), HY murrelets tend to be detected in certain areas which have habitat characteristics in common. Our 2023 results supported those earlier findings in that HY detections were concentrated in PSU 1 south of Cape Arago. and PSU 9 from south of the Chetco River to the California border. These areas have a complex mix of sand and reef, and have some wind protection (Strong 2013b).

## CITED REFERENCES


Bentivoglio, N., J. Baldwin, P.G.R. Jodice, D. Evans-Mack, T. Max, S. Miller, A,K, Nelson, K. Ostrom, C.J. Ralph, M. Raphael, C.S. Strong, T. Thompson, and R. Wilk. Northwest Forest Plan Marbled Murrelet Effectiveness Monitoring: 2000 Annual report. USFWS unpublished report, Portland Oregon. 73 p. https://www.fs.fed.us/r6/reo/monitoring/marbled-murrelet.php (archived)

Buckland, S.T., D.R. Anderson, K.P. Burnham, and J.L. Laake. 1993. Distance sampling, estimating abundance of biological populations. Chapman Hall, New York. 446 pp.

Carter, H,.R., J.G. McChesney, D.L. Jaques. C.S. Strong, M.W. Parker, J.E. Takekawa, D.J. Jory, and D.L. Whitworth. 1992. Breeding populations of seabirds in California, 1989-1991. Vol. 1: population estimates. USDI Interagency agreement no. 14-12-001-30456. 501 p.

Falxa, G.A.; Raphael, M.G., technical editors. 2016. Northwest Forest Plan—The first 20 years (1994-2013): status and trend of marbled murrelet populations and nesting habitat. Gen. Tech. Rep. PNW-GTR-933. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 132 p.

Hamer, T.E. and S.K. Nelson. 1995. Nesting chronology of the Marbled Murrelet. In: C. J. Ralph, G. L. Hunt, Jr., J. F. Piatt, and M. G. Raphael (eds.), Ecology and conservation of the marbled murrelet in North America: an interagency scientific evaluation. USDA Forest Service. PSW- GTR-152. p 49-56.

Jaques, D.L. and C.S. Strong. 2001. Seabird status at Castle Rock National Wildlife Refuge 1997-1999. Unpub. Report to the Humboldt Bay NWR, Loleta, CA. 37 p.

Kuletz, K.J, and J.F. Piatt. 1999. Juvenile Marbled Murrelet nurseries and the Productivity Index. Wilson Bull. 111:257-261.

Lorenz, T.J., M.G. Raphael, R.D. Young, D. Lynch, S.K. Nelson, and W.R. McIver. 2021. Status and trend of nesting habitat for the Marbled Murrelet under the Northwest Forest Plan, 1993 to 2017. USDA, Forest Service. General Technical Report PNW-GTR-998. Pacific Northwest Research Station. Portland, OR. 64 p.

Madsen, S., D. Evans-Mack, T. Hamer, P. Henson, S. Miller, S.K. Nelson, D. Roby, and M. Stapanian. 1999. Marbled Murrelet effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-439. Portland, OR. USDA, Forest Service, Pacific Northwest Res. Sta. 51 p. https://www.fs.fed.us/r6/reo/monitoring/marbled-murrelet.php.

Marshall, D.B. 1988. Status of the Marbled Murrelet in North America with special emphasis on populations in California, Oregon, and Washington. Audubon Society of Portland. 42 p

McIver, W.R., S.F. Pearson, C.S. Strong, M.M. Lance, J. Baldwin, D. Lynch, M.G. Raphael, R.D. Young, N. Johnson. 2021. Status and trend of Marbled Murrelet populations in the Northwest Forest Plan Area, 2000 to 2018. Gen. Tech. Rep. PNW-GTR-996. Portland, Oregon. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 88 p. https://www.fs.fed.us/r6/reo/monitoring/marbled-murrelet.php

McIver, W.R., J. Baldwin, M.M. Lance, S.F Pearson, C. Strong, M.G. Raphael, A. Duarte, K Fitzgerald. 2023. Marbled murrelet effectiveness monitoring, Northwest Forest Plan: At-sea Monitoring - 2022 summary report. 25 p.

Miller, S.L; C.J Ralph, M.G. Raphael, C Strong, C.W. Thompson, J. Baldwin, M.H. Huff, and G.A. Falxa, 2006. At-sea monitoring of marbled murrelet population status and trend in the Northwest Forest Plan area. In: M.H. Huff et al., tech. coords. Northwest Forest Plan—The first 10 years (1994-2003): status and trends of populations and nesting habitat for the marbled murrelet. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: US. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 31-60, Chapter 3.

Miller, S.L., M.G. Raphael, G.A. Falxa, C. Strong, J. Baldwin, T. Bloxton, B.M. Gallagher, M. Lance, D. Lynch, S.F. Pearson, C.J. Ralph, and R.D. Young. 2012. Recent Population decline the Marbled Murrelet in the Pacific Northwest. Condor 114: 771-781. https://www.fs.fed.us/r6/reo/monitoring/marbled-murrelet.php

Nelson, S.K. 1997. Marbled Murrelet. In Poole, A. and F. Gill (eds.) The birds of North America, no. 276. The Birds of North America. Philadelphia, PA. 32 p.

Pearson, S.F., M.M. Lance, K. Beach, K. Saksa, S. Tanedo, and J. Winn. 2023. Washington 2023 at-sea marbled murrelet population monitoring: Research Progress Report. Washington Department of Fish and Wildlife, Wildlife Science Division, Olympia, Washington. 11 p.

