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Pacific Orca Distribution Survey (PODS) conducted aboard the NOAA ship *McArthur II* in March 2008

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Introduction

In 2001 the Southern resident killer whale (SRKW) population was petitioned for listing under the Endangered Species Act (ESA). A series of workshops were held in 2003 and 2004 to identify data gaps and risk factors associated with the 20% decline this population experienced in the late 1990s. The primary data gap identified with this population was its winter distribution. Although the population has been identifiable since 1976, only 12 documented sightings in the winter in coastal waters existed in 2001, ranging form central California to the Queen Charlotte Islands, British Columbia. With the 2005 listing of the population under the ESA, Critical Habitat designation was required but in the initial designation none of the coastal U.S waters were included due to a paucity of sighting data. In order to obtain location data to improve the Critical Habitat designation, as well as obtain other information on behavior and prey selection, winter cruises to locate SRKWs have been conducted annually from 2004, except for the year 2005 (no sea days were allocated to this task in FY05). Here we report on the sighting and acoustic data collected for killer whales and other marine mammal species and seabirds, as well as describe the oceanographic data collected during the Pacific Ocean killer whale and cetaceans Distribution survey, March 2008 (PODs 2008) conducted aboard the NOAA ship *McArthur II*.

Survey Objectives

The overall objective of this cruise was to locate southern resident killer whales (SRKWs) in order to better document their winter range as well as improve our understanding of their behavior and habitat use in these areas. In addition, other biological and oceanographic data were collected to better characterize their environment. Other objectives included photo-identification, behavioral observations, and acoustic study of sounds produced by other cetaceans in this area during the winter.

Study Area

The survey tracklines for the project included the waters of the continental shelf from southern Vancouver Island to central Oregon. This region is within the range of most of the documented sightings of SRKW during the late March timeframe.

Itinerary

The cruise began on 17 March 2008 in Portland, Oregon and ended on 26 March 2008 in Seattle, Washington. A set of predetermined tracklines were established prior to the survey to cover the portion of the study area with the highest probability of encounter of SRKW based on previous sightings. In general, the ship was to initially follow the tracklines from the mouth of the Columbia River north to Grays Harbor, Washington. If no southern resident killer whales were encountered the ship followed a set of tracklines south, potentially as far as central Oregon, depending on weather and whale detections. The ship would then return north repeating these tracklines. Tracklines were modified during the cruise due to weather or other considerations. In addition, modifications were made by transiting directly to areas where recently reported

sightings of killer whales were likely to be southern resident killer whales. The final ship track is shown in Figure 1.

Methods and Materials

Surveys were conducted for marine mammals and seabirds during this cruise. Two survey methods for marine mammals were used, visual and acoustic. In addition, oceanographic data were collected. Scientific Personnel that collected these data are listed in Table 1.

Visual Surveys

Marine Mammals

Line-transect survey methods were the primary visual survey method. This effort was consistent with Southwest Fisheries Science Center's approach for use in estimating abundance (Kinzey et al. 2001). The *McArthur II* traveled at 9-10 knots (through the water) along the designated trackline. A daily watch for marine mammals was maintained during daylight hours by scientific observers on the flying bridge (approximately 0700 to 1800), except when the ship was stopped to conduct other sampling operations, or when precluded by weather. A team of three observers searched with 25x150 binoculars, 7X binoculars, and unaided eye. The two outboard observers scanned from 10 degrees across the trackline to 90 degrees abeam with the Big Eyes. The observers reported sighting angle using the azimuth incorporated into the binocular mount (this azimuth was calibrated to zero at the beginning of the cruise). The recorder monitored the entire 180 degree field of view with 7x 50 binoculars and unaided eye. Sighting conditions, watch effort, sightings, and other required information were entered into a computer, using the program WinCruz (written by R. Holland, SWFSC), hooked up to the ship's GPS (for course, speed and position information). Observers worked for 30 minutes at each of the three stations and rotated through the three positions for a total of 1.5 hours on the flying bridge, with an hour break between sets of rotations.

If weather (sea state, rain, or fog) precluded effective observations with the 25x binoculars, a two observer watch (designated off-effort) was manned on either the flying bridge or bridge with 7x50 binoculars or unaided eye. The observers scanned with unaided eye and 7x50 binoculars for marine mammals. Sighting conditions, watch effort, sightings, and other required information were also entered into a computer by observers, using the program WinCruz (written by R. Holland, SWFSC), hooked up to the ship's GPS (for course, speed and position information).

On sighting a marine mammal or other feature of biological interest, the marine mammal observer team on watch occasionally requested the vessel be maneuvered to approach the cetacean school or feature for investigation. During these occasions, the team went off-effort to allow the ship to approach the group of marine mammals and make estimates of group size. For killer whale sightings, behavioral state data were collected and photographs were taken. Weather permitting, a small boat was deployed for biopsy, behavioral data collection, photographic and other operations for killer whales. Depending on the duration and end location of the encounter the trackline was generally re- intersected at the closet point.

Seabirds

Surveys of marine bird distribution were recorded by trained observers during daylight hours when ship speed exceeded 2.5 m/s (5 knots). Two observers were on watch at all times during survey effort. Observers went off-effort for meals and rest as necessary to avoid fatigue. Observations began at dawn each morning. A primary observer counted and identified all flying or sitting birds within a strip transect extending 300 m out from the bow to the beam of the ship (90° arc), while the second observer recorded data and helped with identification and sightings of birds close to the ship. During mild weather, observations were collected from the flying bridge (deck height = 12.6 m) on the side of the vessel with the best viewing conditions for each survey (e.g., no glare). In the event of precipitation exceeding a light drizzle, observations were collected from the sheltered bridge wing in the lee of the wind (deck height 10.3 m).

