# HICEAS: Hawaiian Islands Cetacean and Ecosystem Assessment Survey

**October 26, 2010**


NATIONAL MARINE FISHERIES SERVICE

SOUTHWEST FISHERIES SCIENCE CENTER
PROTECTED RESOURCES DIVISION

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## Leg 3, *McArthur II* Report: 26 September to 25 October 2010


**Robert Pitman, Cruise Leader**


### 26 SEPTEMBER TO 05 OCTOBER 2010

This is the Leg 3 report from the 2010 Hawaiian Island Cetacean and Ecosystem Assessment Survey (HICEAS 2010) conducted aboard the NOAA Research Vessel *McArthur II*. The primary purpose of this 180-day voyage is to determine the distribution and abundance of whales and dolphins in Hawaiian waters, in part to help assess the impact of fisheries bycatch on their populations. The survey is a joint effort between the Southwest Fisheries Science Center, La Jolla, and the Pacific Island Fisheries Science Center, Honolulu, with survey work being conducted in conjunction with the NOAA Ship *Oscar Elton Sette*.

The study area includes the US Exclusive Economic Zone (EEZ) around the entire Hawaiian Island Chain, from the Big Island (Hawaii) to Kure Atoll, an area of roughly 400 x 1800 nautical miles (approximately 2.5 million km2; Fig. 1 below). Fig. 1 shows a plot of the tracklines for the entire survey as well as the planned tracklines for Leg 3.

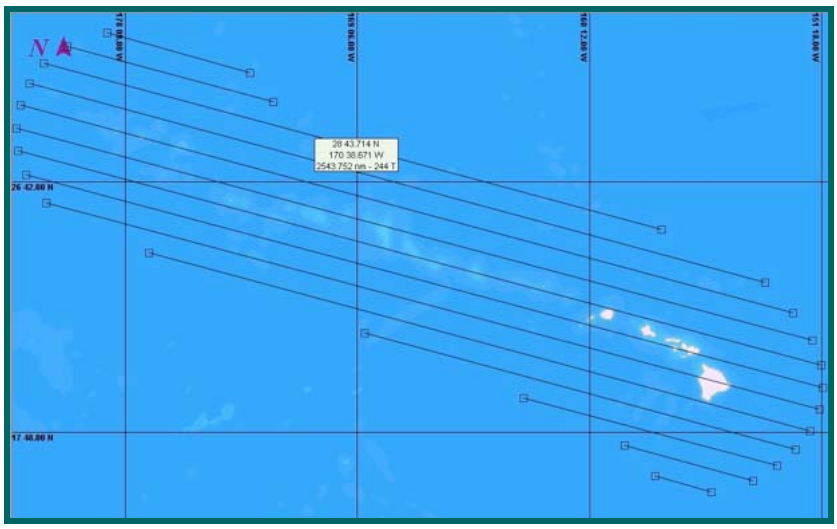

**Figure 1. HICEAS 2010 study area. Shown are the Hawaiian Islands, including the Northwest Hawaiian Islands; and the tracklines for the entire survey.**

During the survey we maintained a visual watch by six marine mammal observers, consisting of 2, 3-person teams with each observer rotating through a 2-hr-on and 2-hr-off watch schedule. Cetaceans were photographed as often as possible to confirm and document identifications, and to contribute to photo-identification catalogs of various species from on-going studies in the Hawaiian Islands. Biopsy samples were collected using crossbows and free-floating or tethered darts – we attempted to sample any animals that rode the bow and launched the RHIB boat for selected species of interest whenever time and weather allowed.

During the same periods when the visual team was on duty, a 3-person acoustics team monitored cetacean vocalizations using a towed hydrophone array that was deployed each morning at dawn and retrieved each evening at dusk (see below). In addition to the mammal observers, two bird observers rotated on 2-hr watches and conducted a 300-m bird and flyingfish strip transect survey during all daylight hours, weather permitting also. We monitored oceanographic conditions with a series of XBT drops throughout the day, morning and evening CTD stations, and maintained a constant record of acoustic backscatter using an EK60.The *McArthur II* departed Honolulu at 13:00 on 26 Sept 2010 and mammal observations began at 14:00. Beginning the next morning, we started a series of six grid lines south of the main Hawaiian Islands (Fig. 2); these lines would take us one day each to survey, and we transited between the lines at night; we finished these lines on the evening of 2 Oct. Due to favorable weather (mostly Beaufort Sea State 3-4), all six transect lines were almost completely surveyed. Cetacean density in this area was, as expected, fairly low averaging 5.3 sightings/day during the 6 days of survey. Sightings were dominated by blackfish: (Risso's dolphin, *Grampus griseu*s - 5 sightings, short-finned pilot whale, *Globicephala macrorhynchus* - 4, , pygmy killer whale, *Feresa attenuata* – 2, and false killer whale *Pseudorca crassidens* - 2) and small dolphins (spotted dolphin, *Stenella attenuata* - 5, striped dolphin, *S. coeruleoalba* - 4). The two false killer whale sightings consisted of single individuals, and no sperm whale, *Physeter macrocephalus* or rorquals (*Balaenoptera* spp.) were reported by the observer team, although the acoustic team did detect sperm whales. Biopsy samples collected from this offshore area included pygmy killer whale (3 samples/1 group), false killer whale (1), and short-finned pilot whale (4/1).

On 3 Oct we transited to the Papahānaumokuākea Monument area after surveying around the islands of Ka'ula and Niihau, then heading west toward Nihoa. Sightings during the transit included short-finned pilot whale - 2; rough toothed dolphin, *Steno bredanensis* – 2, and 1 each of spotted and spinner dolphins; biopsies included 1 spotted dolphin and 3 rough-toothed dolphin.

### 6 -25 October 2010

We conducted a 19-day survey in the Monument that began on the morning of 4 Oct and ended on the morning of 23 Oct. Instead of standardized track lines, we surveyed approximately along the 1000-ftm bottom contour as we traveled westward along the southern side of the banks, atolls and islands of the chain. We surveyed as far west as Laysan Island, circled around it, and then traveled back to Nihoa along the northern half of the archipelago. Nearly the entire planned cruise track in the Monument area was covered in good-to-excellent weather conditions, and although there were relatively few sightings (n = 86) the diversity was fairly high (minimum 13 species). The seven most commonly recorded taxa, accounting for 76% of the total sightings, included: Short-finned pilot whale (12 sightings/7 biopsies); Cuvier's beaked whale (12/0); Bryde's whale (12/5); *Ziphiid* sp. (10/0); rough-toothed dolphin (9/5); bottlenose dolphin (6/6) and false killer whale (4/17). There were surprisingly few sperm whale (3/1) and only one *Stenella* dolphin sighting (striped dolphin 1/1). A lone minke whale, *Balaenoptera acutorostrata*, that tarried in the ship's wake for 30 minutes was perhaps an early migrant.

After we finished our Monument tracklines on the morning of 23 Oct, because the weather was very good (Beaufort 2) and the test area was open, we began to survey a section of the *McArthur II* Leg 4 trackline that runs through a US Navy test area. That line ran from Niihau, to just NE of Kauai. After several hrs on that line, however, the seas kicked up to 20 kts and stayed that way until we got to Maui. At 1400 on 24 Oct, because the weather had slowed us down, Capt. Hubner announced that we had no more time for turning on sightings and we terminated effort and called off the evening CTD. We tied up to the pier in Kahului, Maui, at 0830 on 25 Oct (we were 0.5 hr late due to the weather).