Ralph, C.J. and S.L. Miller. 1995. Offshore population estimates of Marbled Murrelets in California. In: C. J. Ralph, G. L. Hunt, Jr., J. F. Piatt, and M. G. Raphael (eds.), Ecology and conservation of the marbled murrelet in North America: an interagency scientific evaluation. USDA Forest Service. PSW-GTR-152. p 353-360.

Raphael, M.G., J. Baldwin, G.A. Falxa, M.H. Huff, M. Lance, S.L. Miller, S.F. Pearson, C.J. Ralph, C. Strong, and C. Thompson. 2007. Regional population monitoring of the marbled murrelet: field and analytical methods. Gen. Tech. Rep. PNW-GTR-716. Portland, OR. U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p.

Strong, C.S. 2011. Population monitoring and productivity estimates of Marbled Murrelets in Conservation Zones 3 and 4 during 2010. Unpub. Report to the U.S. Fish & Wildlife Service under coop. agreements 13420-9-J901 and 81331-9-J249. 18 p.

Strong C.S. 2013a. Marbled Murrelet population monitoring in Oregon and California during 2012. Annual report to the U.S. Fish and Wildlife Service, cooperative agreements F12AC00446 and F09AC00496. 260 Hazeltime Rd. Cresent City, CA 95531. 15 p.

Strong, C.S. 2013b. Marine micro-habitat use by fledgling and older Marbled Murrelets in Oregon and northern California coastal waters: Where are the kids?. Pacific Seabird Group 40th annual meeting, Portland, OR. Abstract.

Strong, C.S. 2020. Marbled murrelet population monitoring at sea in conservation zone 4 during 2019: Results from southern Oregon and northern California. Annual report to the U.S. Fish and Wildlife Service, cooperative agreements F16AC00554 and F18AC00326. 260 Hazeltime Rd. Cresent City, CA 95531. 26 p.

Strong, C.S. 2022. Marbled murrelet population monitoring at sea in conservation zones 4 and 5 during 2021: Results from southern Oregon and northern California. Unpub. report to the U.S. Fish and Wildlife Service under Cooperative Agreements no F16AC00554 and F20AC00148. 25 p.

U.S. Fish and Wildlife Service. 1997. Recovery plan for the threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, OR. 203 p.

Table 1. A summary of survey effort and number of Marbled Murrelet groups detected in the inshore and offshore subunits of each PSU sample of Conservation Zone 4 during 2023. In parentheses are the number of HY (fledglings) seen.

| | | Inshore subunit | | Offshore subunit | | Observing condition codes: |
|---|---|---|---|---|---|---|
| Month | | | Murrelet | | Murrelet | E=excellent, VG=very good, G=good, F=fair, P=poor |
| Day | | Effort (km.) | Detections | Effort (km.) | Detections | Notes |
| **May** | | | | | | |
| 15, 16 | | | | | | Training |
| 17 | 12 | 17.4 | 18 | 6 | 1 | VG |
| 18 | 5 | 20.4 | 3 | 6.1 | 0 | E and VG |
| | 6 | 20 | 20 | 6 | 1 | E and VG |
| 19 | 17 | 20.7 | 3 | 6 | 0 | G, Beaufort 2 and short swell. Heavy NW wind 21-25 May |
| 26 | 9 | 20.1 | 17 | 6 | 0 | G, attempt PSU 8, 9, but F-P cond. in PSU 8, do 10 instead |
| | 10 | 19.8 | 28 | 6 | 0 | G to VG. NW wind 27-29 May |
| 30 | 16 | 18.6 | 8 | 5.8 | 0 | G, Beaufort 2. Bill McIver aboard |
| **June** | | | | | | NW wind first week of June |
| 7 | 7 | 19.9 | 11 | 5.8 | 0 | G to VG. |
| | 8 | 20.3 | 1 | 6 | 0 | G to VG. |
| 8 | 13 | 20.7 | 88 | 6.5 | 14 | VG to E, Mostly Beaufort zero |
| | 14 | 20 | 123 | 6 | 7 | VG to E, Mostly Beaufort zero |
| 9 | 1 | 20.1 | 18 | 6.2 | 1 | G to VG, litght S wind |
| | 2 | 19.3 | 11 | 6.4 | 1 | G to VG, litght S wind |
| 13 | 11 | 20.3 | 23 | 6.2 | 4 | G |
| 19 | 15 | 22.1 | 5 | 6 | 0 | G to VG. Frank Fogarty aboard |
| 20 | 18 | 20.5 | 15 | 6.1 | 1 | Good conditions |
| 21 | 12 | 18.1 | 6 | 6.1 | 6 | G, short swell. Start replicate 2 samples |
| 23 | 3 | 18.9 | 14 | 6.1 | 0 | G |
| | 4 | 19.8 | 17 | 5.5 | 0 | F-P around Cape Blanco, otherwise VG conditions |
| **July** | | | | | | NW wind throughout for 2 weeks |
| 7 | 9 | 20.5 | 2 (1) | 6 | 0 | VG except at N end. First HY murrelet detection |
| 8 | 1 | 19.9 | 7 (1) | 5.9 | 1 | VG all day. 2 HY murrelets (1 HY not on transect) |
| | 2 | 19.1 | 9 | 5.8 | 0 | VG all day. Windy S of Cape Mendocino for rest of month. |
| 9 | 13 | 20.3 | 61 | 6 | 5 | Exc. Cond. Low swell, Beaufort 0- 1 |
| 12 | 16 | 18.7 | 8 | 6.1 | 0 | G to VG, misty. |
| | 17 | 21.1 | 20 | 6 | 0 | G to VG, misty. Then NW wind for a week |
| 20 | 14 | 20.1 | 74 (3) | 6 | 5 | All VG conditions |
| | 15 | 22 | 9 (1) | 6.1 | 0 | VG except at S end where NW wind picks up |
| 21 | 10 | 18.7 | 52 (2) | 6.2 | 16 | All VG conditions. Murrelets to (and beyond) 3 km out |
| | 11 | 18.8 | 13 | 4.1 | 1 | VG except at S end where NW wind picks up |
| 24 | 5 | 20.7 | 3 | 6 | 0 | VG - E, the only calm day in late July (except N of Cape Blanco) |
| | 6 | 20.7 | 3 | 5.9 | 0 | VG - E, the only calm day in late July (except N of Cape Blanco) |
| 30 | 3 | 20.3 | 12 (5) | 5.9 | 1 | G-VG, the only location where winds light |
| Year Totals | | 637.9 | 702 (13) | 190.8 | 65 | Southern Stratum 2 (PSU 19 - 22) never sampled |