Binoculars (8x magnification) were used to aid in counting and species identification. Data were called out to the secondary observer who immediately entered them into a laptop computer running the "SeeBird" data acquisition program v 2.3.0 (Southwest Fisheries Science Center, La Jolla, CA). The computer was linked to GPS satellite data input so that each observation was associated with a latitude/longitude position and time stamp. Behavior of seabirds was noted and recorded (e.g. sitting, feeding, flying and flight direction, etc). Marine mammals, large aggregations of seabirds, and rare species observed beyond the 300-m observation zone were also recorded, using the SeeBird software's capability to annotate distance outside of 300-m and the "comment" feature in the software.

Acoustic survey - Two different types of acoustic monitoring systems were available during the cruise, a dual towed array system and sonobuoys.

Towed Arrays - hydrophones

The towed array system consisted of 2 hydrophones arrays: a 2 element array (array A); and a 5 element array (array B). Array A consisted of 2 elements with 3.15 m spacing and approximately 330m of lead in cable. The 2 elements for array A had an effective (i.e. flat) frequency response of 100 Hz – 40 kHz. Array A was the primary array deployed (i.e. day and night) during normal survey mode. Array B consisted of 5 elements: two paired phones at either end with 3m spacing between each element in the pair, and a single hydrophone near the middle (330 m from the end pair and 130m from the first pair) for a total aperture of 660m (between the first and last pair). The last element of array B consisted of a broad-band, high-frequency element with a flat frequency response up to 200 kHz. Array B was intended to complement array A during nighttime encounters with resident killer whales in order to improve tracking capabilities. Each array was spooled on its own hydraulically powered winch for deployment and retrieval. Usually, array A was deployed at lengths of 200-300m from the fantail of the ship, depending on the bottom depth and other factors. Approximately 10 lbs of lead weight was attached to each array approximately 180m from the end of the array to sink it to a suitable depth. Array B was deployed with 200m of cable from the first pair of elements (for a total length of ~ 660m).

The deck cable was connected to the dry end of the array after deployment via a weather-proof electronic connector. The deck cable led from the winch into the dry-lab where the array power supply, signal conditioning, and signal processing, and signal recording system were located on the *McArthur II*. Array A was powered by two 12V DC batteries using a differential power (positive, negative & ground) configuration. Array B was powered by a 16V gel-cell.

Towed Arrays - Signal conditioning system

Six channels from both arrays (2 elements from array A, and the first 4 elements from array B) were passed to a 6-channel low pass filter (Alligator Filter Tech. model AAF) set at a fixed 48 kHz corner frequency. The seventh channel (from hydrophone 5 of array B) was sent to a low-pass filter with a corner frequency set at 96 kHz. The signal was then split between a National Instruments 6062E DAQ card for (for high-frequency recordings) and a programmable band-pass filter (Krohn-Hite model 3362) with a corner frequency set at 48 kHz. The high pass filter was adjusted as needed between 500 Hz and 4 kHz (default set at 500Hz) and used to reduce any low-frequency engine and flow noise. All seven channels (i.e. all hydrophones from both arrays) were fed into a MOTU Traveler PC digital interface. The MOTU interface was used to digitize all seven channels of array signals and then sent to ISHMAEL via a fire-wire cable.

Towed Arrays - Signal processing and recording system

One laptop was dedicated for running ISHMAEL sound localization and digital recording software (developed by D. Mellinger, OSU-PMEL, Newport, OR). A second laptop was dedicated to running Whaletrack II (developed by Glenn Gailey, TAMUG, TX). These two computers were connected via a network connection to an Ethernet router which was used to pass information from ISHMAEL to Whaletrack II (see Appendix II for setup procedures).

ISHMAEL was used to record acoustic data and process calls for localization. Generally, data were sampled and recorded at 96 kHz for both arrays. Two-channels were recorded when array A was deployed and 7 channels (2 from array A, and 5 from array B) when both arrays were deployed. In some instances other sample rates and channels were recorded as needed. Recordings were made continuously at 10 minute intervals with times with most start-times aligned on the hour and every ten minutes after the hour.

Animal vocalizations were manually selected in ISHMAEL for localization by windowing the signal with a pointing device (e.g. a trackball or touchpad). Depending on localization method selected n ISHMAEL either a left-right ambiguous bearing, an un-ambiguous bearing, or a relative location was estimated. All bearings and locations were estimated relative to the ship's location. Instantaneous estimates of locations were possible using a newly developed "crossed-pair" localization method in ISHMAEL. The bearing or location estimate and additional information were automatically passed to Whaletrack II via the network connection.

Whaletrack II was used to plot bearings and/or location estimates passed from ISHMAEL. Whaletrack II also acquired and plotted ship position via a serial GPS connection. Ship track history, current heading and speed as well as an estimated position of the array were calculated and stored in an MSAccess database created by Whaletrack II. Information about effort, acoustic contacts and settings of acoustic equipment (e.g. gain and filter cutoffs) were also recorded in Whaletrack II.

Bearings plotted in Whaletrack II were used to estimate the animal's location using a "sequential-bearing fix" technique. This technique involved sequentially plotting several bearings to the target while steadily moving past it. The locations of animal(s) were estimated visually by the computer operator who subjectively assessed the point where the bearing lines intersect. Bearings and estimated locations of animal calls were saved in a Whaletrack II database file. Screen dumps of bearing and ship plots were occasionally saved.

