Marine mammal and seabird abundance and distribution around the Davidson Seamount, July 2010

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Executive Summary

The Davidson Seamount, located 129 km southwest of Monterey, California, was incorporated into the Monterey Bay National Marine Sanctuary on March 9, 2009 and is the first seamount within the National Marine Sanctuary system. The Sanctuary conducted a ship-based survey of the waters above and around the Davidson Seamount during July 2010. The three-day survey onboard the NOAA Ship *McArthur II* was the first dedicated at-sea survey of the Seamount to record marine mammal and seabird observations. Overall, 8 transect lines were surveyed for a total of 605 km of "on-effort" observations. Seventeen species of seabirds and 6 marine mammal species were observed. Cook's Petrel (*Pterodroma cookii*) was the most abundant seabird observed (8.4 birds km^{-2}), followed by Leach's Storm-Petrel (*Oceanodroma leucorhoa*; 5.6 birds km^{-2}). Including off effort sightings, the greatest number on Cook's Petrel ever recorded in California waters were observed. The seabird assemblage to the northwest of the seamount was distinctly different than that to the southeast with the northwest region characterized by more pelagic species such as Cook's Petrels and Leach's Storm-Petrel while the southeast region was characterized by more coastal species such as shearwaters, phalaropes, gulls, and alcids. Of a total of 200 marine mammal sightings, fin whales (*Balaenoptera physalus*) were the most commonly encountered marine mammal (51% of sightings), comprising 94% of whales sighted. In addition, fishes and other ancillary sightings were recorded. This survey in combination with aerial surveys along the same transect lines will serve as a baseline for future studies of the Davidson Seamount.

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Introduction

The Davidson Seamount is an extinct undersea volcano that last erupted approximately 9.8 million years ago. The seamount, located approximately 129 km southwest of Monterey, California and 120 km west of San Simeon, California, is 13 km wide, 42 km long, and 2,280 meters tall. Yet, the summit is still 1,250 m below the sea surface. The Davidson Seamount is one of the largest seamounts in U.S. waters, and was the first underwater feature to be identified as a seamount in 1938 (Brewin *et al.* 2007). The Davidson Seamount Management Zone, including the seamount and surrounding waters (approximately 2007 km^2), was added to the Monterey Bay National Marine Sanctuary on March 9, 2009 (MBNMS 2013) (Figure 1).

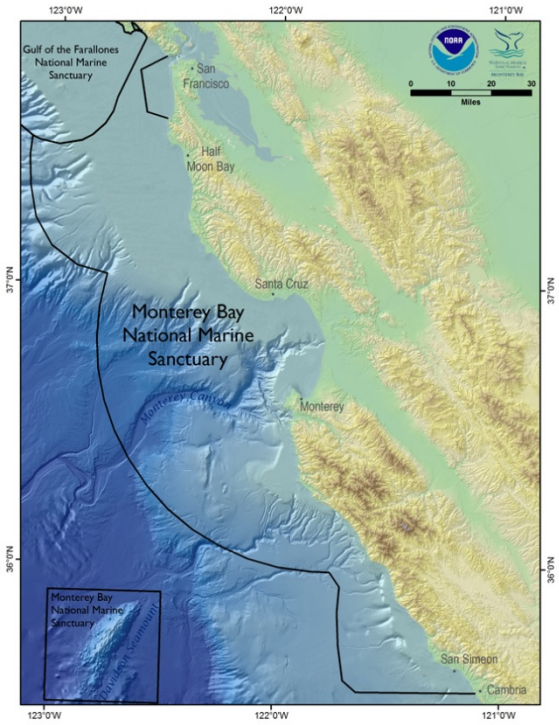

Figure 1. The Monterey Bay National Marine Sanctuary, including the Davidson Seamount Management Zone (lower left box).

Seamounts have important effects upon pelagic ecosystems via internal wave generation, eddy formation, enhanced vertical mixing, and Taylor columns (closed circulation patterns) (Boehlert & Genin 1987, White *et al.* 2007, Rizk & Ryan 2006). These physical dynamics vary depending on the depth of the seamount, and the Davidson Seamount is considered to be a "deep" seamount (having a summit > 400 m), with an actual summit of 1,250 m deep (Genin 2004). While it is often assumed that localized upwelling occurs at seamounts, fueling primary and secondary production, at deep seamounts current-topography interactions are unlikely to impact biological processes in surface waters and it is thought that enhanced horizontal flux is the mechanism that causes animal aggregations over seamounts (Genin 2004, Genin & Dower 2007).

Worldwide, seamounts are considered to be hotspots of pelagic biodiversity, especially for sharks, tunas, billfishes, marine mammals, and seabirds (Morato *et al.* 2008, Morato *et al.* 2010, Holland *et al.* 1999, Holland & Grubbs 2008). Within the California current, marine mammals known to be found

above seamounts include Dall's porpoise, short-finned pilot whales, common dolphins, humpback, fin, blue, and sperm whales (NOAA 2012, Kaschner 2007). No dedicated at-sea marine mammal survey above and around a deep seamount has ever been conducted prior to this survey. Off the coast of California, only one dedicated seabird survey was conducted at a seamount, in 1991 above and around Fieberling Guyot, 980 km west of San Diego, California (Haney *et al.* 1995). This report summarizes the first dedicated, multi-disciplinary, survey of marine mammal, seabird, and oceanographic conditions at the Davidson Seamount during July 2010.

Methods

The NOAA Ship *McArthur II* was used to conduct a 3-day survey of the marine mammal and seabird assemblage above and around the Davidson Seamount.

Study Area

The study area was focused on the water directly above the Davidson seamount, and to both the east and west of the seamount and encompassed a total area of approximately 4000 km^2.

Transect lines were determined based upon the transect lines used during the April 19, 2010 aerial survey of the Davidson Seamount area. There are a total of 22 transects in the aerial survey grid (King & DeVogelaere 2010). To maximize our coverage of the area, we selected every 4th transect line starting at line 0 from the aerial survey grid for a total of 6 transects (Figure 2). Each transect line is approximately 88 km and includes 44.4 km of surface water perpendicular to each side of the axis of the seamount. A half transect was added to the north of the northern most transect line at the same distance between the 2 lines. In addition to the 6 large and 1 half transect, a 30 km transect was conducted over the axis of the seamount (Figure 2).

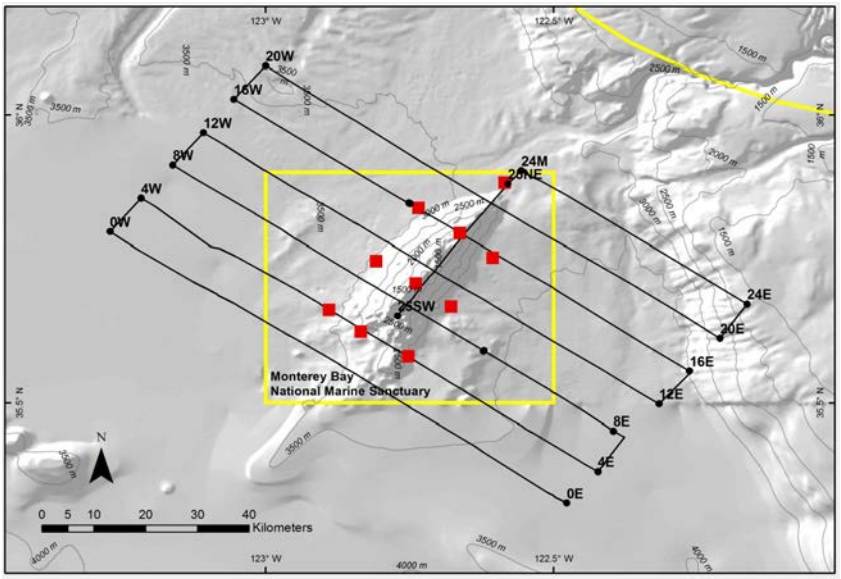

Figure 2. Davidson Seamount study area: Transect lines (black), Hydrographic stations (red squares). Solid yellow line indicates Monterey Bay National Marine Sanctuary boundary and the Davidson Seamount Management Zone.