Table 2. Estimates of Marbled Murrelet density and abundance in Conservation Zone 4 from 2000 to 2023. Data are from the NWFP Program. See Fig. 1 for strata division location.

| | | | | | Number of birds, point estimate | | | Confidence Intervals | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Density, birds per sqr. Km. | Std. error of density | C.V. | Average group size | Stratum 1 area=734 sqr. Km. | Stratum 2 area=425 sqr. km. | Total Zone 4 estimate | Lower | Upper |
| 2000 | 4.2161 | 1.3015 | 0.3087 | 1.73 | 4,420 | 467 | 4,887 | 3,417 | 9,398 |
| 2001 | 3.2842 | 0.7867 | 0.2396 | 1.75 | 3,351 | 456 | 3,807 | 2,983 | 6,425 |
| 2002 | 4.1118 | 0.6198 | 0.1507 | 1.72 | 3,805 | 961 | 4,766 | 3,272 | 6,106 |
| 2003 | 3.8063 | 0.6577 | 0.1728 | 1.70 | 3,640 | 772 | 4,412 | 3,488 | 6,495 |
| 2004 | 4.2723 | 1.1499 | 0.2691 | 1.70 | 3,911 | 1,041 | 4,952 | 3,791 | 9,021 |
| 2005 | 3.1687 | 0.7479 | 0.2360 | 1.52 | 3,292 | 381 | 3,673 | 2,740 | 6,095 |
| 2006 | 3.4104 | 0.5092 | 0.1493 | 1.62 | 3,537 | 416 | 3,953 | 3,164 | 5,525 |
| 2007 | 3.2342 | 1.1257 | 0.3481 | 1.61 | 3,470 | 279 | 3,749 | 2,659 | 7,400 |
| 2008 | 4.5597 | 0.8184 | 0.1795 | 1.71 | 4,685 | 600 | 5,285 | 3,809 | 7,503 |
| 2009 | 3.7859 | 0.7536 | 0.1990 | 1.66 | 3,891 | 497 | 4,388 | 3,599 | 6,952 |
| 2010 | 3.1615 | 0.9024 | 0.2854 | 1.62 | 2,769 | 896 | 3,665 | 2,248 | 6,309 |
| 2011 | 5.1960 | 1.8112 | 0.3486 | 1.64 | 4933 | 1,090 | 6,023 | 2,782 | 10,263 |
| 2012 | 4.2794 | 1.0653 | 0.2489 | 1.65 | 4,439 | 521 | 4,960 | 3,414 | 8,011 |
| 2013 | 5.2162 | 1.0677 | 0.2047 | 1.61 | 5,417 | 629 | 6,046 | 4,531 | 9,282 |
| 2014 | | | | | No surveys | | | | |
| 2015 | 7.5423 | 1.2682 | 0.1681 | 1.70 | 7,262 | 1,481 | 8,743 | 7,409 | 13,125 |
| 2016 | | | | | No surveys | | | | |
| 2017 | 7.3731 | 1.0967 | 0.1487 | 1.66 | 6,740 | 1,806 | 8,546 | 6,277 | 11,331 |
| 2018 | | | | | No surveys | | | | |
| 2019 | 5.8849 | 1.2880 | 0.2189 | 1.70 | 5,936 | 885 | 6,821 | 5,576 | 11,063 |
| 2020 | | | | | No surveys | | | | |
| 2021 | 4.4275 | 0.9940 | 0.2245 | 1.65 | 4,476 | 656 | 5,132 | 3,739 | 8,243 |
| 2022 | | | | | No surveys | | | | |
| 2023 | 5.66 | 1.11 | 0.196 | 1.67 | 5,775 | 787 | 6,562 | 4,024 | 9,082 |

Table 3. Marbled Murrelet detections per km by PSU location and in 200 m wide distance-to-shore categories during PSU sampling surveys of Zone 4 in 2023.