Sonobuoy System

Type AN/SSQ-57B USN sonobuoys (effective audio frequency response 10 Hz – 20 kHz) transmitting at various radio frequencies (164-167 MHz range) were deployed as conditions warranted. Sonobuoys are self-contained units that automatically power-up upon contact with water and transmit sounds via radio waves. All sonobuoys were set at 90m hydrophone deployment depths and 8 hour operating life (auto-scuttle setting). The sonobuoy radio signals were received by a mast mounted antennae connected to an ICOM IC-PCR1000 receiver that was controlled through a PC-based software interface. Acoustic signals from the receiver were recorded to a hard-drive using ISHMAEL and a NI 6062E DAQ card or the internal PC sound card.

Towed Arrays - Monitoring

Array A was monitored 24/7 as the ship proceeded on the tracklines weather permitting and except for oceanographic data collection during CTD deployment. The vessel slowed from survey speed to approximately 3 knots at the midpoint of each line in order to provide improved acoustic monitoring conditions. Array B was deployed primarily at night, to facilitate tracking, and recovered in the morning. On occasion it was left out during the daytime. The array(s) were retrieved during nighttime CTD operations (usually between 20:00 and 21:00) but were re-deployed immediately afterwards. Only 2 channel recordings were made from Array A, even when both arrays were deployed. This allowed faster computational times when obtaining bearings and localizations.

A single visual observer on the flying bridge monitored the 2 element array aurally using a headset at all times when the visual team was on effort. If a killer whale vocalization was detected (or possibly detected), a member of bio-acoustics team was called to begin acoustics monitoring in the acoustics lab and proceed to attempt to localize calls. If killer whale sounds were detected at night, the bio-acoustician on watch would attempt to localize and track them until the visual observers came on watch at daybreak.

If southern resident killer whales were detected, every effort was made to remain with these animals for as long as possible. Visual sightings as well as acoustic data from the towed acoustic array or sonobouys were used to track the whales. Behavioral data were collected during visual observations, and if weather permitted, a small boat was deployed in order collect behavioral data, predation event remains, and photographs.

Photo-ID Photographs of marine mammals were taken on an opportunistic basis. The animals were either approached by the research vessel during normal survey operations, approached the research vessel on their own, or were approached by a small boat. Photographs of individuals were taken with digital 35 mm SLR cameras using 300 and 400 mm lenses for those species that have photo-ID existing catalogs.

Biopsy Sampling - Biopsies for genetic analyses of killer whales were collected on an opportunistic basis in U.S. and Canadian waters. Samples collected for killer whales were only taken from small boats using the method outlined by Barrett-Leonard et al. (1996). For cetaceans that approached within 10m to 30m of the bow of the *McArthurII* biopsy samples were collected using a dart fired from a dart rifle (S. Claussen per.comm.).

Prey remains/fecal collection – Prey remains from predation events (scales, tissue) of marine mammals and fecal samples were collected on an opportunistic basis. These samples were

collected from animals that were approached by the small boat using a long-handled (4-m) fine-mesh net.

Behavioral Observations – Behavioral observations of marine mammals were taken on an opportunistic basis. The animals to be observed were approached by the research vessel during normal survey operations, approached the vessel on their own, or were approached by a small boat. Observations recorded from the *McArthurII* included general behavioral state. During small boat operations a focal follow approach was used that was similar to Ford and Ellis (2006).

Oceanography

Thermosalinograph Sampling

The ship's Sea-bird Electronics Thermosalinograph (TSG) sampled surface water temperature and salinity continuously during the entire cruise track. The data from the TSG and from a GPS were continuously recorded by the ship's Scientific Computing System (SCS). The TSG information was also used in the field by the oceanographer to record latitude, longitude, surface water temperature, and salinity during expendable bathyothermograph (XBT) casts, surface water sampling, and CTD casts.

Expendable Bathyothermographs (XBTs) Deployment and Surface Water sampling

Expendable bathyothermographs (XBTs) were deployed at 0900, 1200, and 1500 hours, and surface water samples were collected at 0600, 0900, 1200, 1500, and 1800 hours local ship time, and at other times, under the discretion of the Chief Scientist (e.g., surface water samples are also taken every hour when in the presence of killer whales). For XBT deployments, Sippican Deep Blue probes were used and data were transmitted to the Shipboard Environmental data Acquisition System. After each XBT drop, a surface water sample for chlorophyll a analysis was collected in a bucket deployed over the side of the ship. Immediately following bucket sampling, a 50 ml sample of the water was filtered onto a 2.5 cm GF/F filter. All filters were wrapped in foil, labeled, and stored frozen in Ziploc freezer bags until sample analysis, which occurred on the ship within <1-2 weeks of collection. For extraction, the filters were placed in culture tubes with 8 ml of 90% (v/v) acetone and stored in the freezer for a minimum of 2 hours. The tubes were then allowed to equilibrate with room temperature, and fluorescence was measured using a Turner Designs 10-AU Digital Field Fluorometer.