Hydrographic stations (CTD casts & zooplankton net tows) were located on 4 transect lines, spaced equidistant along the axis of the seamount, although only 2 of the transect lines were selected for shipboard surveys. Three stations were occupied along each transect except for transect 22, where only one station was occupied. Along each transect, one station was located along the axis of the seamount, one 7 km to the east, and one 7 km to the west of the axis. Only the station along the axis of the transect was occupied for transect 22 (Figure 2).

Daytime Operations

During daylight hours, approximately 0700 – 1900, a daily watch for marine mammals and seabirds was maintained on the flying bridge. Surveys were conducted at a ship speed of 10 kt along the designated transect line. At the beginning of each day, search effort started on the eastern waypoint of the trackline, or at the breakoff point from the prior evening.

Marine Mammal Observations

Six marine mammal observers used line transect survey methods to collect cetacean and pinniped abundance data. Each observer worked in 2-hour rotations, manning each of the following three stations on the flying bridge for 40 minutes: a port side 7 x 50 binocular station, a center-line "naked eye" position, and a starboard 7 x 50 binocular station. In addition, each observer occupied the data recorder position. An "independent observer" kept a separate watch of animals sighted during the cetacean survey operations, to be compared later with the observer team's data. Big-eye (25 x 150) binoculars, mounted on both the port and starboard sides of the flying bridge were used to aid with marine mammal identification and group size estimation. Marine mammals were identified to the lowest possible taxonomic level and for each sighting, environmental conditions and sighting details (group size estimation) were recorded.

Seabird Observations

Two seabird observers conducted visual surveys of seabirds using handheld and 25 x 150 big-eye binoculars. Details of seabird methods are presented in Newton et al. (2009) and are summarized here. Seabirds were recorded during daylight hours on the side of the ship with the best viewing conditions. Seabirds were identified to species when possible, and recorded from the bow to 90 degrees and out to 300 m as estimated by the observer via a rangefinder as described by (Heinemann 1981). Seabirds following the ship were counted only once if they approached the ship and flew into the transect strip. Seabirds that flew into the strip as a result of being flushed were not counted. Group size and seabird behavior was recorded (sitting or flying) for each sighting. The data were not corrected for bird 'flux' (Spear *et al.* 1992) because flight direction was not recorded for flying seabird observations. In addition to the "on effort" seabird sightings, all birds seen during the survey were recorded and counted by the seabird observers.

Both marine mammal and seabird observers recorded sightings of fish, marine debris, and other ancillary sightings.

Night Operations

Night operations commenced at approximately 2000 and finished by 0300. Each night between 3 and 6 stations were occupied.

Zooplankton Net Tows

At each station, an oblique bongo net tow was deployed to a depth of 200 meters and for a duration of 45 minutes. The bongo has a 505 micron mesh on the starboard side and a 333-micron mesh on the port side. Samples were preserved in formalin and transported back to University of California Santa Cruz for processing and archiving. For each sample krill were identified to species if possible, counted, and measured. Overall krill counts are represented as the number of krill per 1000 m^3.

CTD Sampling

A SeaBird 9/11+ CTD was used each night to collect temperature and salinity profiles. At each station, a CTD cast to 1000 m was conducted. Cast descent rates were 30 m per minute for the first 100 m of the cast and then 60 m/min for the remainder of the cast. Raw CTD data was processed using standard processing techniques with Seasave V 7.20c software.

Humboldt Squid Sampling

At each station, during the CTD cast, one or more scientific personnel fished for Humboldt squid (*Dosidicus gigas*) using a pole with a squid jig (as described in (Stewart *et al.* 2012).

Shipboard Data

Sea surface temperature was recorded by a SeaBird SBE38 mounted near the bow of the ship. In addition, a SeaBird SBE45 thermosalinograph (TSG) recorded sea surface temperature and salinity approximately 125 ft behind the SBE38. Both systems operated continuously while underway. Temperature data is reported from the SBE38 due to its close proximity to the sea water input. To determine prey (zooplankton, krill, and fish) abundance a SIMRAD EK60 scientific depth sounder was operated continuously at 38, 70, 120, and 200 kHz. Acoustic backscatter data were recorded to a depth of 200 m. Only the SBE38 temperature data was processed for this report. All other shipboard data are archived at UC Santa Cruz and at the Monterey Bay National Marine Sanctuary for future analysis.

Statistical Analysis

All statistical analyses were run using SYSTAT software version 12.01 (SYSTAT 2007). To minimize the probability of a type II error (failure to detect a difference when one exists), we used an alpha level of 0.20 for significance in all analyses reported in this manuscript.

Results

Daytime Operations

Over 3 days, seven transects were completed perpendicular to the main axis of the Davidson Seamount (574 total kilometers) and one transect traversed directly over the main axis of the seamount (31 km transect length) for a total of 605 km (See Figure 2).

Marine Mammals

Overall, 200 sightings of 668 individual marine mammals were sighted during the 3 day survey (see Appendix IV). Fin whales (*Balaenoptera physalus*) were the most commonly encountered marine mammal (51% of all marine mammal sightings). Observers identified 102 sightings comprising 197 individuals (encounter rate of 0.33 km^{-1}; Figure 3). The majority of sightings were located above and to the west of the seamount (Figure 4). Fin whales comprised 94% of all whale sightings and were the only large whale identified to species. All other large whale sightings were identified as either "Unidentified Rorqual" (7 sightings of 9 individuals) or "Unidentified Ziiphid" (1 sighting of 4 individuals). No Sperm whales were observed.

Three species of small cetaceans were encountered. There were 21 sightings of 78 individual Dall's porpoise (*Phocoenoides dalli*). One large pod of dolphins was encountered (300 individuals) comprising 2 species: 65% Northern right whale dolphin (*Lissodelphis borealis*) and 45% Pacific white-sided dolphin (*Lagenorhynchus obliquidens*).

Northern fur seals (*Callorhinus ursinus*) were the most common pinniped sighted (68% of all pinniped sightings). Observers identified 42 sightings comprising 48 individuals; the majority of which were on the southern 2 transects south of the seamount (Figure 5). Other pinniped sightings included California sea lions (*Zalophus californianus*; 6 sightings of 6 individuals) and Northern elephant seals (*Mirounga angustirostris*; 6 sightings of 6 individuals).