| Distance | PSU | | | | | | | | | | | | | | | | | | Total by |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Distance |
| Offshore | | | | | | | | | | | | | | | | | | | Offshore |
| 400 | | | 2.31 | 0.42 | | 0.58 | 0.20 | 0.19 | | 0.20 | | | 1.86 | 2.60 | | 1.56 | 0.37 | 1.18 | 11.45 |
| 600 | 0.59 | 0.57 | | | | 0.59 | | | 0.19 | 0.27 | 1.76 | 0.93 | | | 0.17 | | 0.19 | | 5.25 |
| 800 | | 1.22 | 0.61 | | | | | | 0.80 | | | 3.26 | | 5.60 | | 0.64 | | | 12.13 |
| 1000 | 0.61 | | 0.39 | 0.61 | 0.19 | 2.55 | | | | 2.20 | | | 0.60 | 8.60 | 0.56 | 0.21 | 2.23 | | 18.75 |
| 1200 | 2.59 | 1.80 | | | 0.38 | | | | 2.20 | | | | 4.00 | 5.29 | 0.37 | 0.21 | | 1.51 | 18.36 |
| 1400 | | | 1.95 | 2.40 | 0.56 | | 1.67 | | 0.39 | 6.78 | | 0.22 | | 8.40 | 0.19 | | 1.18 | | 23.74 |
| 1600 | 0.78 | 0.61 | | | | 0.20 | | | | 2.40 | 3.82 | | 17.00 | 4.40 | | | | 0.20 | 29.41 |
| 1800 | 0.39 | | 0.21 | | | 0.63 | 0.40 | | 0.20 | 4.40 | | 0.89 | 5.96 | | 1.29 | | 0.38 | | 14.75 |
| 2000 | | | | | | 0.17 | | | | | 2.31 | 0.98 | | 4.40 | | 0.89 | | | 8.75 |
| 2200 | | | | | | | | | | | | | | 1.17 | | | | 0.16 | 1.33 |
| 2400 | | | 0.17 | | | | | | | | | | 0.83 | | | | | | 1.00 |
| 2600 | 0.17 | | | | | | | | | | 0.24 | 0.17 | | 0.83 | | | | | 1.41 |
| 2800 | | 0.16 | | | | | | | | | | | 2.15 | | | | | | 2.31 |
| 3000 | 0.16 | | | | | | | | | 2.58 | | | | | | | | | 2.74 |
| Detections | | | | | | | | | | | | | | | | | | | |
| per km | 5.30 | 4.35 | 5.64 | 3.43 | 1.14 | 4.71 | 2.26 | 0.19 | 3.77 | 18.83 | 8.14 | 6.45 | 32.41 | 41.29 | 2.57 | 3.50 | 4.35 | 3.05 | 151.38 |

Table 4. Age ratios (HY:AHY) and HY encounter rates (ER; HY/Km effort) of Common Murres and Marbled Murrelets in the Conservation Zone 4 since 2000. Data are between 10 and 31 July, and include extra-PSU surveys prior to 2013 (thus numbers from the prior decade differ from Strong 2022). Only portions of Stratum 1 were sampled prior to 2010.

| | | **Common Murre** | | **Marbled Murrelet** | | | |
|---|---|---|---|---|---|---|---|
| | Effort, km. | HY:AHY Ratio | HY density | AHY | HY | HY:AHY Ratio | HY density |
| 2000 | 131.2 | 0.259 | 1.601 | 83 | 7 | 0.084 | 0.053 |
| 2001 | 90.4 | 0.186 | 2.279 | 74 | 3 | 0.041 | 0.033 |
| 2002 | 52 | 0.256 | 0.981 | 71 | 2 | 0.028 | 0.038 |
| 2003 | 78.5 | 0.248 | 0.994 | 119 | 12 | 0.101 | 0.153 |
| 2004 | 72.4 | 0.146 | 1.519 | 79 | 0 | 0.000 | 0.000 |
| 2006 | 72.9 | 0.124 | 0.466 | 56 | 13 | 0.232 | 0.178 |
| 2007 | 59.5 | 0.152 | 0.571 | 75 | 5 | 0.067 | 0.084 |
| 2008 | 96.3 | 0.268 | 3.801 | 72 | 6 | 0.083 | 0.062 |
| 2009 | 219.8 | 0.117 | 0.814 | 249 | 16 | 0.064 | 0.073 |
| 2010 | 342.3 | 0.051 | 0.164 | 358 | 9 | 0.025 | 0.026 |
| 2011 | 388.9 | 0.052 | 0.424 | 630 | 8 | 0.013 | 0.021 |
| 2012 | 284.1 | 0.059 | 0.736 | 519 | 10 | 0.019 | 0.035 |
| 2013 | 336.1 | 0.207 | 3.079 | 303 | 14 | 0.046 | 0.042 |
| 2015 | 339.4 | 0.121 | 1.293 | 614 | 8 | 0.013 | 0.024 |
| 2017 | 231.6 | 0.012 | 0.043 | 556 | 6 | 0.011 | 0.026 |
| 2019 | 310.7 | 0.001 | 0.006 | 461 | 4 | 0.009 | 0.013 |
| 2021 | 320.2 | 0.192 | 0.878 | 328 | 8 | 0.024 | 0.025 |
| 2023 | 233.4 | 0.141 | 1.337 | 312 | 11 | 0.035 | 0.047 |
| **Total, mean** | **3659.7** | **0.144** | **1.166** | **3591** | **142** | **0.050** | **0.052** |

Table 5. Pelagic Cormorant nest counts and nesting success data at 3 colonies in Del Norte County, northern California over various years 1989 – 2023.
'WBN' = well-built productive nest, 'W/C' = nest with chicks, and 'Tot C' = total number of fledge-age chicks. 'C/WBN' is a measure of reproductive success.