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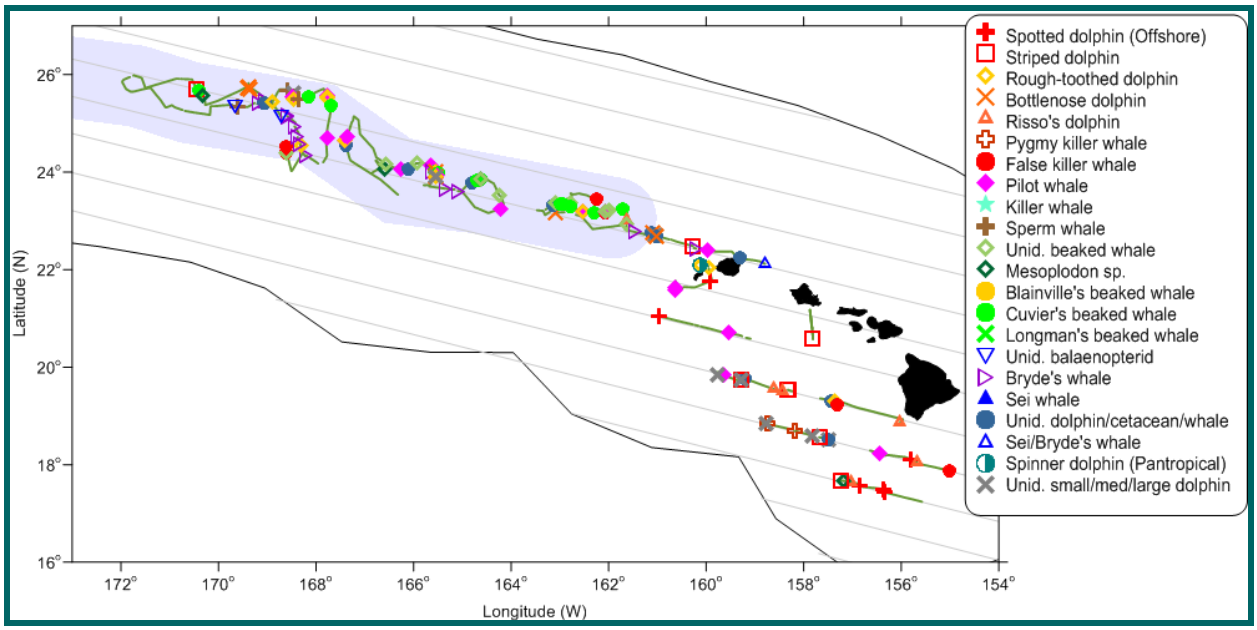



**Figure 2. Survey coverage during HICEAS Leg 3 showing Hawaiian Islands, the 200 mile EEZ (dark border lines), overall transect lines (light green parallel lines), cruise track covered during Leg 3 (dark green lines; see also Fig. 3), and the waters of Papahānaumokuākea Monument (light blue).**

## CETACEAN PHOTOGRAPHY REPORT - JIM COTTON AND CHRIS CUTLER

This leg of HICEAS 2010 was very good to the paparazzi, notably as our ranks swelled with the addition of Cornelia (having temporarily forsaken the acoustics lab for the flying bridge), Sophie (our on-the-spot, image-taking birder), and Dani (enthusiastic visiting acoustician who proved she's as adept at detecting high frequency 'clicks' as she is at creating them – on the shutter button). Though not always availing themselves readily to have their photos taken, the subaquatic 'models' made brief above-surface appearances and showed enough fin, and gave us enough head-shots, to make the camera-toters rather pleased. (Now if they could only work on the lighting). Among the 4236 photos we took this leg (see Table 1 below), dozens of which show uniquely scarred fins (the principal "fingerprint" used by cetologists for recognizing individual animals), included are a few of our favorites on pages 4-5.

Table 1. Summary of photographs.

| Species | No. sightings Leg 3 | No. photos Leg 3 | Total sightings | Total photos |
|---|---|---|---|---|
| Short-finned pilot whale | 13 | 934 | 17 | 1171 |
| Bryde's whale | 13 | 657 | 17 | 791 |
| Rough-toothed dolphin | 9 | 262 | 10 | 286 |
| Bottlenose dolphin | 7 | 265 | 8 | 269 |
| Striped dolphin | 5 | 23 | 12 | 193 |
| Risso's dolphin | 5 | 192 | 5 | 192 |
| False killer whale | 5 | 402 | 9 | 720 |
| Cuvier's beaked whale | 4 | 227 | 4 | 227 |
| Spotted dolphin | 3 | 25 | 3 | 25 |
| Pygmy killer whale | 2 | 751 | 3 | 757 |
| Sperm whale | 2 | 56 | 16 | 920 |
| Fraser's dolphin | 1 | 425 | 1 | 425 |

| Species | No. sightings Leg 3 | No. photos Leg 3 | Total sightings | Total photos |
|---|---|---|---|---|
| Common minke whale | 1 | 14 | 1 | 14 |
| Unidentified medium delphinid | 1 | 3 | 1 | 3 |
| Long-beaked common dolphin | | | 2 | 10 |
| Short-beaked common dolphin | | | 3 | 36 |
| Longman's beaked whale | | | 2 | 943 |
| Sei whale | | | 1 | 13 |
| Blue whale | | | 2 | 74 |
| Unidentified rorqual | | | 2 | 20 |
| **Total** | **71** | **4236** | **119** | **7089** |

**Photographers: JC: Jim Cotton; CC: Chris Cutler; CO: Cornelia Oedekoven; SW: Sophie Webb.**

**Photographers: DC: Danielle Cholewiak; JC: Chris Cutler; JC Jim Cotton; CO: Cornelia Oedekoven.**

## Cetacean Biopsy Report –Suzanne Yin

Leg 3 was one of those fun, yet scientifically successful legs. With an extended period of excellent weather, we were able to launch the RHIB almost every day, and we collected tissue samples from 9 different species (see table). Perhaps most importantly, we were able to add to our tally of false killer whales, one of the key target species of this cruise. Analysis of these samples will commence almost immediately, with samples being sent back to San Diego during this in-port. Hopefully these efforts will lead to a better understanding of the population structure of false killer whales.

Many thanks to our coxswains, Dave Hermanson and David LaPointe, for their excellent RHIB driving, as well as all the scientists who helped with samples and small boat operations. Thanks also to mammal observers (Richard Rowlett in particular) who stayed on flying bridge and directed the launch to the animals. We really appreciate all your help. Also, we are looking forward to the return of our wayward team member, Desray Reeb, who will rejoin the team for legs 4-5.