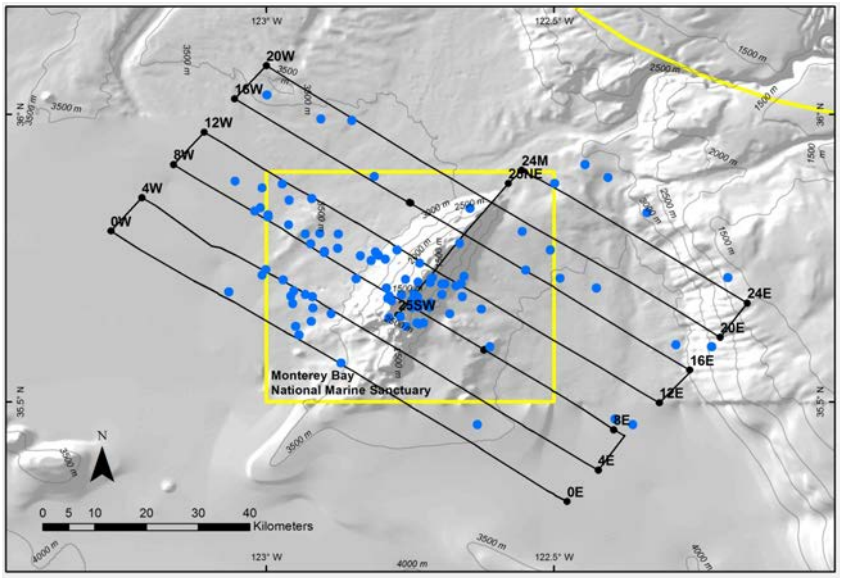

Figure 3. Fin whale sightings (blue circles)

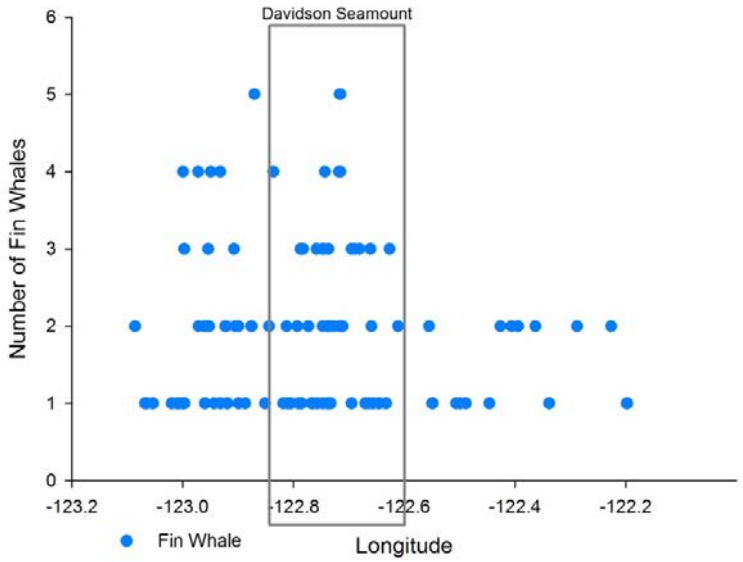

Figure 4. Fin whale sightings relative to the top of the Seamount (approximate longitude -122.6 – -122.85).

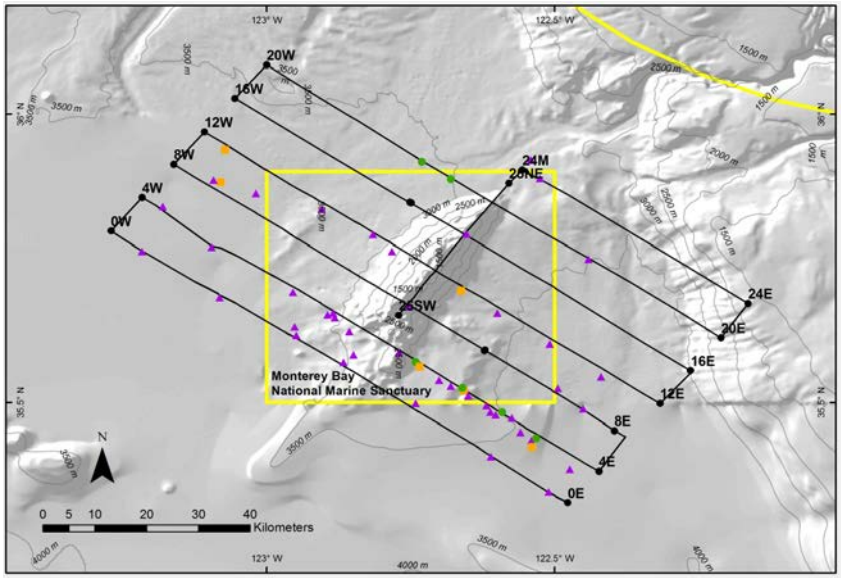

Figure 5. Pinniped sightings: Northern fur seal (purple triangles), elephant seal (orange squares), and California sea lion (green circles).

Seabirds

Overall there were 316 sightings of 1033 individual seabirds comprising 17 different species (see Appendix IV). Cook's Petrel (*Pterodroma cookii*) and Leach's Storm-Petrel (*Oceanodroma leucorhoa*) were the 2 most commonly encountered species (77% of seabird sightings and 82% of all seabirds observed; Figure 6). Cook's Petrels were encountered at a rate of 8.4 birds km^{-2} (121 sightings of 507 individuals) and Leach's Storm-Petrels were encountered at a rate of 5.6 birds km^{-2} (124 sightings of 338 individuals). The majority of the sightings of the two species were above and to the west of the seamount (Figure 7). Including off effort sightings, observers recorded the greatest number of Cook's Petrel ever observed in California waters (5,125 total birds; see Appendix V for full summary of all birds recorded during the survey; (Rogers *et al.* 2011).

Other seabird species sighted include both Red and Red-necked Phalaropes (*Phalaropus fulicarius* and *P. lobatus*, respectively), Arctic Terns (*Sterna paradisaea*), and Scripp's Murrelet (*Synthliboramphus scrippsi*; formerly Xantus' Murrelet). There were several sightings of migrating shorebird species, 11 Short-billed Dowitcher (*Limnodromus griseus*), 15 Least Sandpipers (*Calidris minutilla*), and 6 Black-bellied Plovers (*Pluvialis squatarola*). One landbird species landed on the ship for a short period of time one morning, an Ash-throated Flycatcher (*Myiarchus cinerascens*).

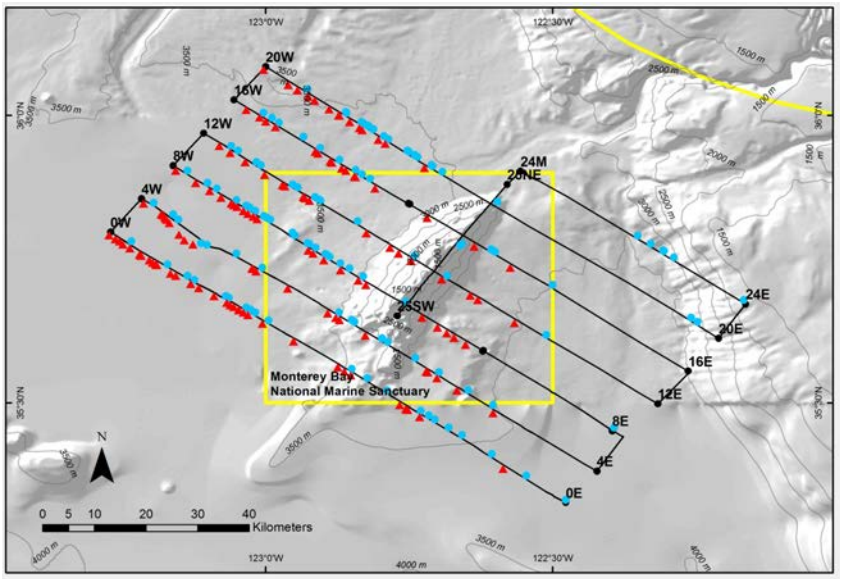

Figure 6. Seabird sightings: Cook's Petrel (red triangles) and Leach's Storm-Petrel (blue circles). Dots are offset from the transect lines to avoid overlap of sightings.