| | Tolowa Rock | | | | Hunter Island | | | | Castle Rock NWR | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | WBN | WBN W/C | Tot C | (C/WBN) | WBN | WBN W/C | Tot C | (C/WBN) | Count Date | WBN |
| 1989 | | | | | | | | | | 178 |
| 1996 | 19 | 16 | 29 | 1.53 | | | | | | |
| 1997 | 24 | 18 | 38 | 1.58 | | | | | 16-Jun | 186 |
| 1998 | 2 | 0 | 0 | 0 | | | | | 7-Jul | 25 |
| 1999 | 14 | 13 | 20 | 1.43 | | | | | 28-May | 143 |
| 2006 | 11 | 7 | 8 | 0.73 | | | | | | |
| 2007 | 24 | 22 | nd | nd | | | | | | |
| 2008 | 20 | 20 | 52 | 2.6 | | | | | | |
| 2009 | 19 | 15 | 35 | 1.84 | | | | | | |
| 2010 | 9 | 7 | 17 | 1.89 | | | | | | |
| 2011 | 0 | | | | | | | | 12-Jul | 88 |
| 2012 | 4 | 3 | 3 | 0.75 | | | | | | |
| 2013 | 20 | 19 | 53 | 2.65 | | | | | 16-Jun | 235 |
| 2014 | 25 | 24 | 71 | 2.84 | 31 | 29 | 66 | 2.13 | | |
| 2015 | 17 | 11 | 27 | 1.59 | 26 | 23 | 51 | 1.96 | | |
| 2016 | 12 | 8 | 19 | 1.58 | 24 | 12 | 12 | 0.5 | | |
| 2017 | 3 | 3 | 1 | 0.33 | 38 | 31 | 60 | 1.58 | 7-Jul | 182 |
| 2018 | 17 | 15 | 32 | 1.88 | 52 | 45 | 107 | 2.06 | | |
| 2019 | 2 | 2 | 1 | 0.5 | 2 | 0 | 0 | 0 | 25-Jun | 33 |
| 2020 | 16 | 15 | 33 | 2.06 | 15 | 14 | no data | | 27-Jul | 227 |
| 2021 | 24 | 21 | 47 | 1.96 | 25 | 21 | 37 | 1.45 | 26-Jun | 245 |
| 2023 | 10 | 5 | 13 | 1.3 | 45 | 33 | 79 | 1.75 | 9-Jul | 188 |
| Means | 13.9048 | 12.2 | 26.3 | 1.5 | 28.7 | 23.1 | 51.5 | 1.4 | | 154.2 |

1989 source data: Carter et al. 1992
1997-99 source data: Jaques and Strong, 2001.

Table 6. Tabulation of common seabirds and cetaceans counted while on PSU surveys in Zone 4 during 2023.

| | May | | | | June | | | | | | July | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Day** | **17** | **18** | **19** | **26** | **30** | **7** | **8** | **9** | **13** | **19** | **20** | **21** | **23** | **7** | **8** | **9** | **12** | **20** | **21** | **24** | **30** | **Season** |
| **PSU sampled >** | **12** | **5, 6** | **17** | **9, 10** | **16** | **7, 8** | **13, 14** | **1, 2** | **11** | **15** | **18** | **12** | **3, 4** | **9** | **1, 2** | **13** | **16, 17** | **14, 15** | **10, 11** | **5, 6** | **3** | **Total** |
| **BIRDS** | | | | | | | | | | | | | | | | | | | | | | |
| **Common Loon** | | 1 | 2 | | | 5 | 1 | 3 | 6 | | | | | | 1 | | | | 2 | | | 21 |
| **Pacific Loon** | | | 1 | | | | 1 | 2 | | | | | | | 2 | | | | | | | 6 |
| **Western Grebe** | 15 | | 4 | | 12 | | 2 | | | 3 | | 1 | | 7 | | 3 | 2 | 1 | | | | 50 |
| **Sooty Shearwater** | | 2 | | | | | | | | | | | | | | | | | | | | 2 |
| **Brown Pelican** | 44 | 96 | 5 | 14 | 18 | 34 | 209 | 73 | 75 | 40 | | 75 | 2 | 204 | 198 | 94 | 22 | 88 | 118 | 75 | 20 | 1504 |
| **Double-crested Cormorant** | | | | 1 | | | | | | | | | | | | | | | | | | 1 |
| **Brandt's Cormorant** | 2 | 13 | | 17 | 1 | 7 | 1 | 22 | 4 | 2 | | 1 | 72 | 4 | 37 | 4 | 1 | 4 | 17 | 21 | 4 | 234 |
| **Pelagic Cormorant** | 4 | 25 | | 33 | | 21 | | 26 | 8 | | | 5 | 12 | 5 | 5 | 8 | | 4 | 4 | | | 160 |
| **Cormorant species** | | | | 3 | 1 | 1 | | 22 | 2 | | | 2 | 13 | 7 | 8 | | 1 | 1 | 1 | 1 | 3 | 67 |
| **White-winged Scoter** | 6 | | | | | | | | | 11 | | | | | | 71 | | | 2 | | | 90 |
| **Surf Scoter** | | | | | | 48 | 3 | 3 | 4 | 4 | | 1 | | | 5 | 130 | | | 100 | | | 298 |
| **Scoter species** | | | | 2 | 2 | | 2 | | | 65 | | | | | 8 | 36 | 1 | 1 | 1 | | | 118 |
| **Red-necked Phalarope** | | | | | | | | | | | | | | | | | | | | | 2 | 2 |
| **Caspian Tern** | 4 | | 2 | | 7 | | | | | | | | | | | | 4 | | | 1 | | 18 |
| **Common Murre** | 559 | 731 | 153 | 119 | 5 | 263 | 40 | 387 | 1915 | 743 | 107 | 320 | 355 | 209 | 864 | 169 | 170 | 1085 | 586 | 355 | 159 | 9294 |
| **Pigeon Guillemot** | 2 | 14 | | 11 | | 16 | 8 | 10 | 5 | 2 | | 4 | 4 | 26 | 36 | | | 13 | 6 | 28 | | 185 |
| **Marbled Murrelet** | 35 | 39 | 5 | 83 | 17 | 22 | 419 | 57 | 45 | 9 | 22 | 20 | 52 | 2 | 36 | 106 | 45 | 167 | 131 | 9 | 20 | 1340 |
| **Ancient Murrelet** | | | | | | | | | | | | | 4 | | | | | | | | | 4 |
| **Cassin's Auklet** | | | | | | | | | | | | | | | 3 | | | | | 11 | 178 | 192 |
| **Rhinoceros Auklet** | | 16 | | | | 1 | 3 | 10 | 3 | | | 3 | 6 | 2 | 4 | | | | 30 | 28 | 6 | 112 |
| **Tufted Puffin** | | 3 | | | | | | | | | | | | | | | | | | | | 3 |
| **MARINE MAMMALS** | | | | | | | | | | | | | | | | | | | | | | |
| **Harbor Seal** | | 1 | | | | 3 | | | | | 1 | | | | | | 1 | 2 | 15 | | | 23 |
| **Steller Sea Lion** | 1 | 2 | 4 | | | | | 2 | 1 | 113 | | | 2 | | 72 | | | 60 | 98 | | 1 | 356 |
| **California Sea Lion** | 1 | | 1 | | | | 3 | 1 | 3 | | 2 | | | | | | 1 | | | | | 12 |
| **Gray Whale** | 4 | | | | | | 8 | | | 1 | 1 | 2 | 1 | | 1 | | | | | 1 | | 19 |
| **Humpback Whale** | | | | | | | | | | | | | | | | 1 | | | | | | 1 |
| **Minke Whale** | | | | | | | | | | | | | | | 1 | | | | | | | 1 |
| **Harbor Porpoise** | 7 | 25 | 10 | 2 | 8 | 4 | 12 | | | 2 | 5 | 2 | | | | 17 | 7 | 6 | 4 | 5 | | 121 |