Table 2: Summary of biopsy effort.

| Species | Common name | No. samples: Leg 3 | Total samples | No. takes Leg 3 | Total takes |
|---|---|---|---|---|---|
| *Balaenoptera edeni* | Bryde's whale | 6 | 6 | 9 | 9 |
| *Feresa attenuata* | Pygmy killer whale | 3 | 3 | 15 | 15 |
| *Globicephala macrorhynchus* | Short-finned pilot whale | 11 | 11 | 22 | 22 |
| *Physeter macrocephalus* | Sperm whale | 1 | 4 | 34 | 37 |
| *Pseudorca crassidens* | False killer whale | 18 | 27 | 29 | 38 |
| *Stenella attenuata* | Pantropical spotted dolphin | 1 | 1 | 1 | 1 |
| *Stenella coeruleoalba* | Striped dolphin | 1 | 1 | 1 | 1 |
| *Steno bredanensis* | Rough-toothed dolphin | 8 | 8 | 22 | 22 |
| *Tursiops truncatus* | Bottlenose dolphin | 12 | 13 | 18 | 19 |
| | **Total** | **61** | **74** | **151** | **164** |

## Cetacean Acoustics Report – Tina Yack, Anne Simonis and Eiren Jacobson

The first few days of the leg began with the acoustics team doing array surgery. This extensive operation involved splicing the new Oil-6 array onto the deck cable (see photos below). The new array is comprised of 2 mid-frequency hydrophones and 3 high frequency hydrophones. After 2 1/2 days of splicing and testing the array was deployed on 29 Sept.

**Photographs of array splicing procedure from 26-28 September 2010.**

This leg the acoustics team eavesdropped underwater for approximately 259 hrs of standard effort and spent 33 hrs on acoustic chase (Table 3). During this time we had 141 acoustic detections (Table 4; Fig. 3). Several new species were added to the list of HICEAS encounters this leg, including bottlenose dolphins (8), Cuvier's beaked whale (8), Risso's dolphin (4), pygmy killer whale (2), *Mesoplodon* sp. (2), and Fraser's dolphin (1). Other acoustic encounters included sperm whale (13), pilot whale (11), rough-toothed dolphin (7), false killer whale (4), and spotted and striped dolphin (4).

This leg 18% of our acoustic detections were beaked whales. At the beginning of the leg visiting scientist T. Yack added a new acoustics tool to the suite of computer software: a PAMGUARD computer was set up and configured for automated echolocation click detection and beaked whale classification; it also provided a chirping alarm when beaked whale clicks are detected.

Table 3. Acoustic monitoring effort by leg.

| Leg | Start date | End date | Time on effort (HH:MM:SS) | Time on chase (HH:MM:SS) | Total time |
|---|---|---|---|---|---|
| 1 | 0/08/2010 | 08/21/2010 | 125:42:17 | 2:10:40 | 127:52:57 |
| 2 | 08/28/2010 | 09/22/2010 | 322:51:43 | 10:09:49 | 333:01:32 |
| 3 | 09/29/2010 | 10/25/2010 | 25840:03 | 33:11:39 | 291:51:42 |

Table 4. Acoustic detections by leg - species designations are for those species matched to a visual sighting.

| Species | Leg 1 total | Leg 2 total | Leg 3 total | Grand total |
|---|---|---|---|---|
| *Tursiops truncatus* | 0 | 0 | 8 | 8 |
| *Pseudorca crassidens* | 0 | 7 | 4 | 11 |
| *Probable Pseudorca crassidens* | 0 | 0 | 4 | 4 |
| *Lagenodelphis hosei* | 0 | 0 | 1 | 1 |
| *Globicephala macrorhynchus* | 1 | 0 | 11 | 12 |
| *Feresa attenuata* | 0 | 0 | 2 | 2 |
| *Grampus griseus* | 0 | 0 | 4 | 4 |
| *Steno bredanensis* | 1 | 0 | 7 | 8 |
| *Physeter macrocephalus* | 16 | 48 | 13 | 77 |
| *Stenella attenuata* | 3 | 1 | 4 | 8 |
| *Stenella coeruleoalba* | 0 | 8 | 4 | 12 |
| *Ziphius cavirostris* | 0 | 0 | 8 | 8 |
| *Indopacetus pacificus* | 0 | 2 | 0 | 2 |
| Probable beaked whale | 0 | 2 | 11 | 13 |
| Unid. Ziphiid | 0 | 0 | 4 | 4 |
| *Mesoplodon* sp. | 0 | 0 | 2 | 2 |
| Mixed dolphin | 0 | 0 | 5 | 5 |
| Unid. cetacean | 0 | 1 | 13 | 14 |
| Unid. dolphin | 26 | 58 | 36 | 120 |
| **Total** | **47** | **127** | **141** | **315** |

PAMGUARD successfully complemented the suite of acoustic protocols that were already in place and aided in beaked whale click detection and tracking (Fig. 4). The PAMGUARD click detector now features a Wigner transform plot that can be displayed on selected clicks in real-time. The Wigner transform maps a 1D time signal into a 2D time frequency representation, with time along the x-axis and frequency along the y-axis. This feature allowed acoustic technicians to easily discriminate between beaked whale echolocation (a frequency upsweep is visible in the Wigner plot: see Fig. 4c) and dolphin echolocation, and also led to a newly-discovered ability to discriminate pilot whale clicks (a frequency downsweep is visible in the Wigner plot: see Fig. 5c). Rainbow Click software was also used to detect clicks on the mid-frequency and high-frequency hydrophones this leg.

The use of automated click detectors this leg also enabled the acousticians to verify separate animal subgroups. Examples of this using both PAMGUARD and Rainbow Click are shown in Figs. 6 and 7. In the first example showing PAMGUARD software, two subgroups of rough-toothed dolphins were detected during the encounter at ~115º and ~165º (Fig. 6). In the second example Rainbow click software shows three subgroups of Risso's dolphin detected at ~15º, 30º, and ~60º.