CTD Casts

A CTD (conductivity-temperature-depth) station was occupied each evening one hour after sunset, weather and sufficient depth permitting. In the event that a CTD cast was cancelled due to inclement weather or because the ship was tracking killer whales, an XBT was also deployed when the surface water sample was collected at 1800 hours. CTD data and seawater samples were collected using a SeaBird 9/11+ CTD with a 12-place rosette and Niskin bottles. All casts were to 1000m (depth permitting) with the descent rate set at 30 m/min for the first 100m of the cast, then 60 m/min after that, including the upcast between bottles. Niskin bottle water samples were collected at 12 standard depths (0, 10, 20, 30, 40, 50, 75, 100, 150, 200, 500, 1000) between the surface and 1000 meters, or to within 10 m of the bottom. For each cast, water samples were collected for chlorophyll a analysis at all depths to 200 m. Immediately following sampling, a 50 ml sample of the water was filtered onto a 2.5 cm GF/F filter. All filters were wrapped in foil, labeled, and stored frozen in Ziploc freezer bags until sample analysis, which occurred on the

ship within <1-2 weeks of collection. Chlorophyll a extraction and analysis were conducted using the same protocol as above. Water samples for salinity analysis were collected at 100, 500, and 1000 m (or to within 10 m of bottom). Three additional salt samples were collected every other day so that the depths sampled were 30 m, 100m, 150m, 200 m, 500 m, and 1000 m. Water samples for salinity analysis were stored upright at ambient room temperature. Salinity samples were processed within one month after the cruise at the University of Washington Marine Chemistry Laboratory in Seattle. Water samples (approximately 40 ml) for nutrient analysis from each of the 11 depths up to 500 m were transferred into pre-rinsed (10% HCl and H2O) vials and frozen upright. Nutrient samples were processed within 1 year after the cruise, at the University of Washington Marine Chemistry Laboratory in Seattle.

Results and Discussion

Search Effort and Sightings – Marine mammals

A total of 1223.1 km were surveyed in the study area during eight of the 10 total sea days, yielding an average of 152.9 km/day (Table 2, Figure 2). However, only 487.7 km were considered on-effort, and of the 735.4 km total off–effort, 118.2 km were conducted on the flying bridge and 617.2 were conducted on the bridge. Survey efforts were hampered from 23-25 March due to inclement weather.

A total of 45 marine mammal sightings were made during all effort categories (Table 3). The majority of sightings were made while on-effort (39) although a few were observed while off–effort (6) (Table 4). Seven identifiable cetacean and one pinniped species were sighted (Figure 3). The most commonly sighted species were unidentified large whales, followed by harbor porpoise (*Phocoena phocoena*) and gray whales (Eschrichtius *robustus*). Two groups of killer whales (transients) were initially sighted without an acoustic cue (see Acoustics section). No ship-based biopsy attempts were made. We collected one biopsy sample from southern resident killer whales (J pod) encountered on 25 March in Canadian waters.

Search effort and sightings - Seabirds

A total of 931.7 kilometers of on-effort survey observations were collected between 18 Mar 2008 and 24 Mar 2008; total effort for each day is shown in Table 5. Observation conditions were generally good: average Beaufort sea state was 3, and the Observing Condition factor, which is a qualitative measure of the ability to detect small, fast-moving species such as phalaropes or storm-petrels, was either Fair or Good for all surveys.

A total of 6,012 seabirds were observed and counted during on-effort transects (Table 6). Ninety percent of all birds counted were from only six species: common murre (*Uria aalge*, 59.3%), black-legged kittiwake (*Rissa tridactyla*, 13.8%), rhinoceros auklet (*Cerorhinca monocerata*, 7.3%), Cassin's auklet (*Ptychoramphus aleuticus*, 4.0%), western-glaucous-winged hybrid gulls (*Larus occidentalis x glausescens*, 3.0%), and northern fulmars (*Fulmarus glacialis*, 2.5%). The observed species composition indicates an assemblage of primarily non-breeding late winter migrants (e.g. kittiwakes) and resident breeding species (e.g. murres), as well as a few non-breeding summer migrants (e.g. sooty shearwaters).

Acoustic detections

During the eight days at sea in the study area, the towed array system (i.e. at least one towed array) was deployed and monitored for a total of 159 hours. Excluding the first and last sea days

(when partial days only were possible) average daily acoustic effort (day and night) was approximately 21.1 hours per day. If the times the array had to be retrieved for the daily CTD cast and inclement weather periods are excluded (~ 28 hrs) , the resulting 159 hour effort represents approximately 95% of the time 'available' for conducting acoustic effort. All acoustic data during on-effort period were digitally recorded to hard drives. There were no significant malfunctions of the acoustic array or any related acoustic hardware. No sonobuoys were deployed.

A total of seven acoustic detections were made during the cruise. All were attributed (or possibly attributed) to killer whales although sperm whales (*Physeter macrocephalus*) could not be ruled out (Table 7). Of these, four acoustic detections were visually confirmed, including a night-time detection of the southern resident J-pod that was acoustically tracked until daylight when the pod was visually located. Of those acoustic detections that were not visually confirmed, one (# 7) was of a few faint killer whale calls that were not heard again. The two remaining detections (#1 and #9) were clicks and could not be definitively attributed to killer whales in the field.

Killer whale encounters

Two of the three ecotype of killer whales found in the North Pacific Ocean, transients and residents, were encountered during the cruise (Table 8). For the resident type, J pod from the southern community was observed in U.S. and Canadian waters. We were able to conduct small boat operations with this group of whales for several hours and one biopsy sample was collected. No predation event or fecal samples were collected. We also encountered two groups of transients, both off southern Washington.