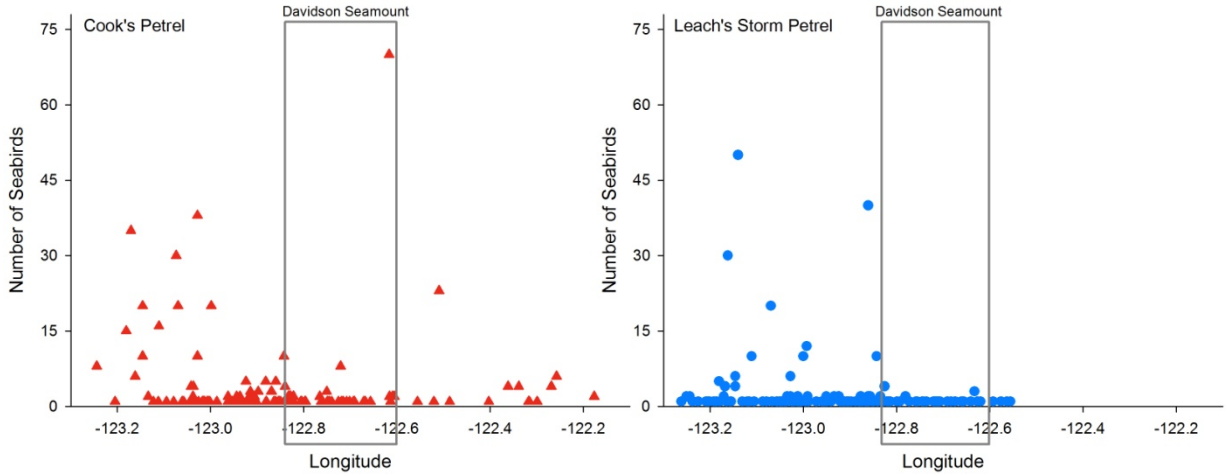

Figure 7. Cook's Petrel (red triangles) and Leach's Storm-Petrel (blue circles) sightings relative to the top of the Seamount (approximate longitude -122.6 – -122.85).

Fishes, Marine Debris, and Other Sightings

In addition to the marine mammal and seabird sightings, observers sighted 13 ocean sunfish (*Mola mola*), 6 albacore tuna (*Thunnus alalunga*) schools, salmon shark (*Lamna ditropis*), mako shark (*Isurus oxyrinchus*), blue shark (*Prionace glauca*), numerous egg yolk jellies (*Phacellophora camschatica*), and approximately 25 floating kelp patties. Observers recorded all marine debris sightings which included 3

plastic bags, a large plastic drum, 4 buoys, a Kit Kat candy wrapper, one plastic water bottle, and a paper coffee cup.

Nighttime Operations

Zooplankton Net Tows

Overall, we conducted 10 zooplankton net tows. Four along the axis of the seamount, 3 to the west, and 3 to the east (Fig. 2). We identified 7 total species of krill in the 10 samples, with *Euphausia pacifica* being the most abundant and found at every station. The second most abundant species, *Nyctiphanes difficilis*, was also found at every station but in much lesser abundance. The greatest abundance of krill (*Euphausia pacifica*) occurred at the stations along the axis and to the west of the seamount (Figures 8 and 9, respectively). However, there is no statistically significant difference between the 3 transects or the 3 seamount locations.

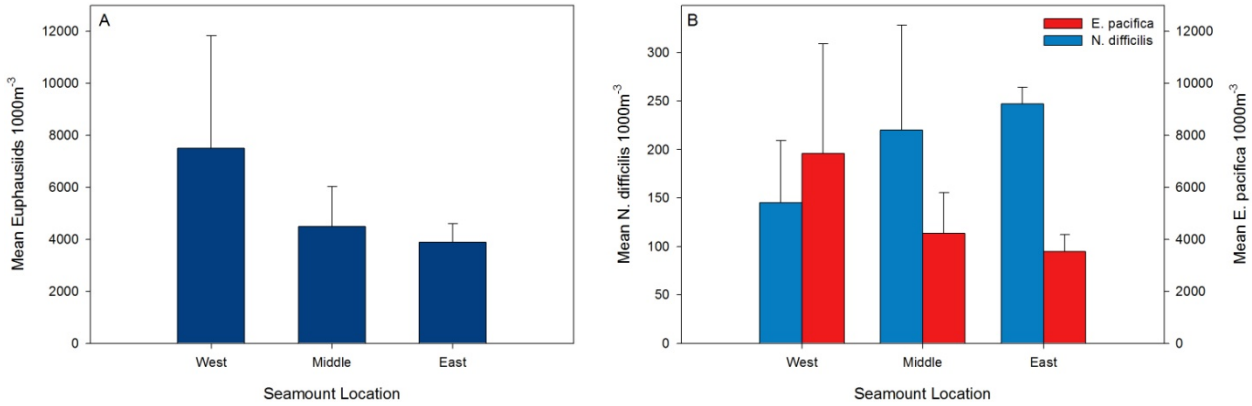

Figure 8. A. Mean number Total Euphausiids (± SE) found at stations to the west of the seamount, along the axis (middle), and to the east of the Davidson Seamount. B. Mean number (± SE) *Nyctiphaes difficilis* (blue) and *Eupahusia pacifica* (red).

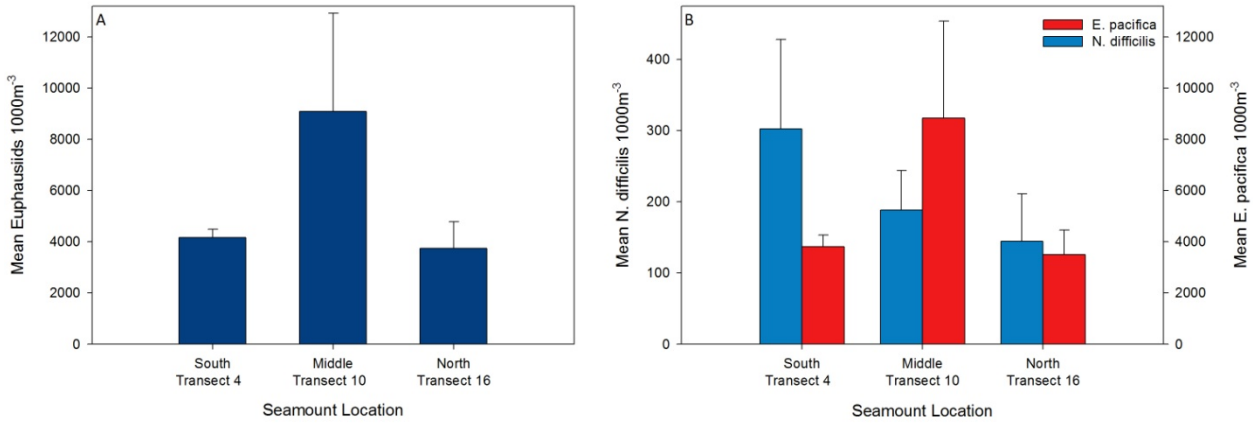

Figure 9. A. Mean number Total Euphausiids (± SE) found at stations to the South (transect 4), middle (transect 10), and North (transect 16) of the Davidson Seamount (see Fig. 2 for station locations). B. Mean number (± SE) *Nyctiphaes difficilis* (blue) and *Eupahusia pacifica* (red).