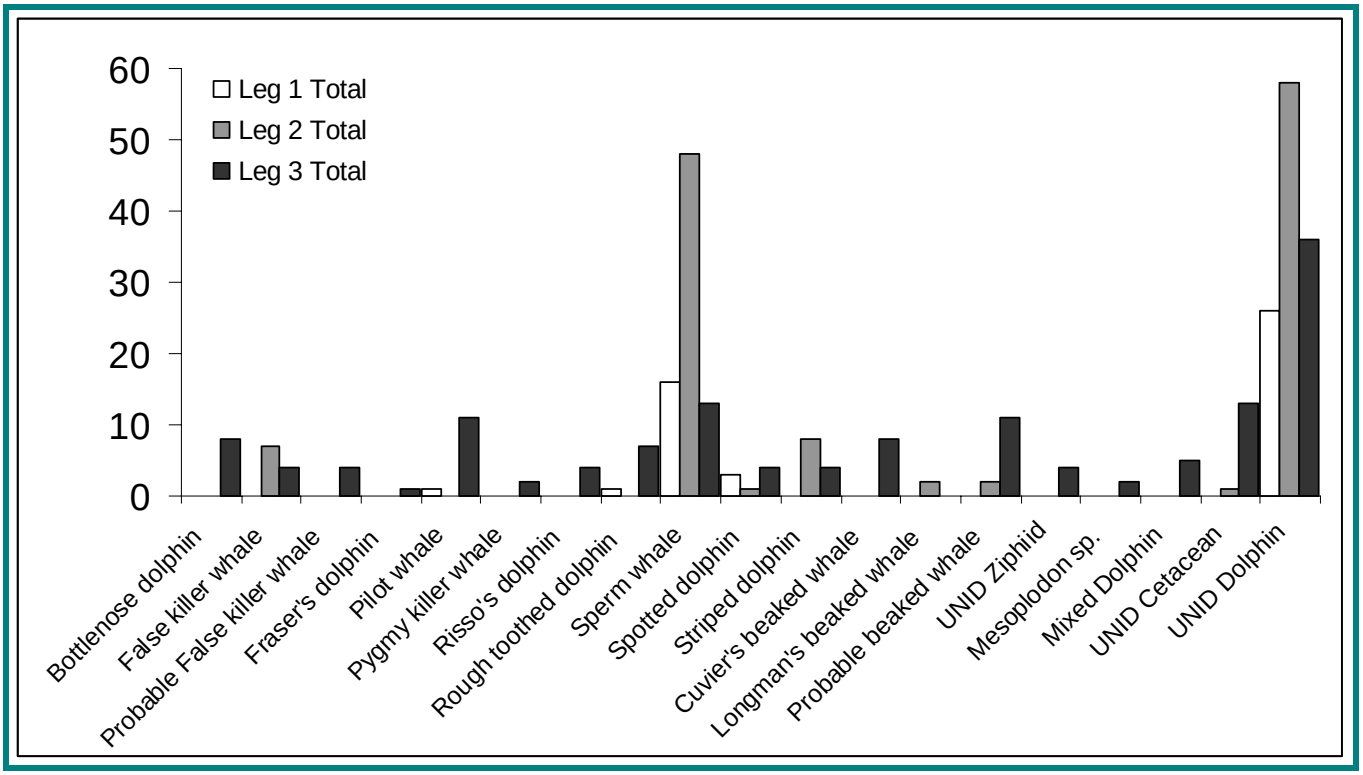



**Figure 3. Acoustic encounters for each species and acoustic ID category by survey leg; Leg 1 (white); Leg 2 (gray); Leg 3 (black).**

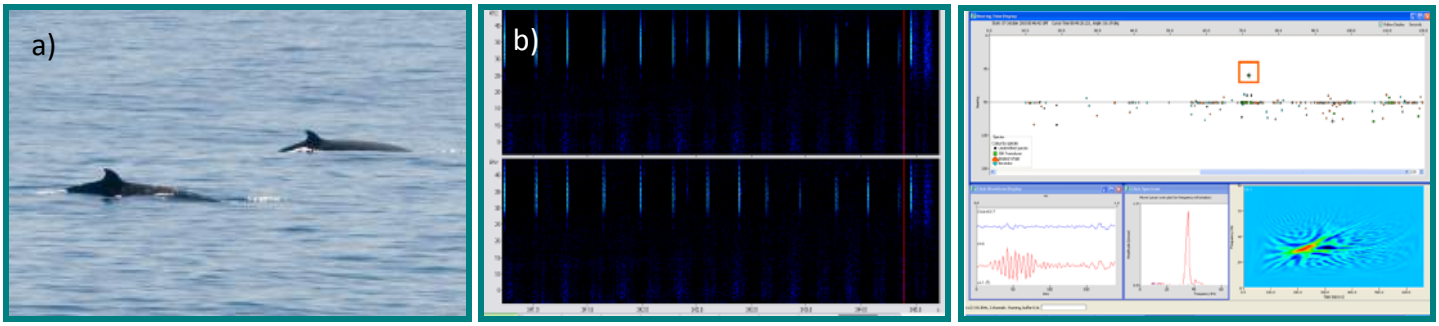



**Figure 4. *Ziphius cavirostris*, Cuvier's beaked whale. a) Photograph showing 2 of multiple individuals encountered in several groups on 19 October 2010. b) Spectrogram showing click train recorded during an encounter on 17 October 2010 (SR: 96kHz, FFT 1024, Hanning, overlap 50%). c) Beaked whale click detection using PAMGUARD. The top panel shows the bearing of an echolocation click, the bottom panels show the waveform on the two high-frequency hydrophones (left), the frequency spectrum (middle), and the Wigner transform plot (right). Note that this example and the spectrogram example are from different time periods.**

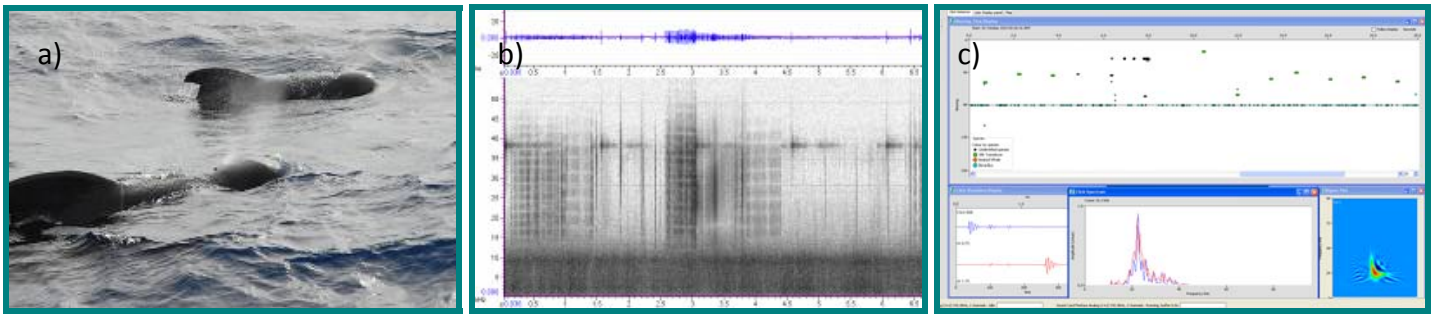



**Figure 5. *Globicephala macrorhynchus*, short-finned pilot whale. a) Photograph showing two adults near vessel during an encounter on 2 October 2010. b) Spectrogram showing echolocation clicks recorded during an encounter on 18 October 2010 (SR: 192kHz, FFT 2048, Hanning, overlap 50%). c) Pilot whale click detection and classification using PAMGUARD. The top panel shows the bearing of an echolocation click train, the bottom panels show the waveform on the two high-frequency hydrophones (left), the frequency spectrum (middle), and the Wigner plot (right). Note that this example and the spectrogram example are from different time periods.**

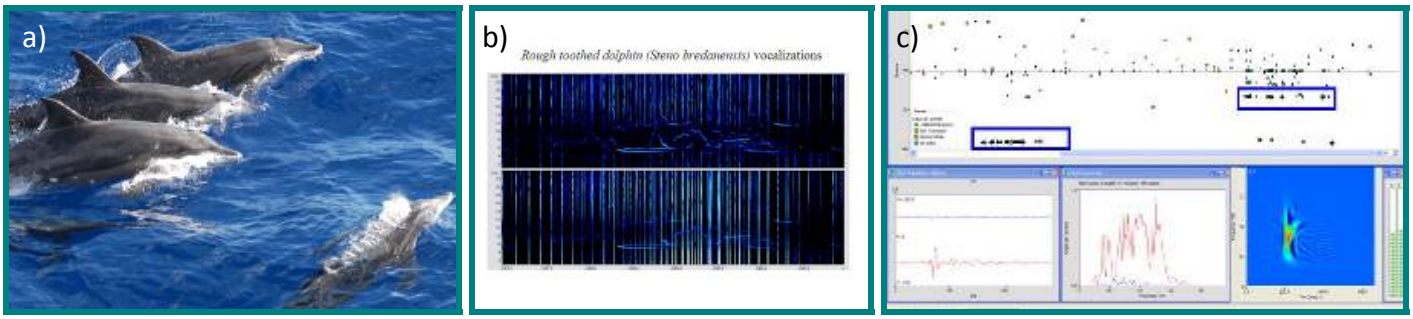



**Figure 6. *Steno bredanensis*, rough-toothed dolphin. a) Photograph showing small subgroup of *S. bredanensis* individual approaching boat. b) Spectrogram showing whistles and echolocation clicks recorded on two channels (SR: 96 kHz, FFT 1024, Hamming, overlap 75%). c) Click detection/classification using PAMGUARD. The blue boxes in the top panel indicate the echolocation click trains (bearing relative to ship is along the y-axis). The bottom panels show the waveform on the two high-frequency hydrophones (left), the frequency spectrum (middle), and the Wigner plot (right). Note that this example and the spectrogram example are from different time periods.**