Oceanography

Twenty-five XBT deployments and six CTD deployments were made during the cruise (Table 9, 10, 11, Figure 5). Forty-seven surface chlorophyll samples, 57 CTD chlorophyll samples, 22 salinity samples, and 60 nutrient samples were collected.

Acknowledgements

This cruise report is dedicated to Stephen Claussen. We are grateful to the officers and crew of the *McArthur II* for their support, and their expertise was essential to the success of this cruise. The accomplishments of the cruise would not have been possible without the dedication and hard work of the research team participants. Cruise logistics were assisted by NWFSC staff, including Christel Martin, and Nick Adams and other staff from Vera Trainer's program. We appreciate the support and assistance of several colleagues at the SWFSC. Special thanks to Damon Holzer, NWFSC for expert development of the figures. Marine mammal research in the U.S. was conducted under NMFS Permit No. 782-1824-01 issued to the NWFSC and in Canada under DFO Marine Mammal License 2008-03 and SARA License 84.

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Table 1. Participating scientists.

Name[1]	**Position**	**Org**
Brad Hanson	Chief Scientist, Mammal Observer	NWFSC
Dawn Noren	Co-Cruise Leader, Mammal Observer	NWFSC
Candice Emmons	Killer whale ID Specialist	NWFSC
Stephen Claussen	Mammal Observer	Biowaves
Michael Richlen	Mammal Observer	NWFSC
Marla Holt	Acoustician	NWFSC
Aly Azarra	Acoustician	Biowaves
Steve DeBlois	Acoustician	NWFSC
Shelly Nance	Oceanographer	Biowaves
Troy Guy	Seabird Observer	OSU/NWFSC
Peter Sanzenbacher	Seabird Observer	NWFSC

Table 2. Visual survey effort summary for marine mammals (kilometers) by sea state.

Effort type	Sea State								
	0	1	2	3	4	5	6	7	Total
On Effort Flying Bridge	0	38.9	71.3	285.3	114.1	1.0	7.1	0	487.7
Off Effort Flying bridge	0	0	2.4	62.7	47.7	0	5.4	0	118.2
Off Effort Bridge	0	36.6	156.9	106.5	81.2	163.2	55.2	17.7	864.1
Total	0	45.6	230.5	454.5	243.0	164.2	67.6	17.7	1223.1

Table 3. Visual sightings summary - Cetaceans and pinnipeds.

Code	Species	Total Sightings	Average group size
22	*Lagenorhynchus obliquidens*	1	5
37	*Orcinus orca*	3	10.3
40	*Phocoena phocoena*	10	1.6
44	*Phocoenoides dalli*	3	1.3
69	*Eschrichtius robustus*	9	1.9
74	*Balaenoptera physalus*	1	6
76	*Megaptera novaeangliae*	2	1
77	Unidentified Dolphins	2	66
79	Unidentified Large Whale	13	1.5
MA	*Mirounga angustirostris*	1	1
	Total	45	

Table 4. Cetacean and pinniped sightings.

Sighting #	Date	Time	Latitude	Longitude	Species code	Species	# of animals
1	18-Mar	0806	N46:33.48	W124:13.74	69	Er	2
2	18-Mar	0908	N46:33.41	W124:11.92	40	Pp	1
3	18-Mar	0913	N46:34.21	W124:11.73	40	Pp	2
4	18-Mar	0915	N46:34.55	W124:11.67	79	Unid Lg Whale	2
5	18-Mar	0938	N46:35.39	W124:16.33	40	Pp	1
6	18-Mar	1201	N46:38.88	W124:38.09	77	Unid Dolphin	2
7	18-Mar	1259	N46:40.99	W124:28.65	77	Unid Dolphin	130
8	18-Mar	1320	N46:41.04	W124:28.86	37	Oo (transient)	3
9	18-Mar	1424	N46:41.92	W124:22.85	79	Unid Lg Whale	1
10	18-Mar	1440	N46:43.08	W124:18.96	76	Mn	1
11	18-Mar	1451	N46:43.96	W124:16.46	69	Er	2
12	18-Mar	1502	N46:44.46	W124:13.99	79	Unid Lg Whale	3
13	18-Mar	1507	N46:44.71	W124:13.04	69	Er	2
14	18-Mar	1537	N46:45.44	W124:14.27	69	Er	3
15	18-Mar	1537	N46:45.44	W124:14.28	79	Unid Lg Whale	1
16	18-Mar	1541	N46:45.48	W124:14.69	40	Pp	2
17	18-Mar	1548	N46:45.53	W124:15.34	69	Er	2
18	18-Mar	1645	N46:45.03	W124:29.04	40	Pp	1
19	19-Mar	0908	N47:00.12	W124:49.59	MA	Ma	1
20	19-Mar	1145	N46:51.74	W124:26.20	40	Pp	2
21	19-Mar	1231	N46:48.98	W124:15.94	69	Er	1
22	19-Mar	1243	N46:47.84	W124:13.54	69	Er	2
23	19-Mar	1250	N46:47.18	W124:12.59	40	Pp	1
24	19-Mar	1746	N46:23.02	W124:16.99	79	Unid Lg Whale	1
25	20-Mar	1059	N46:20.11	W124:12.24	79	Unid Lg Whale	1
26	20-Mar	1138	N45:17.26	W124:04.51	69	Er	2
27	20-Mar	1151	N46:15.62	W124:05.74	79	Unid Lg Whale	2
28	21-Mar	1023	N44:05.15	W124:21.05	79	Unid Lg Whale	2
29	21-Mar	1033	N44:05.33	W124:18.75	40	Pp	3
30	21-Mar	1238	N44:23.56	W124:25.99	44	Pd	1
31	21-Mar	1410	N44:32.47	W124:11.57	69	Er	1
32	21-Mar	1815	N45:03.38	W124:13.58	40	Pp	1
34	21-Mar	1846	N45:06.71	W124:19.03	44	Pd	2
35	21-Mar	1854	N45:07.50	W124:20.38	40	Pp	2
36	21-Mar	1858	N45:07.94	W124:21.12	44	Pd	1
37	22-Mar	0745	N46:21.72	W124:18.16	79	Unid Lg Whale	2
38	22-Mar	0836	N46:25.90	W124:21.26	37	Oo (transient)	3
39	22-Mar	1429	N46:54.76	W124:25.20	79	Unid Lg Whale	1
40	22-Mar	1430	N46:54.91	W124:25.35	79	Unid Lg Whale	1
41	22-Mar	1442	N46:56.77	W124:27.27	76	Mn	1
42	22-Mar	1514	N47:01.64	W124:32.32	79	Unid Lg Whale	2
43	22-Mar	1551	N47:06.74	W124:38.08	79	Unid Lg Whale	1
44	22-Mar	1854	N47:27.94	W125:10.93	74	Bp	6
45	22-Mar	1930	N47:28.49	W125:18.77	22	Lo	5
46	25-Mar	0730	N48:20.94	W124:22.61	37	Oo (J pod)	25