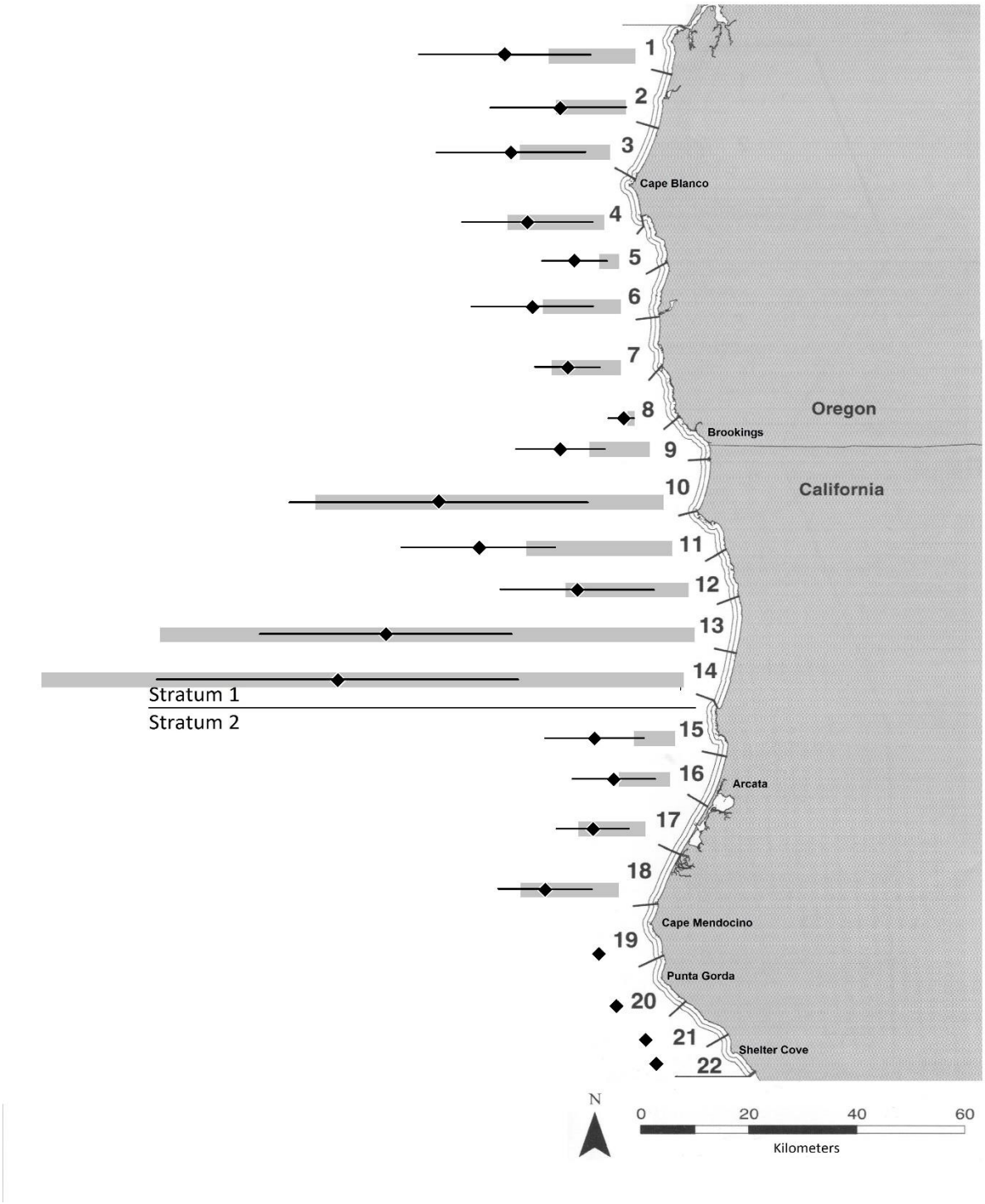


Figure 1. Conservation Zone 4 showing PSU locations, Strata division, and density of murrelets during the 2023 effort (gray bars). The mean (diamonds) and +- 1 standard deviation (black line) of all surveys from 2000 to 2023 are also shown. PSU 19 – 22 were not surveyed in 2023.