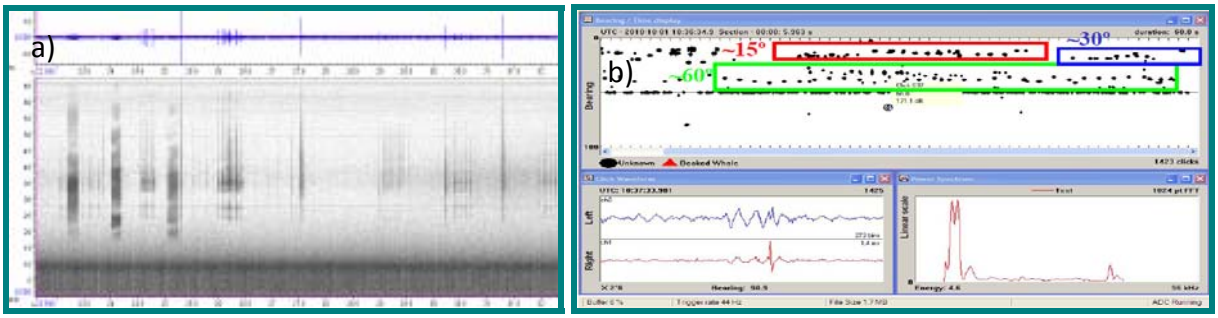



**Figure 7. *Grampus griseus*, Risso's dolphin. a) Spectrogram showing echolocation clicks and buzzes recorded during an encounter on 22 October 2010 (SR: 192kHz, FFT 2048, Hanning, overlap 50%). b) Detection of *G. griseus* echolocation using Rainbow Click with the mid-frequency system. The top panel shows the bearing of separate echolocation click trains, one at 15° and one at 30° (and the EK60 38kHz at 60°), the bottom panels show the waveform on the two mid-frequency hydrophones (left), the frequency spectrum (right), of one click. Note that this example and the spectrogram example are from different time periods.**

Another goal of the added acoustic PAMGUARD platform this leg was to compare automated localization of groups using click detection to standard manual tracking of groups using Ishmael and Whaltrack software. This worked very well in some cases when there were small groups of animals with clear click trains. An example of this comparison is shown in Fig. 7.

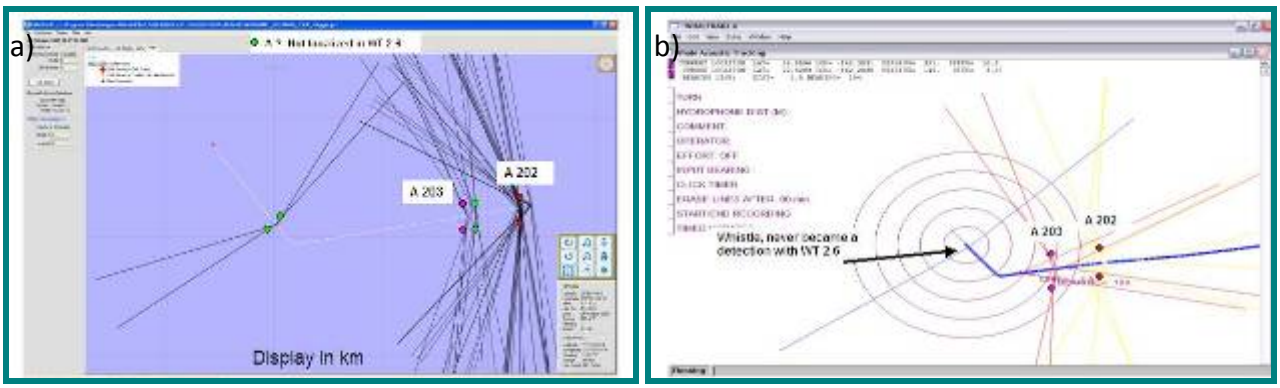



**Figure 8. Acoustic localization of dolphin groups using phone-pair bearing methods. The lines show bearings to detected vocalizations and the dots indicate convergences to the group location. a) Shows the PAMGUARD map display (kilometers) to three groups of dolphins on 20 October and b) shows the simultaneous Whaltrack map display (nautical miles).**

Successful acoustic detection and tracking of false killer whale groups continued this leg (Figure 9). Twice this leg the acoustics team notified visual observers of probable false killer whales after groups had passed the beam of the ship and successfully directed the ship to the groups enabling visual observers to sight and track the groups.

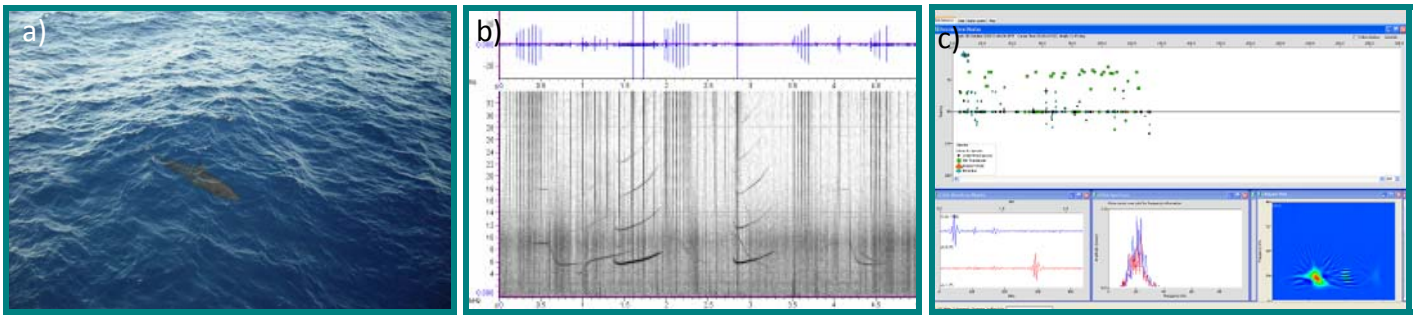



**Figure 9. *Pseudorca crassidens*, false killer whale. a) Photograph showing *P. crassidens* individual approaching boat. b) Spectrogram showing whistles and echolocation clicks recorded during an encounter with *P. crassidens* on 20 October 2010 (SR: 192kHz, FFT 2048, Hanning, overlap 50%).**

Another exciting highlight for acoustics this leg was a rare encounter with a large group Fraser's dolphin (Fig. 10). During this encounter the acoustics team heard and recorded several different whistle types and thousands of echolocation clicks that can be analyzed to inform whistle and click classification for future surveys.