Note: No sighting #33
44 total cetacean sightings

Table 5. Marine bird survey effort, in linear distance surveyed by day.

Survey Date	Total kilometers surveyed
18 March 2008	132.53
19 March 2008	138.53
20 March 2008	96.5
21 March 2008	174.63
22 March 2008	147.97
23 March 2008	121.02
24 March 2008	120.63
Total	931.68

Table 6. Seabird species observed during marine bird survey effort. Species are listed in descending order of numerical importance; counts include both flying birds and birds on the water.

Common name	**Scientific name**	**Total count**	**Percentage of total**
Common murre	*Uria aalge*	3564	59.28
Black-legged kittiwake	*Rissa tridactyla*	829	13.79
Rhinoceros auklet	*Cerorhinca monocerata*	440	7.32
Cassin's auklet	*Ptychoramphus aleuticus*	241	4.01
Western x glaucous-winged gull	*Larus occidentalis x glaucescens*	183	3.04
Northern fulmar	*Fulmarus glacialis*	153	2.54
Unidentified dark shearwater	*Puffinus* spp.	73	1.21
Short-tailed shearwater	*Puffinus tenuirostris*	64	1.06
Mew gull	*Larus canus*	56	0.93
Surf scoter	*Melanitta perspicillata*	48	0.80
Red-breasted merganser	*Mergus serrator*	47	0.78
Unidentified gull	*Larus* spp.	46	0.77
Herring gull	*Larus argentatus*	37	0.62
Brant	*Branta bernicla*	34	0.57
Western gull	*Larus occidentalis*	32	0.53
Pigeon guillemot	*Cepphus columba*	22	0.37
Black-footed albatross	*Phoebastria nigripes*	20	0.33
Glaucous-winged gull	*Larus glaucescens*	20	0.33
Brandt's cormorant	*Phalacrocorax penicillatus*	17	0.28
Unidentified alcid	Family Alcidae	16	0.27
Sooty shearwater	*Puffinus griseus*	14	0.23
Ancient murrelet	*Synthliboramphus antiquus*	13	0.22
Red-throated loon	*Gavia stellata*	9	0.15
California gull	*Larus californicus*	6	0.10
Double-crested cormorant	*Phalacrocorax auritus*	3	0.05
Western grebe	*Aechmophorus occidentalis*	3	0.05
Harlequin duck	*Histrionicus histrionicus*	2	0.03
Manx shearwater	*Puffinus puffinus*	2	0.03
Marbled murrelet	*Brachyramphus marmoratus*	2	0.03
Pacific loon	*Gavia pacifica*	2	0.03
Thayer's gull	*Larus thayeri*	2	0.03
Unidentified murrelet	Family Alcidae	2	0.03
Canada goose	*Branta canadensis*	1	0.02
Common loon	*Gavia immer*	1	0.02
Fork-tailed storm-petrel	*Oceanodroma furcata*	1	0.02

Table 6.(con't). Seabird species observed during marine bird survey effort. Species are listed in descending order of numerical importance; counts include both flying birds and birds on the water

Common name	**Scientific name**	**Total count**	**Percentage of total**
Glaucous gull	*Larus hyperboreus*	1	0.02
Laysan albatross	*Diomedea immutabilis*	1	0.02
Pelagic cormorant	*Phalacrocorax pelagicus*	1	0.02
Ring-billed gull	*Larus delawarensis*	1	0.02
Unidentified jaeger	*Stercorarius* spp.	1	0.02
Unidentified loon	*Gavia* spp.	1	0.02
White-winged scoter	*Melanitta fusca*	1	0.02
Total		6012	100.00

Table 7. Acoustic detections of marine mammals

Date	Time	Latitude	Longitude	1st detection	Species	Ecotype
3/17/2008	20:50	46.2044	-124.6274	Acoustics	O.o. or P.m.?	N/A
3/18/2008	08:19	46.5735	-124.1910	Acoustics on Flying Bridge	O. orca	Unknown
3/18/2008	13:22	46.6854	-124.4726	Visual	O. orca	Transient?
3/19/2008	16:11	46.4882	-124.5916	Acoustics on Flying Bridge	O. orca	Offshore or Resident?
03/22/08	06:17	46.2228	-124.476	Acoustics	O.o. or P.m.?	N/A
3/22/2008	8:45	46.4474	-124.3539	Visual	O. orca	Possible Transient
3/25/2008	4:00	48.4731	-124.6445	Acoustics	O. orca	S.R. J-Pod

Table 8. Killer whale encounters.