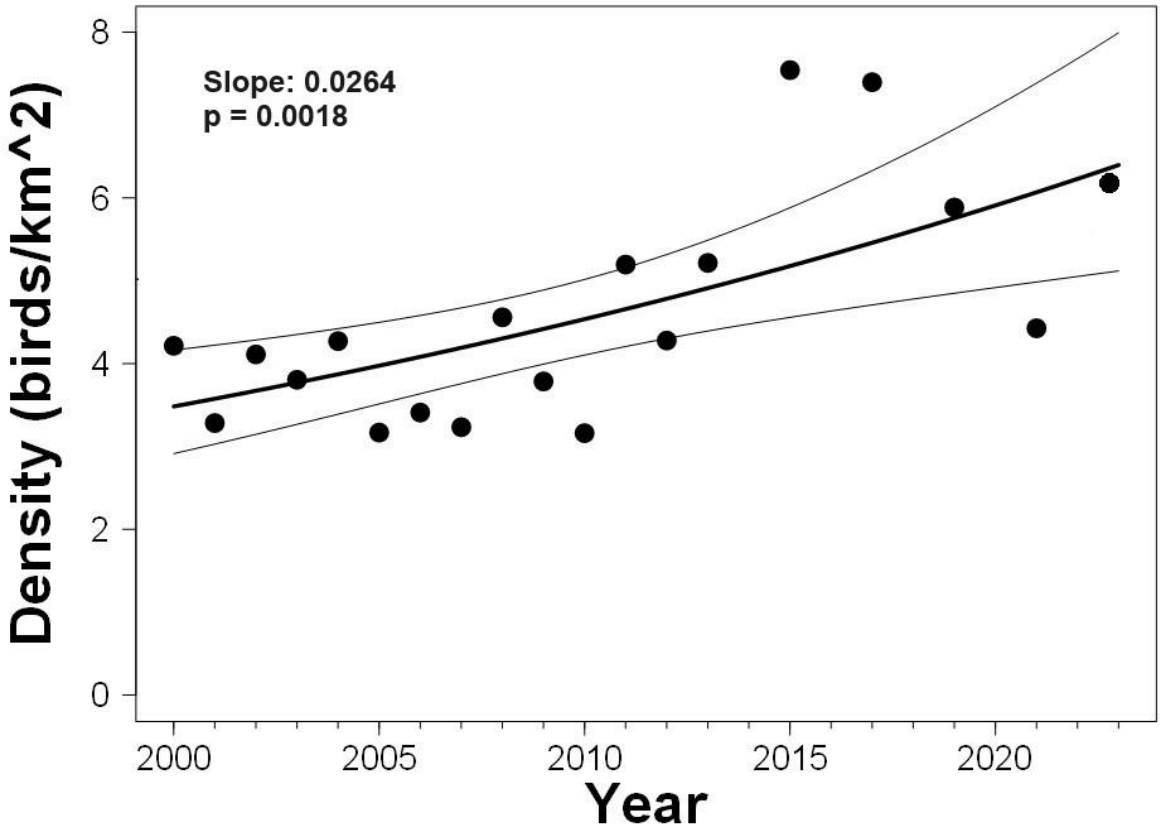


Figure 2. Trend in Marbled Murrelet density over time in Conservation Zone 4. Figure adapted from Jim Baldwin of the at-sea Marbled Murrelet population monitoring group.