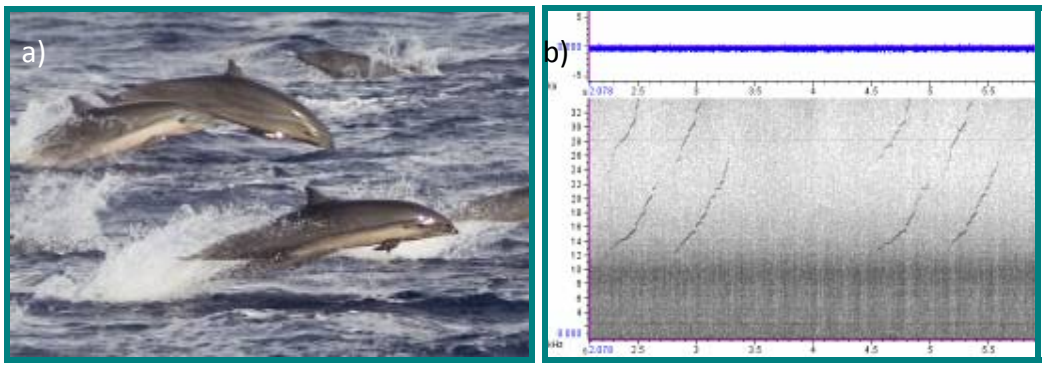
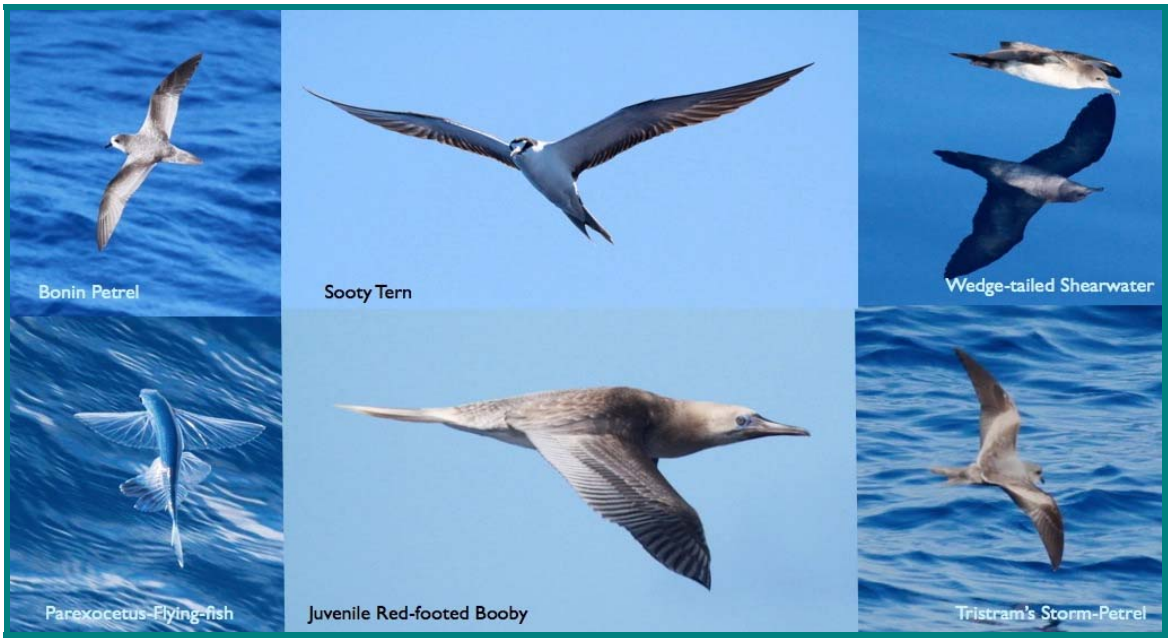



**Figure 10. *Lagenodelphis hosei*, Fraser's dolphin. a) Photograph showing individuals of mixed age classes during encounter on 15 October 2010. b) Spectrogram showing examples of paired whistles recorded during encounter on 15 October 2010 (SR: 192kHz, FFT 2048, Hanning, 50% overlap)**.

## Seabirds – Michael Force and Sophie Webb

To date, we have recorded a total of 22,895 birds of 47 species, from our 300m strip transect bird survey. In the table below, we present bird taxa and numbers recorded during each of the three first legs of HICEAS 2010, including Leg 1 (13-20 Aug; does not include the transit from San Diego to the HICEAS study area); Leg 2 (24 Aug-21 Sept) and Leg 3 (26 Sept-24 Oct). Some obvious trends in the table are the increase in the number of local breeders, coincident with our survey effort near their nesting islands during Leg 3 (e.g., Bonin Petrel, Wedge-tailed Shearwater, Tristram's Storm-Petrel and Blue-gray Noddy); and a decrease in migrant species as we progressed into the fall season (e.g., Herald, Mottled and Black-winged Petrels, and Pacific Golden-Plover).

**Photographs by Sophie Webb.**




**Photographs by Sophie Webb.**

**Table 5. Summary of bird species by leg.**

| Species | Leg 1 | Leg 2 | Leg 3 | All flocks | Total individuals |
|---|---|---|---|---|---|
| Northern Pintail *(Anas acuta)* | 0 | 0 | 1 | 0 | 1 |
| Unid. duck (Ring-necked?) *(Aythya sp.)* | 0 | 0 | 1 | 0 | 1 |
| Black-footed Albatross *(Phoebastria nigripes)* | 0 | 6 | 0 | 0 | 6 |
| Kermadec Petrel *(Pterodroma neglecta)* | 1 | 7 | 3 | 0 | 11 |
| Herald Petrel *(Pterodroma arminjoniana)* | 0 | 3 | 0 | 0 | 3 |
| Tahiti Petrel *(Pterodroma rostrata)* | 0 | 0 | 1 | 0 | 1 |
| Mottled Petrel *(Pterodroma inexpectata)* | 0 | 1 | 32 | 0 | 33 |
| Juan Fernandez Petrel *(Pterodroma externa)* | 1 | 1 | 0 | 0 | 2 |
| Hawaiian Petrel *(Pterodroma sandwichensis)* | 23 | 70 | 19 | 19 | 131 |
| White-necked Petrel *(Pterodroma cervicalis)* | 0 | 2 | 3 | 1 | 6 |
| Juan Fernandez/White-necked Petrel *(Pt. externa/cervicalis)* | 0 | 1 | 0 | 1 | 2 |
| Bonin Petrel *(Pterodroma hypoleuca)* | 0 | 367 | 862 | 2 | 1231 |
| Black-winged Petrel *(Pterodroma nigripennis)* | 1 | 135 | 68 | 5 | 209 |
| Cook's Petrel *(Pterodroma cookii)* | 0 | 27 | 8 | 6 | 41 |
| Stejneger's Petrel *(Pterodroma longirostris)* | 0 | 4 | 4 | 0 | 8 |
| Cook's/Pycroft's Petrel *(Pterodroma cooki/pycrofti)* | 1 | 10 | 2 | 0 | 13 |
| Unid. Cookilaria *(Pterodroma* sp.*)* | 1 | 1 | 3 | 0 | 5 |
| Unid. *Pterodroma (Pterodroma* sp.*)* | 0 | 1 | 0 | 0 | 1 |
| Bulwer's Petrel *(Bulweria bulwerii)* | 20 | 81 | 5 | 2 | 108 |
| Jouanin's Petrel *(Bulweria fallax)* | 1 | 0 | 0 | 0 | 1 |