Date	Duration of encounter	Latitude	Longitude	Ecotype	Whales Present
3/18/2008	~ 40 minutes	46.6854	-124.4726	Transients	Unk.
3/22/2008	2hr 18min	46.4474	-124.3539	Transients	Unk.
3/25/2008	9hrs 27min	48.4731	-124.6445	Resident	J pod

Table 9. Summary of environmental data.

Sample type	Cruise total
CTD casts	6
CTD chlorophyll samples	57
Surface chlorophyll samples	47
Nutrient samples	60
Salinity samples	22
XBT drops	25

Table 10. XBT deployment locations

XBT #	Serial #	Max depth (m)	Sea surface temp (°C)	PST Date	PST time	Latitude (N)	Longitude (W)
1	973138	68	8.5	3/18/08	956	46 35.64	124 19.93
2	973134	163	8.5	3/18/08	1200	46 38.49	124 39.82
3	973130	370	8.7	3/18/08	1819	46 46.68	124 51.92
4	973129	160	8.4	3/19/08	900	47 00.27	124 48.39
5	973133	65	8.7	3/19/08	1200	46 50.95	124 23.02
6	973137	156	8.5	3/19/08	1500	46 36.94	124 36.50
7	1006009	174	8.8	3/20/08	900	45 31.18	124 20.60
8	1006013	96	9.0	3/20/08	1200	45 15.07	124 07.13
9	1006017	175	9.0	3/20/08	1500	45 00.17	124 19.63
10	1006014	99	9.0	3/20/08	1945	44 40.30	124 25.00
11	1006018	124	9.0	3/21/08	900	44 03.70	124 40.59
12	1006010	84	9.1	3/21/08	1200	44 17.95	124 23.08
13	1006019	72	9.4	3/21/08	1500	44 39.42	124 15.64
14	1006015	73	8.0	3/22/08	1000	46 25.22	124 19.39
15	1006011	132	8.4	3/22/08	1200	46 32.70	124 28.12
16	1006012	71	8.6	3/22/08	1500	46 59.21	124 29.75
17	1006016	149	7.8	3/23/08	900	48 12.43	123 41.94
18	1006020	161	7.9	3/23/08	1200	48 22.52	124 07.65
19	1005916	134	8.1	3/23/08	1500	48 23.45	124 30.71
20	1005920	243	8.2	3/24/08	900	48 28.75	124 37.91
21	1005924	140	8.2	3/24/08	1200	48 14.21	124 00.84
22	1005915	156	7.8	3/24/08	1522	48 21.24	124 03.27
23	1005919	181	8.1	3/25/08	920	48 21.63	124 25.39
24	1005923	169	8.0	3/25/08	1200	48 30.91	124 34.20
25	1005914	54	8.2	3/25/08	1500	48 39.11	124 57.33

Table 11. CTD deployment locations.

CTD #	Number of depths sampled	Max depth (m)	Local Date PST	Local Start Time PST	Lat (decimal degrees)	Long (decimal degrees)
1	12	1010	3/17/08	2031	46.79	-125.29
2	12	700	3/18/08	2036	46.24	-124.57
3	11	425	3/20/08	2030	45.26	-124.60
4	12	1000	3/21/08	2035	47.56	-125.45
5	9	130	3/22/08	2038	48.36	-124.06
6	10	175	3/23/08	2037	48.29	-124.16