CTD Sampling

We conducted CTD casts prior to each zooplankton net tow (Fig. 2). We deployed each cast to 1000 m without incident. The depth of the 10°C isotherm ranged between 52 m – 77 m and on average was located at 58.7 m ± 7.42 SD. See Appendix III for water column profiles from each CTD cast.

Humboldt Squid Sampling

We did not catch a single Humboldt squid at any of the 10 stations.

Shipboard Data

Sea surface temperature along the survey transect lines (0700 – 1900 PDT) ranged between 13.38 – 15.18 °C and averaged 14.53 °C (± 0.378 SD).

Discussion

This survey was the first dedicated, systematic, at-sea survey of marine mammals and seabirds at the Davidson Seamount. In addition, the survey conducted the first zooplankton net tows and CTD casts over the seamount. Prior to the at-sea survey, the MBNMS conducted 2 aerial surveys over the seamount in January and April 2010 (King & DeVogelaere 2010), and recorded marine mammals and seabirds from the *R/V Western Flyer* during a 6 day ROV survey of the Davidson Seamount in May 2002 (Benson 2002).

Large whales are known to forage in areas of steep topography with enhanced productivity and food availability (Croll *et al.* 1998, Croll *et al.* 2005, Fiedler *et al.* 1998), similar to the conditions at the Davidson Seamount during the survey. In California, fin whales forage on euphausiids in addition to sardines and are present year round (Clapham *et al.* 1997, Munger *et al.* 2009). In central California, fin whales were the most commonly sighted baleen whale during multiple coast wide surveys between 1991 – 2005, and their abundance appears to be increasing (Barlow & Forney 2007). In the Southern California Bight, during summer months, fin whales are associated with greater zooplankton abundance (Munger et al. 2009). While few, if any, studies of direct observations of fin whales at seamounts exist, passive acoustic arrays have recorded fin whales at various seamounts off the west coast of North America (Union Seamount and LaPerouse Bank, Canada; Pioneer Seamount, California; (NOAA 2012, Ford *et al.* 2010). In this survey, the majority of fin whale sightings were above and to the west of the seamount where, based upon zooplankton net tows, krill abundance was greatest; and foraging behavior was noted by observers. Unfortunately, at this time, we have not analyzed zooplankton backscatter values along the transect lines to compare krill densities along the transect lines with fin whale sightings. The distribution of Cook's Petrel and Leach's Storm-Petrel was similar to the whale observations, although sightings extended much farther west than the majority of fin whale observations.

The seabird assemblage to the northwest of the seamount was distinctly different than that to the southeast with the northwest region characterized by more pelagic species such as Cook's Petrel and Leach's Storm-Petrel while the southeast region was characterized by more coastal species such as

shearwaters, phalaropes, gulls, and alcids. Leach's Storm-Petrel is the most abundant breeding storm petrel in California (BLM 2002) with between 100 – 1,400 birds nesting on the Farallon Islands (NCCOS 2007, Carter *et al.* 1992). In general, off California, Leach's Storm-Petrels are highly pelagic and are found farther offshore, beyond the continental slope (BLM 2002, NCCOS 2007). Leach's Storm Petrel densities around the Davidson Seamount (5.6 birds km^{-2}) are similar to the densities reported during the upwelling season (March 15 – August 15) in the Biogeographic Assessment of North/Central California (NCCOS 2007). With the inclusion of the Davidson Seamount into the Monterey Bay National Marine Sanctuary, sanctuary waters now include a small portion of the Leach's Storm-Petrel preferred habitat.

Cook's Petrel, a globally vulnerable species (BirdLife International 2012), currently breeds on just 2 islands off the coast of New Zealand (TIB 2012). It was first recorded in the continental United States in 1983, when a specimen was found on a driveway in Santa Cruz, California (Tyler & Burton 1986). In North America, the majority of sightings are from offshore of Baja California Sur, Mexico with a few sightings off Central California (Roberson & Bailey 1991). Other confirmed sightings of Cook's Petrel include one near the San Juan Seamount (137 km south of Pt. Conception) and another 105 miles southwest of Pt. Conception, both in August 1984 (Roberson 1986). There is one possible prior sighting from the Davidson Seamount, a single bird photographed in November 1979; however it is possible that the sighting is of a De Filippe's Petrel (*Pterodroma defilippiana*) and not a Cook's Petrel (Roberson 1986). More recent sightings include 185 individuals off Monterey Bay in 2009 and 237 off of Santa Barbara at the San Juan Seamount in 2010 (NARBA 2009, NARBA 2010). While no longer considered a species on the list of California Rare Birds (CRBC), the number of birds recorded at the Davidson Seamount is by an order of magnitude the greatest number ever observed in California waters (Rogers et al. 2011).

One of the only studies of seabirds above and around a seamount, Fieberling Guyot (980 km west of San Diego, California), found Cook's Petrel both above the seamount and "away" from the seamount (> 30 km; (Haney et al. 1995). The surveys also recorded Leach's Storm-Petrel, but only in areas away from the seamount. Total seabird abundance was significantly greater over the seamount vs. away (0.67 birds km^{-2} and 0.27 birds km^{-2}, respectively; (Haney et al. 1995); however, these values are much less than what was observed at the Davidson Seamount (1.7 birds km^{-2}). Both this study and the study by Haney et al. (1991) are single surveys, in very different locations, many years apart, making comparisons between the two only speculative.

In comparison to the aerial surveys conducted earlier in 2010, observers identified 2 grey whales, a killer whale, a Cuvier's beaked whale, and a single sperm whale on January 14th. During the April aerial survey, observers identified 2 sperm whales, 2 humpback whales, and a single blue whale. Due to the constraints of an aerial survey, it is unknown if the large whales identified were foraging at the time of the sightings. Seabirds are often difficult to identify to species during aerial surveys; however, during the January survey, observers recorded several storm-petrel sightings. The only other aerial survey of the Davidson Seamount occurred during July 2000. Observers recorded one sighting each of Risso's dolphin (*Grampus griseus*), Black-footed Albatross (*Phoebastria nigripes*), and ocean sunfish (number of individuals per sighting is unknown; MacKnight *et al.* 2011). In 2002, during an ROV expedition to the Davidson Seamount, observers maintained a visual watch onboard the *R/V Western Flyer* for marine mammals, seabirds, and surface active fishes (Benson 2002). Overall, 22 sightings of 8 species were recorded. Dall's porpoise was the most common sighting (19 observations of 51 individuals), while Pacific-white sided dolphin was the most abundant marine mammal observed (one observation of 450 individuals). The most common seabird species encountered was the Black-footed Albatross (Benson 2002). All other marine mammal and seabird species observed during the July 2010 survey, including the three migrating shorebird species, were within their normal summertime natural history

distributions. While difficult to make comparisons between the aerial surveys and the two at-sea surveys, it is evident from the data that large whales, dolphins, and storm-petrels are utilizing the Davidson Seamount and surrounding waters.

Very little quantitative data exists for marine mammal and seabird distribution data over seamounts, thus it is difficult to compare our results to other at-sea surveys, especially for marine mammals. Data from the at-sea surveys, along with the sightings from the two 2010 aerial surveys, will serve as baseline data for future Davidson Seamount surveys.