| Species | Leg 1 | Leg 2 | Leg 3 | All flocks | Total individuals |
|---|---|---|---|---|---|
| Unid. *Bulweria (Bulweria* sp.*)* | 0 | 1 | 0 | 0 | 1 |
| Flesh-footed Shearwater *(Puffinus carneipes)* | 0 | 0 | 3 | 0 | 3 |
| Wedge-tailed Shearwater *(Puffinus pacificus)* | 110 | 666 | 7980 | 4581 | 13,337 |
| Buller's Shearwater *(Puffinus bulleri)* | 1 | 4 | 0 | 1 | 6 |
| Sooty Shearwater *(Puffinus griseus)* | 3 | 53 | 14 | 0 | 70 |
| Short-tailed Shearwater *(Puffinus tenuirostris)* | 0 | 79 | 45 | 0 | 124 |
| Sooty/Short-tailed shearwater *(Puffinus* sp.*)* | 1 | 35 | 9 | 0 | 45 |
| Christmas Shearwater *(Puffinus nativitatis)* | 0 | 0 | 4 | 0 | 4 |
| Newell's Shearwater *(Puffinus (newelli) auricularis)* | 1 | 67 | 26 | 11 | 105 |
| Unid. shearwater *(Puffinus* sp.*)* | 1 | 0 | 0 | 3 | 4 |
| Manx-type Shearwater *(Puffinus* sp.*)* | 0 | 1 | 0 | 0 | 1 |
| Wilson's Storm-Petrel *(Oceanites oceanicus)* | 0 | 0 | 6 | 0 | 6 |
| Leach's Storm-Petrel *(Oceanodroma leucorhoa)* | 0 | 6 | 13 | 4 | 23 |
| Leach's/Band-rumped Storm-Petrel *(O. leucorhoa/castro)* | 0 | 3 | 4 | 0 | 7 |
| Band-rumped Storm-Petrel *(Oceanodroma castro)* | 1 | 2 | 4 | 1 | 8 |
| Tristram's Storm-Petrel *(Oceanodroma tristrami)* | 0 | 4 | 337 | 104 | 445 |
| Unid. storm-petrel *(Oceanodroma sp.)* | 0 | 0 | 1 | 2 | 3 |
| white-rumped storm-petrel *(Oceanodroma/Oceanites* sp.*)* | 0 | 0 | 2 | 0 | 2 |
| “dark-rumped” storm-petrel *(Oceanodroma* sp.*)* | 0 | 0 | 1 | 0 | 1 |
| Red-tailed Tropicbird *(Phaethon rubricauda)* | 9 | 55 | 11 | 0 | 75 |
| White-tailed Tropicbird *(Phaethon lepturus)* | 9 | 25 | 20 | 0 | 54 |
| Unid. tropicbird *(Phaethon* sp.*)* | 1 | 1 | 1 | 2 | 5 |
| Masked Booby *(Sula dactylatra)* | 0 | 9 | 104 | 18 | 131 |
| Brown Booby *(Sula leucogaster)* | 0 | 13 | 237 | 25 | 275 |
| Red-footed Booby *(Sula sula)* | 12 | 138 | 632 | 425 | 1207 |
| Unid. booby *(Sula* sp.*)* | 1 | 2 | 0 | 0 | 3 |
| Great Frigatebird *(Fregata minor)* | 6 | 10 | 54 | 17 | 87 |
| Unid. frigatebird *(Fregata* sp.*)* | 6 | 13 | 8 | 13 | 40 |
| Pacific Golden-Plover *(Pluvialis fulva)* | 75 | 22 | 253 | 0 | 350 |
| Bar-tailed Godwit *(Limosa lapponica)* | 0 | 0 | 3 | 0 | 3 |
| Ruddy Turnstone *(Aerenaria interpres)* | 0 | 10 | 8 | 0 | 18 |
| Sanderling *(Calidris alba)* | 3 | 2 | 0 | 0 | 5 |
| Lesser Black-backed Gull *(Larus fuscus)* | 0 | 0 | 1 | 0 | 1 |
| Brown Noddy *(Anous stolidus)* | 6 | 102 | 223 | 823 | 1154 |
| Black Noddy *(Anous minutus)* | 3 | 45 | 37 | 228 | 313 |
| Blue-gray Noddy *(Procelsterna cerulea)* | 0 | 0 | 20 | 6 | 26 |
| Unid. noddy *(Anous* sp.*)* | 0 | 0 | 0 | 281 | 281 |
| White Tern *(Gygis alba)* | 8 | 79 | 68 | 289 | 444 |
| Sooty Tern *(Onychoprion fuscata)* | 50 | 138 | 170 | 1977 | 2335 |

| Species | Leg 1 | Leg 2 | Leg 3 | All flocks | Total individuals |
|---|---|---|---|---|---|
| Gray-backed Tern *(Onychoprion lunata)* | 0 | 2 | 3 | 0 | 5 |
| Unid. *Sterna* tern *(Sterna* sp.*)* | 0 | 1 | 1 | 0 | 2 |
| South Polar Skua *(Stercorarius maccormicki)* | 0 | 2 | 6 | 1 | 9 |
| Pomarine Jaeger *(Stercorarius pomarinus)* | 2 | 2 | 7 | 1 | 12 |
| Parasitic Jaeger *(Stercorarius parasiticus)* | 0 | 8 | 13 | 3 | 24 |
| Long-tailed Jaeger *(Stercorarius longicaudus)* | 2 | 14 | 6 | 1 | 23 |
| Parasitic/Long-tailed Jaeger *(Stercorarius. parasiticus/longicaudus)* | 0 | 1 | 0 | 0 | 1 |
| Unid. jaeger *(Stercorarius* sp.*)* | 0 | 1 | 0 | 1 | 2 |
| **Total (47 species)** | 360 | 2333 | 11347 | 8854 | **22,894** |

## Oceanographic Data Collections – Justin Garver

Leg 3 came and went quite smoothly for *McArthur II* oceanography. I managed to avoid any catastrophic sensor issues, and lucked out with quick repairs on the few malfunctions that did occur. The SBE 38 temperature sensor, which records data constantly to our oceanographic event logger, showed multiple errors in the beginning of the leg. After multiple failed attempts to fix the issue without impacting the recording data, the decision was made to try for a permanent fix. Luckily, our guess as to where the issue was originating from was correct, and within 45 minutes we were back in business with error free data. Although the CTD performed honorably the entire leg, we did encounter an issue a few weeks into the trip. Fortunately, CET Charlie Goertzen recognized the source of the issue right away. After a hard days work re-terminating the sea cable, we dropped the CTD the very next night without any error signals the remainder of the leg.

In terms of the dynamic oceanographic conditions this leg, there is not a whole lot of excitement to report. Multiple daily surface chlorophyll stations confirmed what was apparent when you gazed into the crystal blue water from the fantail: the surface chlorophyll levels were extremely low. The sea surface temperatures as well as salinity and conductivity also fluctuated very little from day to day within the area covered. The mixed layer, however, did fluctuate slightly depending on our location. The mixed layer range was between about 27m at the shallowest and 110m at the deepest. These extremely deep mixed layers were in areas off of the island shelf and usually occurred on days with very few sightings. The CTD data was also quite consistent however I did see a slight increase in chlorophyll levels between 60 and 140 m on the days that we had an extremely high number of beaked whale sightings.