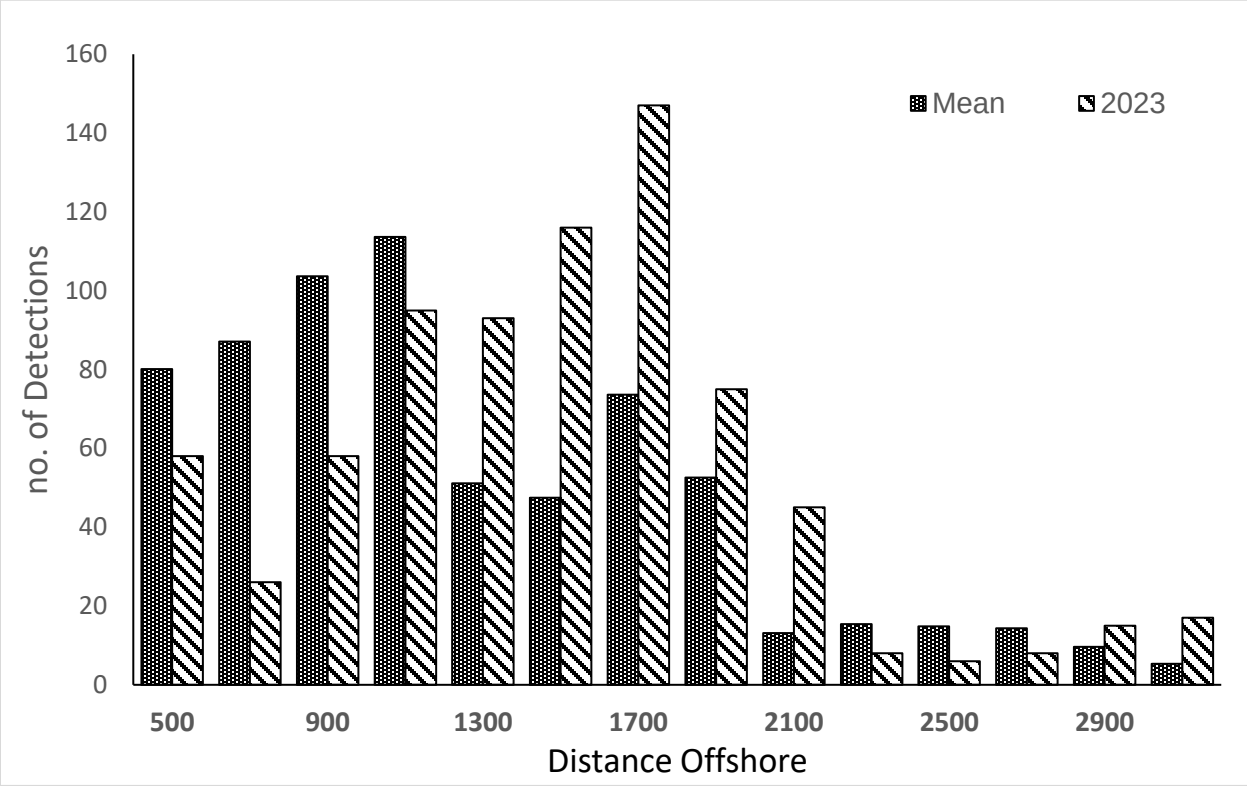


Figure 3. Number of Marbled Murrelet detections by 200 m increments of distance from shore in Conservations Zone 4 from 2010 to 2021 (averaged, dark bars) compared with 2023 (diagonal pattern).

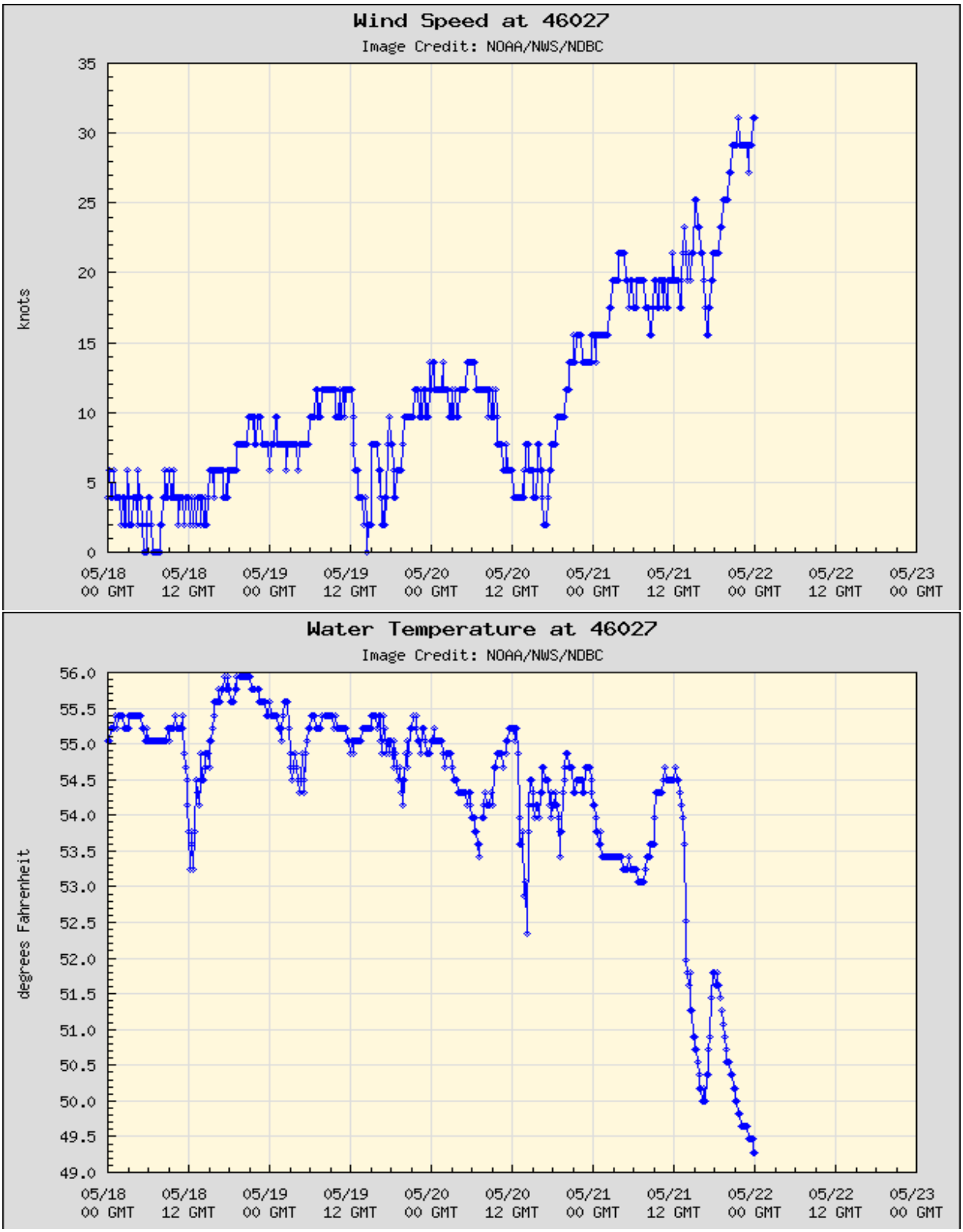


Figure 4. Graphic representation of the strong wind driven upwelling event on 21-22 May 2023. Figures from NOAA National Data Buoy Center buoy # 46027, 6 nm. offshore of Crescent City.