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Appendix I

Daily Operations Summary

Thursday July 22, 2010
Media day event onboard *McArthur II* with reporters & photographers from the Santa Cruz Sentinel & Watsonville Register-Pajaronian newspapers.
http://www.santacruzsentinel.com/ci_15583590
http://www.register-pajaronian.com/fe_view_article_window.php?story_id=9188&page_id=72&heading=0
http://www.montereyherald.com/local/ci_15584684?nclick_check=1

Observers were brought onboard by the ship's RHIB from Santa Cruz Harbor around 1500. The ship pulled anchor and departed Santa Cruz around 1600. The ship initially transited west past the Long Marine Lab campus at Terrace Point before heading out to the Davidson Seamount.

The ship arrived at the Davidson Seamount just past 2300. The night crew completed CTD casts and Bongo net tows at stations 16W and 16M. Squid jigging took place during the CTD cast at each station, unfortunately no squid were caught. Once both stations were complete the ship transited to point 0E to wait for daytime operations to commence.

Friday July 23, 2010
Began daytime operations at station 0E at 0700. All transect lines are to the NW or SE at a ship speed of 10 kts +/- 0.5 kts. Completed transect lines 0 and 4, and portion of transect 8 under overcast skies with very light wind and calm seas. We had to deviate from transect line 4 to avoid a large ship, however we remained "on-effort" searching for marine mammals and seabirds the entire time.

Nighttime operations took place between 2000 and 0200.We conducted CTD casts and Bongo net tows at stations 4W, 4M, & 4E. Squid jigging took place during the CTD cast at each station, but once again no squid were caught. At the completion of station 4E, the ship transited to the break-off point on transect 8.

Saturday July 24, 2010
Daytime operations began again at 0700 at the break-off point on transect 8 from Friday. We finished the remainder of transect 8, transect 12, and a portion of transect 16 prior to 1900. We went "off-effort" during transect 8 to identify and count a large school of Pacific white-sided and northern right whale dolphins. Each observer provided an independent estimate of the best/high/low numbers of animals in the school with the percentage of each species. A reasonable average was determined based on the estimates. Weather was again overcast with calm seas and light wind.

Nighttime operations commenced at 2000 and finished around 0300 Sunday morning. We occupied 4 stations (10E, 10M, 10W, & 16E) and conducted CTD casts and Bongo net tows at each station. We caught no squid while jigging during each CTD cast. At the completion of Station 16E, the ship transited to the break-off point on transect 16.

Sunday July 25, 2010

Daytime operations began again at 0700 at the break-off point on transect 16 from Saturday. Weather was the same, overcast skies and calm seas, but with more wind (Beaufort 3 conditions all day). We finished the remainder of transect 16 and all of transect 20. We had extra time to survey, so we added 2 additional transects. Transect 24 is parallel to, and 4 miles north of, transect 20. We ended transect 24 at the axis of the seamount. We then made a 90 degree left turn to complete a transect down the axis of the Davidson Seamount. We went "off-effort" for approximately 2 miles from the turning point to avoid double counting any marine mammals or seabirds. The axis transect (transect 25) began at almost the same location as station 22M and continued along the axis until 1845 when the ship had to return to complete station 22M prior to departing the Davidson Seamount for San Francisco.

The ship reached station 22M around 2000 and conducted a CTD cast and Bongo net tow. One last attempt to jig for squid was unsuccessful. After the completion of the Bongo net tow at 2200 the ship departed the seamount and headed for San Francisco.

Monday July 26, 2010

After traveling north all night, the ship was 15 miles off of Half Moon Bay at sunrise. No marine mammal or seabird observations were conducted. Due to tide restrictions, we could not go under the Golden Gate Bridge until the early afternoon. The ship docked at Pier 27 in San Francisco at approximately 1500. We offloaded all of our gear and returned to Santa Cruz/Monterey.

Appendix II

Transect Lines

ID	Latitude	Longitude	ID	Latitude	Longitude	Distance (km)
0E	35.325	-122.477	0W	35.797	-123.270	88.88
4E	35.383	-122.424	4W	35.855	-123.217	89.03
8E	35.441	-122.371	8W	35.913	-123.164	86.16
12E	35.498	-122.317	12W	35.971	-123.111	88.61
16E	35.556	-122.264	16W	36.029	-123.058	88.84
20E	35.613	-122.211	20W	36.087	-123.005	88.51
24E	35.672	-122.164	24M	35.903	-122.556	43.74
25NE	35.88	-122.579	25SE	35.651	-122.771	30.77

CTD Station Locations

Station	Latitude	Longitude
4E	35.5807	-122.7515
4M	35.6230	-122.8217
4W	35.6597	-122.8836
10E	35.6700	-122.6797
10M	35.7051	-122.7394
10W	35.7459	-122.8077
16E	35.7538	-122.5943
16M	35.7932	-122.6598
16W	35.8314	-122.7250
22M	35.8799	-122.5856