Overall it was a successful Leg 3 for oceanography. I would like to thank Charlie Goertzen for his help with the CTD and SBE38 repairs, as well as helping me with the survey tech duties. I would also like to thank David LaPointe for his help running the CTD casts when needed.

Table 6. Summary of oceanographic effort, Leg 3.

| Leg | No. CTD casts | No. CTD chlorophyll samples | No. surface chlorophyll samples | No. XBT drops | No. salinity samples |
|---|---|---|---|---|---|
| 3 | 51 | 288 | 91 | 93 | 12 |
| Cruise total | 68 | 368 | 179 | 179 | 30 |

Table 7. Summary of effort, Leg 3.

| Date | Beginning time/ Ending time | Begin latitude-longitude Ending latitude-longitude | Distance | Average beaufort |
|---|---|---|---|---|
| 092610 | 1405<br>1756 | N21:10.32 W157:52.33<br>N20:34.72 W157:48.64 | 34.6 nmi | 3.5 |
| 092710 | 0625<br>1808 | N19:21.59 W157:39.76<br>N18:52.82 W156:01.42 | 89.3 nmi | 3.9 |
| 092810 | 0622<br>1756 | N18:17.47 W156:38.37<br>N17:50.09 W154:57.12 | 90.4 nmi | 4.0 |
| 092910 | 0623<br>1755 | N17:14.36 W155:34.51<br>N17:40.68 W157:14.44 | 93.9 nmi | 4.0 |
| 093010 | 0620<br>1821 | N19:30.47 W158:14.06<br>N19:54.19 W159:47.08 | 70.1 nmi | 2.4 |
| 100210 | 0634<br>1818 | N20:34.98 W159:05.55<br>N21:02.61 W160:57.56 | 100.1 nmi | 5.2 |
| 100310 | 0639<br>1759 | N21:46.09 W160:37.56<br>N22:05.23 W160:06.98 | 78.0 nmi | 4.8 |
| 100410 | 0644<br>1836 | N22:54.78 W161:43.75<br>N23:13.12 W163:28.52 | 80.1 nmi | 4.7 |
| 100510 | 0654<br>1842 | N23:15.42 W164:11.27<br>N23:42.52 W165:41.63 | 85.1 nmi | 4.4 |
| 100610 | 0702<br>1840 | N23:32.32 W166:19.27<br>N24:03.58 W166:40.95 | 66.5 nmi | 4.0 |
| 100710 | 0710<br>1846 | N24:10.56 W167:57.41<br>N24:37.64 W168:41.95 | 69.0 nmi | 3.4 |
| 100810 | 0713<br>1843 | N24:24.35 W168:16.77<br>N25:25.19 W168:53.85 | 61.2 nmi | 3.4 |
| 100910 | 0716<br>1902 | N25:25.72 W168:54.30<br>N25:15.38 W170:41.82 | 90.0 nmi | 4.8 |
| 101010 | 0739<br>1858 | N25:16.44 W170:44.34<br>N25:57.50 W171:47.75 | 77.5 nmi | 5.2 |
| 101110 | 0731<br>1805 | N25:58.71 W171:44.77<br>N25:42.26 W170:26.55 | 73.9 nmi | 4.0 |
| 101210 | 0727<br>1833 | N25:41.70 W170:25.88<br>N25:41.39 W169:20.46 | 61.2 nmi | 4.0 |
| 101310 | 0735<br>1631 | N25:49.36 W169:23.15<br>N25:38.21 W168:32.92 | 57.9 nmi | 3.9 |
| 101410 | 0718<br>1814 | N25:35.96 W168:31.01<br>N25:34.51 W167:47.13 | 29.7 nmi | 2.2 |
| 101510 | 0716<br>1611 | N25:33.72 W167:46.28<br>N24:11.99 W167:51.32 | 76.2 nmi | 2.7 |
| 101610 | 0713<br>1831 | N23:58.65 W166:53.08<br>N25:00.57 W167:07.41 | 77.0 nmi | 4.0 |
| 101710 | 0714<br>1830 | N24:59.98 W167:07.36<br>N24:04.55 W166:05.30 | 88.1 nmi | 4.0 |
| 101810 | 0707<br>1830 | N24:04.80 W166:05.52<br>N23:43.86 W165:48.59 | 46.9 nmi | 2.8 |
| 101910 | 0702<br>1826 | N23:37.70 W165:00.20<br>N23:19.01 W164:08.96 | 62.2 nmi | 2.0 |
| 102010 | 0700<br>1727 | N23:13.92 W163:17.72<br>N23:26.44 W162:16.29 | 67.1 nmi | 1.3 |
| 102110 | 0700<br>1653 | N23:22.47 W163:01.99<br>N23:10.64 W162:04.53 | 47.1 nmi | 2.6 |

| Date | Beginning time/ Ending time | Begin latitude-longitude Ending latitude-longitude | Distance | Average beaufort |
|---|---|---|---|---|
| 102210 | 0652<br>1812 | N23:10.89 W162:03.86<br>N22:42.92 W161:13.45 | 57.2 nmi | 1.4 |
| 102310 | 0652<br>1804 | N22:44.11 W161:16.19<br>N22:22.49 W159:50.35 | 73.1 nmi | 3.7 |
| 102410 | 0645<br>1329 | N22:22.32 W159:49.41<br>N22:07.18 W158:47.62 | 57.5 nmi | 4.9 |

Table 8. Marine mammal sightings, Leg 3.

| Code | Species | No. sightings |
|---|---|---|
| 002 | Pantropical spotted dolphin *Stenella attenuata* (offshore) | 6 |
| 013 | Striped dolphin *Stenella coeruleoalba* | 8 |
| 015 | Rough-toothed dolphin *Steno bredanensis* | 12 |
| 018 | Bottlenose dolphin *Tursiops truncatus* | 9 |
| 021 | Risso's dolphin *Grampus griseus* | 6 |
| 026 | Fraser's dolphin *Lagenodelphis hosei* | 1 |
| 032 | Pygmy killer whale *Feresa attenuata* | 2 |
| 033 | False killer whale *Pseudorca crassidens* | 6 |
| 036 | Short-finned pilot whales *Globicephala macrorhynchus* | 18 |
| 046 | Sperm whale *Physeter macrocephalus* | 3 |
| 048 | Dwarf sperm whale *Kogia sima* | 1 |
| 049 | Unid. beaked whale | 10 |
| 051 | Unid. mesoplodont beaked whale *Mesoplodon* sp. | 4 |
| 061 | Cuvier's beaked whale *Ziphius cavirostris* | 12 |
| 070 | Unid. rorqual *Balaenoptera* sp. | 2 |
| 071 | Common minke whale *Balaenoptera acutorostrata* | 1 |
| 072 | Bryde's whale *Balaenoptera edeni* | 13 |
| 077 | Unid. dolphin | 4 |
| 080 | Dwarf/Pygmy sperm whale *Kogia* sp. | 1 |
| 096 | Unid. cetacean | 7 |
| 099 | Sei/Bryde's whale *Balaenoptera borealis/edeni* | 1 |
| 102 | Gray's spinner dolphin *Stenella longirostris longirostris* | 1 |
| 177 | Unid. small delphinid (dolphin) | 5 |
| 277 | Unid. medium delphinid (dolphin) | 1 |
| 377 | Unid. large delphinid (dolphin) | 2 |
| | **Total** | **136** |