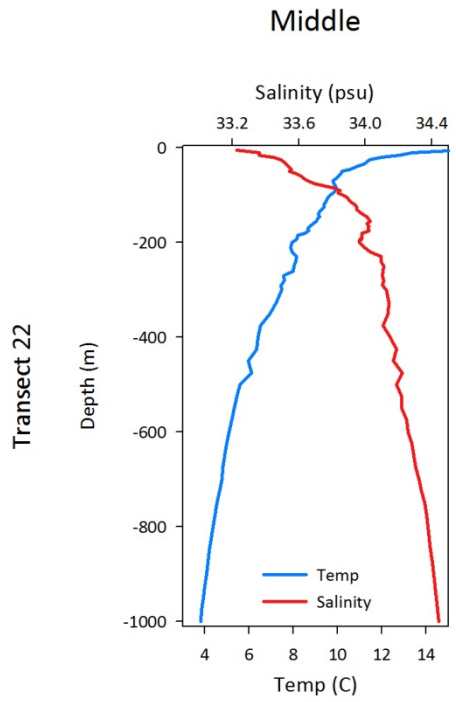
Bongo Net Tow Locations

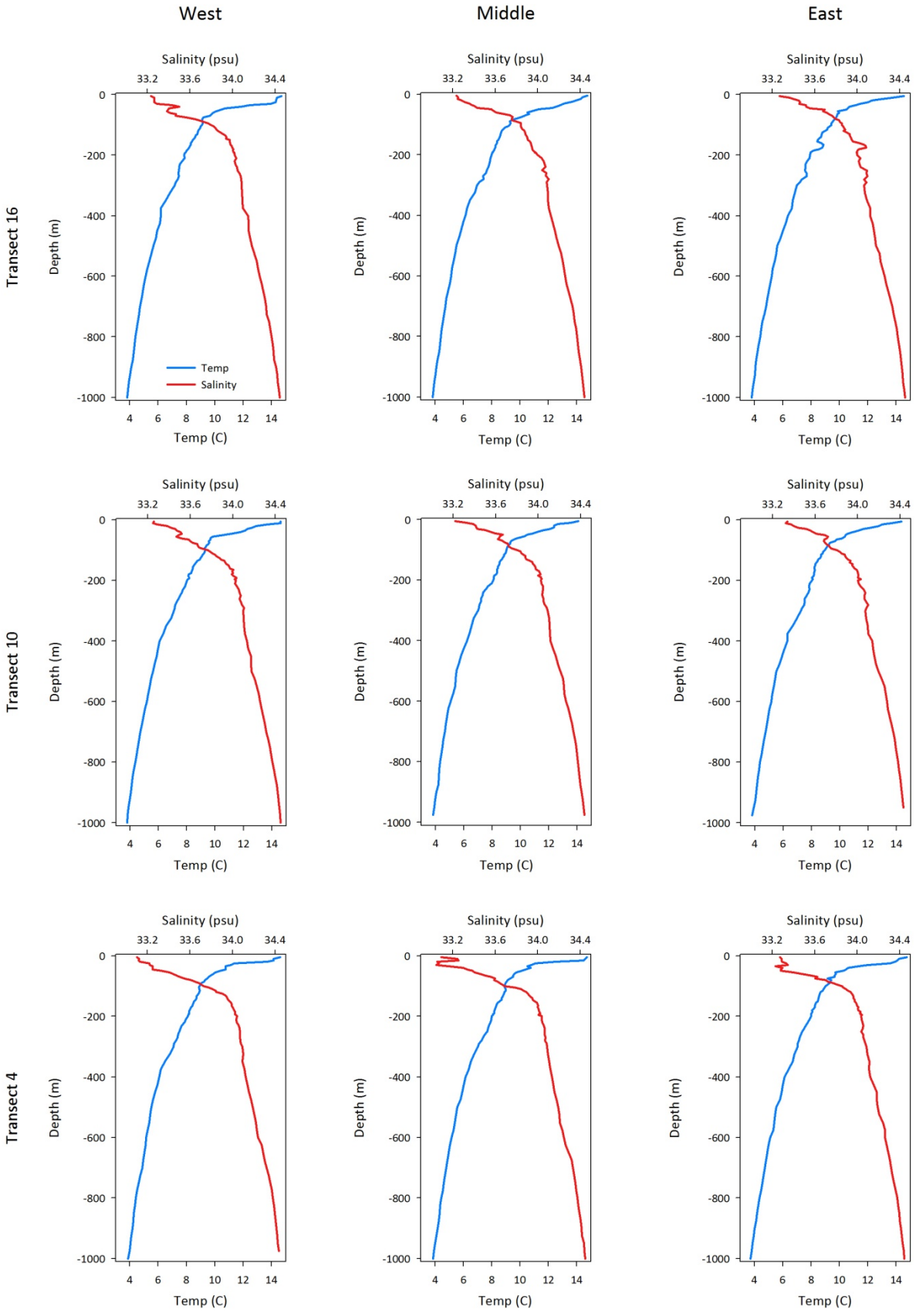
Station	Latitude	Longitude
4E	35.5809	-122.7522
4M	35.6239	-122.8342
4W	35.6616	-122.8892
10E	35.6673	-122.6777
10M	35.7075	-122.7390
10W	35.7465	-122.8076
16E	35.7521	-122.6053
16M	35.7949	-122.6626
16W	35.8385	-122.7343
22M	35.8824	-122.5844

Appendix III

Water Column profiles

Temperature (blue) and Salinity (red) profiles from each of the 10 CTD casts.




West
Middle
East
Transect 16
Transect 10
Transect 4
Salinity (psu)
33.2 33.6 34.0 34.4
Depth (m)
0 -200 -400 -600 -800 -1000
Temp
Salinity
4 6 8 10 12 14
Temp (C)

Appendix IV

Seabird & Marine Mammal Sightings

		Day 1 - July 23, 2010		Day 2 - July 24, 2010		Day 3 - July 25, 2010		Overall Total		Seabirds
Seabird Species	Scientific Name	# Sightings	# of Individuals	# Sightings	# of Individuals	# Sightings	# of Individuals	# Sightings	# of Individuals	per km^2
Cook's Petrel	*Pterodroma cookii*	39	166	42	235	40	106	121	507	8.39
Leach's Storm Petrel	*Oceanodroma leucohoa*	55	191	42	82	27	65	124	338	5.59
Red-necked Phalarope	*Phalaropus lobatus*	6	33	5	52	1	1	12	86	1.42
Red Phalarope	*Phalaropus fulicarius*	9	11	3	11	5	9	17	31	0.51
Least Sandpiper	*Calidris minutilla*	2	14					2	14	0.23
Arctic Tern	*Sterna paradisaea*	5	5	3	3	6	6	14	14	0.23
Short-billed Dowitcher	*Limnodromus griseus*	1	11					1	11	0.18
Xantus' Murrelet	*Synthiloboramphus scrippsi*	3	4	1	1	3	4	7	9	0.15
Black-bellied Plover	*Pulvialis squatarola*			1	6			1	6	0.10
Long-tailed Jaeger	*Stercorarius longicaudus*					3	3	3	3	0.05
Pink-footed Shearwater	*Puffinus creatopus*	1	1	2	2			3	3	0.05
Sooty Shearwater	*Puffinus griseus*	1	1	1	1	2	2	4	4	0.07
Black-footed Albatross	*Phoebastria nigripes*			1	1			1	1	0.02
Cassin's Auklet	*Ptychoramphus aleuticus*			1	1			1	1	0.02
Northern Fulmar	*Fulmaris glacialis*	1	1					1	1	0.02
California Gull	*Larus californicus*					1	1	1	1	0.02
Western Gull	*Larus occidentalis*					1	1	1	1	0.02
Unidentified Alcid		1	1					1	1	0.02

Unidentified Tern				1	1			1	1	0.02
Total	124	439	103	396	89	198	316	1033	17.09	

		Day 1 - July 23, 2010		**Day 2 - July 24, 2010**		**Day 3 - July 25, 2010**		**Overall Total**		**Marine Mammals**
Marine Mammals	Scientific Name	# Sightings	# of Individuals	# Sightings	# of Individuals	# Sightings	# of Individuals	# Sightings	# of Individuals	per km
Fin Whale	*Balenoptera physalus*	19	36	45	87	38	74	102	197	0.33
Northern Right Whale Dolphin	*Lissodelphis borealis*			1	165					0.27
Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	1	5	1	135			2	140	0.22
Dall's Porpoise	*Phocoenoides dalli*	11	38	4	15	6	25	21	78	0.13
Northern Fur Seal	*Callorhinus ursinus*	29	35	8	8	5	5	42	48	0.08
Unidentified Rorqual				4	6	3	3	7	9	0.01
California Sea Lion	*Zalophus californianus*	4	4			2	2	6	6	0.01
Elephant Seal	*Mirounga angustirostris*	3	3	3	3			6	6	0.01
Unidentified Fur Seal		4	4					4	4	0.01
Unidentified Ziphiid						1	4	1	4	0.01
Unidentified Otariid		3	3			1	1	4	4	0.01
Unidentified Dolphin		3	5					3	5	0.01
Unidentified Pinniped		2	2					2	2	0.00
Total		79	135	65	419	56	114	200	668	1.1

Appendix V

Total Seabirds Observed

Written by:
Peter Pyle, Lead Seabird Observer
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22 July 2010. Boarded NOAA Ship *McArthur II* in Santa Cruz harbor at 1500 and departed harbor around 1600. Had to perform drills and get survey ready. Noted a few seabirds, nothing out of the ordinary.

23 July 2010. Performed 2+ ~50 nmi of transects in SE-to-NW orientation over the SW end of Davidson Seamount. Began at 0700 at station 35.325 N 122.477 W, up to station 35.797 N 123.270 W, in four miles to 35.855 N 123.217 W, back down to 35.383 N 122.424 W, and then partially back up to 35.591 N 122.621 W by 2000. Weather calm with high overcast all day. Coastal assemblage at very SE end of grid with rest of time (all but 2 hr) in pelagic assemblage over and to NW of seamount. Totals:

Black-footed Albatross - 2
Northern Fulmar - 3 dark-morphs
Cook's Petrel 3,005. Hourly totals: 50, 65, 85, 500, 450, 1000, 450, 250, 50, 15, 15, 25, 60. At least 8 flocks of 100-300 sitting birds observed, and 10-30 flying birds in view at all times through most of day. Photos of up to 90.
Buller's Shearwater 2
Pink-footed Shearwater 5
Sooty Shearwater 14
Leach's Storm-Petrel 1,745 with hourly peak of 400 between 1300 and 1400. Two dark-rumped birds noted. Good proportion of birds in inner-primary molt.
Semipalmated Plover 1 - this and most of following coastal shorebirds circling boat at dawn and within first two hours.
Whimbrel 4
Western Sandpiper 4
Least Sandpiper 84
Short-billed Dowitcher 37
Red-necked Phalarope 98 most/all adults
Red Phalarope 31 adults
Western Gull 2
Arctic Tern 29 about 50/50 adult/SYs
Long-tailed Jaeger 1 SY
Xantus' Murrelet 18 - At least 12 scrippsii and 1 hypoleuca
Rhinoceros Auklet - 1
Ash-throated Flycatcher - 1 HY on boat through morning
Fin Whale 30
Cuvier's Beaked-Whale 2
Pacific White-sided Dolphin 5
Dall's Porpoise 25
N Elephant Seal 6

N Fur Seal 20
Guadalupe Fur Seal 1 possible
California Sea Lion 15
Steller's Sea Lion 1 possible
Mola Mola 5
Blue Shark 1
Mako Shark 1
Albacore 20
Pacific Saurry - several schools jumping

24 July 2010. Continued performing parallel transects from yesterday, gradually heading NE. Began at 0700 where we left off yesterday at 35.591 N 122.621, heading NW to 35.913 N 123.164 W, then NE four nmi to 35.971 N 123.111 W, down transect to 35.498 N 122.317 W, four miles NE to 35.556 N 122.264 W and back to near the top of the mount at 35.847 N 122.751 W. Weather similar to yesterday but winds slightly stronger 5-10 knots, and overcast a bit lower. Coastal assemblage continued at SE end of grid but spent more time today in this water mass - line appears generally N-S so as we work east we seem to spend more time in coastal and less time in pelagic waters. Totals:

Black-footed Albatross 5
Northern Fulmar 1 dark-morph
Cook's Petrel 1,395. Hourly totals: 40, 250, 350, 175, 100, 200, 20, 35, 20, 5, 100, 100. Fewer flocks of sitting birds but more flying birds in broad fronts heading generally NNE. Some flying high, 10-20 m above water (photos) and flapping like gulls. A couple small dark ones may have been Pycrofts and one with white collar and seemingly fresher plumage photographed.
Buller's Shearwater 1
Pink-footed Shearwater 5
Sooty Shearwater 4
Leach's Storm-Petrel 666. Four dark-rumped and about 10% Guadalupe types.
Black-bellied Plover 6 in full breeding plumage headed S at end of day.
Least Sandpiper 1 early in day
Short-billed Dowitcher 1 early in day
Red-necked Phalarope 187 most/all adults
Red Phalarope 50 adults
Arctic Tern 17 about 50/50 adult/SYs
South Polar Skua 6
Pomarine Jaeger 1
Long-tailed Jaeger 5 - 4 SYs and 1 TY.
Xantus' Murrelet 2 scrippsii
Cassin's Auklet - 1
Fin Whale 60
Pacific White-sided Dolphin 150
Northern Right Whale Dolphin 200
Dall's Porpoise 12
N Elephant Seal 5
N Fur Seal 7
California Sea Lion 3
Mola Mola 2
Blue Shark 1

Salmon Shark 1
Albacore 20

25 July 2010. Continued performing parallel transects from yesterday, gradually heading NE. Began at 0700 where we left off yesterday at 35.847 N 122.751 W, heading NW to 36.029 N 123.058 W, then NE four nmi to 35.613 N 122.211 W, down transect to 36.087 N 123.005 W, four miles NE to 35.672 N 122.164 W, back to the spine of the mount at its NE end (35.879 N 122.580 W) then SW down the spine until 1845, ending the day at 35.651 N 122.778 W. Weather again similar to yesterday but winds slightly stronger, 8-13 knots. Assemblages continue to be pelagic toward NW and coastal toward the SE. Totals:

Black-footed Albatross 5
Northern Fulmar 1 dark-morph, 1 dead light-morph
Dark-rumped Petrel - 1. See description below.
Cook's Petrel 725. Hourly totals: 55, 200, 250, 75, 5, 5, 50, 5, 60, 10, 6, 4.
Pink-footed Shearwater 3
Sooty Shearwater 7
Leach's Storm-Petrel 425. Two dark-rumped and about same proportion of Guadalupe types as yesterday.
Baird's Sandpiper 1 landed on ship at end of day, above center of Davidson Seamount.
Red-necked Phalarope 14
Red Phalarope 27
California Gull 1
Western Gull 2
Arctic Tern 15
South Polar Skua 2
Long-tailed Jaeger 10. 2 adults
Xantus' Murrelet 10 most/all scrippsii
Rhinoceros Auklet - 1
Fin Whale 80
Cuvier's Beaked Whale 2
Baird's Beaked whale 2-6 probables
Pacific White-sided Dolphin 75
Northern Right Whale Dolphin 75
Dall's Porpoise 25
N Elephant Seal 3
N Fur Seal 8
California Sea Lion 1
Mola Mola 6
Salmon Shark 1
Albacore 5

Dark-rumped Petrel - 1. At 35.693 N 122.732 W, over Davidson Seamount, 62.76 miles (101 km) SW (bearing 227°) of Point Sur, MTY, at 1903. Abe Borker and I had just finished censusing birds and were beginning to pack up the flying bridge, at 15 m above the water surface. Weather was high overcast and fairly bright. We had been studying 1000's of Cook's Petrels over the past three days but had identified no other *Pterodroma* petrels. I noticed a large, dark-backed *Pterodroma* petrel flying left to right (south at that point) about 400 m in front of the vessel. I looked for about 2

seconds with 10x binoculars then alerted Abe reached for my camera. I could not find it in my camera and took 4-5 shots of empty water. Abe did the same thing.

During my brief view I saw that it was mostly blackish on the back and upper surface of the wings. I did not notice any contrast, "M pattern" or otherwise, except for a darker crown than back and distinct white above the bill, typical of and unique to Dark-rumped among *Pterodroma* petrels. I did not see the underparts or enough detail of the head pattern to attempt distinguishing between Hawaiian and Galapagos petrels. The size was about in between those of Sooty and Pink-footed shearwaters, and the flight style and wing shape was diagnostic of *Pterodroma*. I recognized it immediately as one of the two Dark-rumped Petrel species based on field experience with about 100 birds and review of over 1,900 photographs of these petrels taken off Hawaii (ms. in review, North American Birds).

26 July 2010. About 15 nmi off Half Moon Bay at dawn, heading N to San Francisco. Moving slow to time docking in SF with slack tide this afternoon. Broke down equipment and worked on reports. Lots of murres (with chicks), Sooty Shearwaters, gulls etc. but did not notice anything unusual.