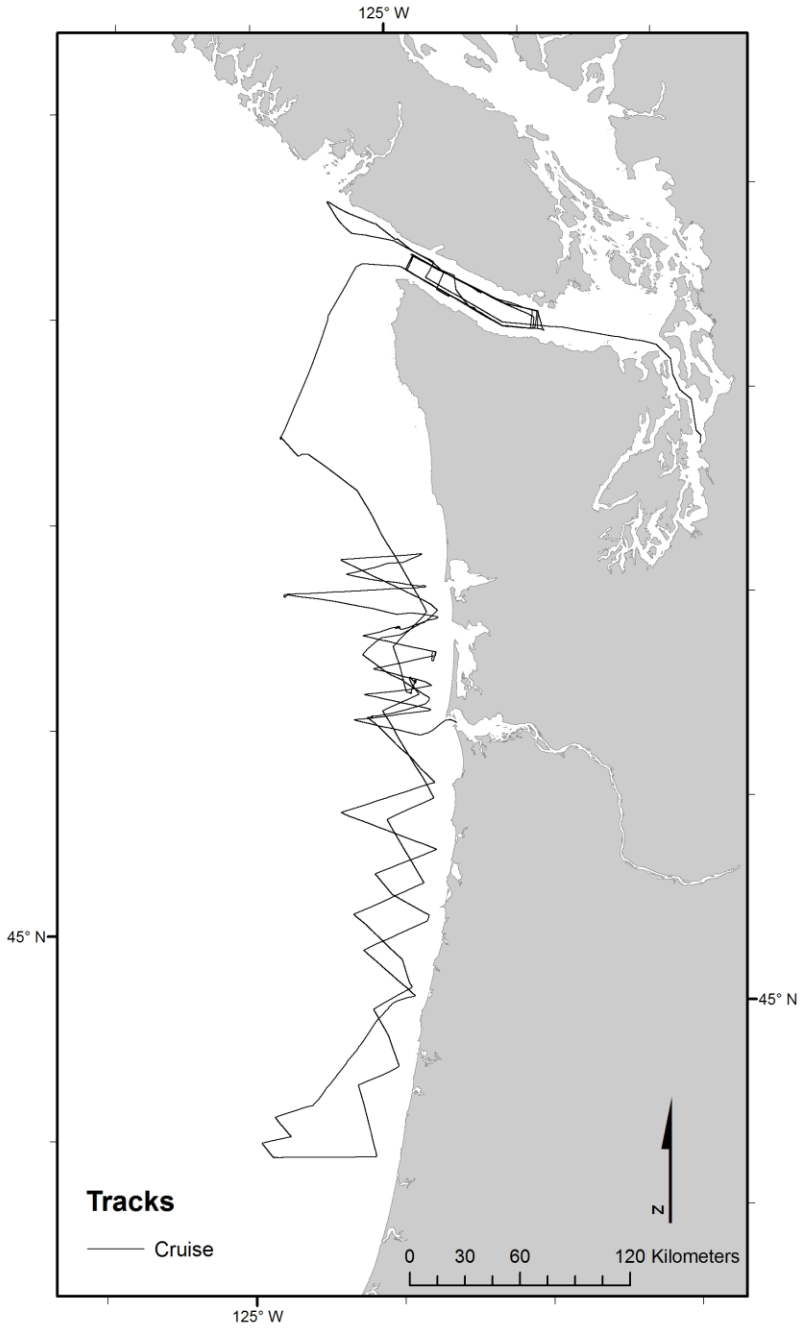

Figure 1. Cruise track of the McArthur II from 17 - 26 March 2008.

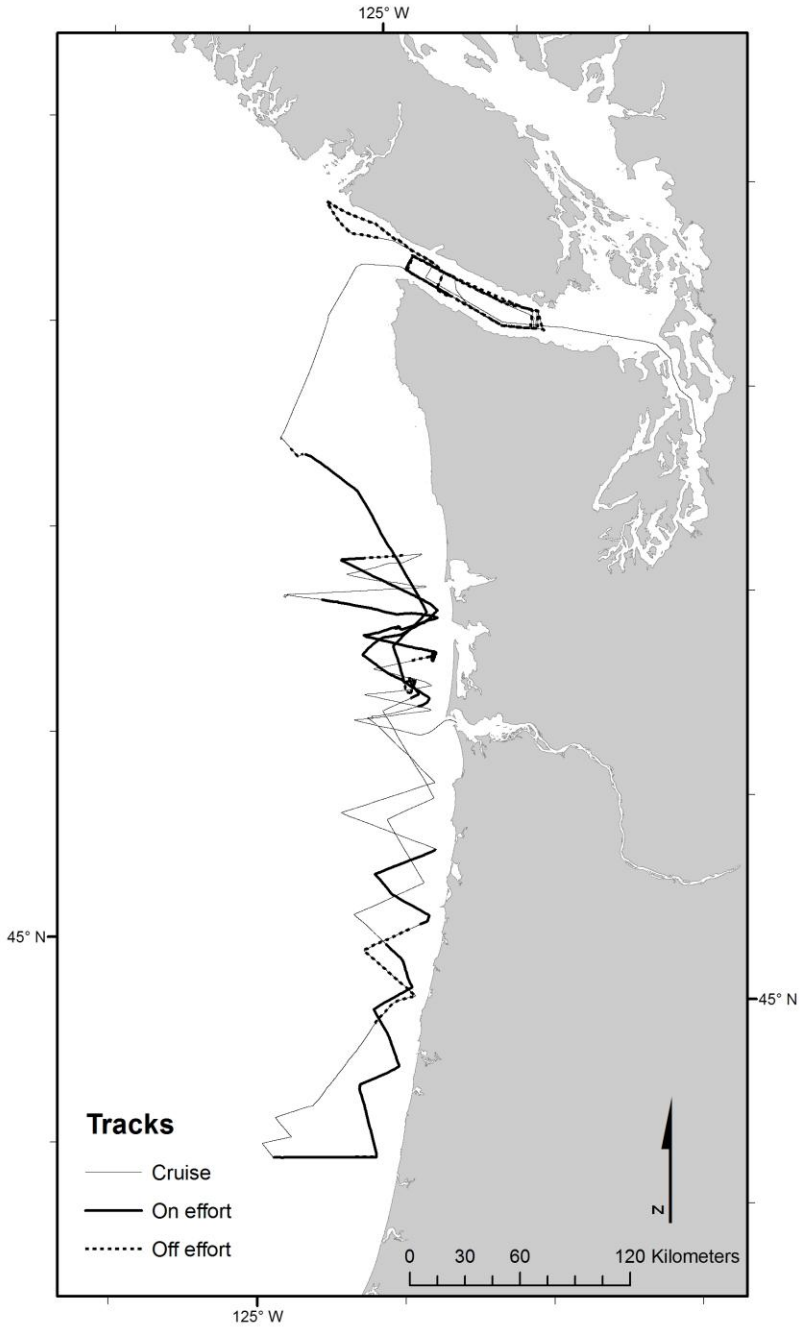

Figure 2. Visual On and Off – effort monitoring of marine mammals from 17 - 26 March 2008.

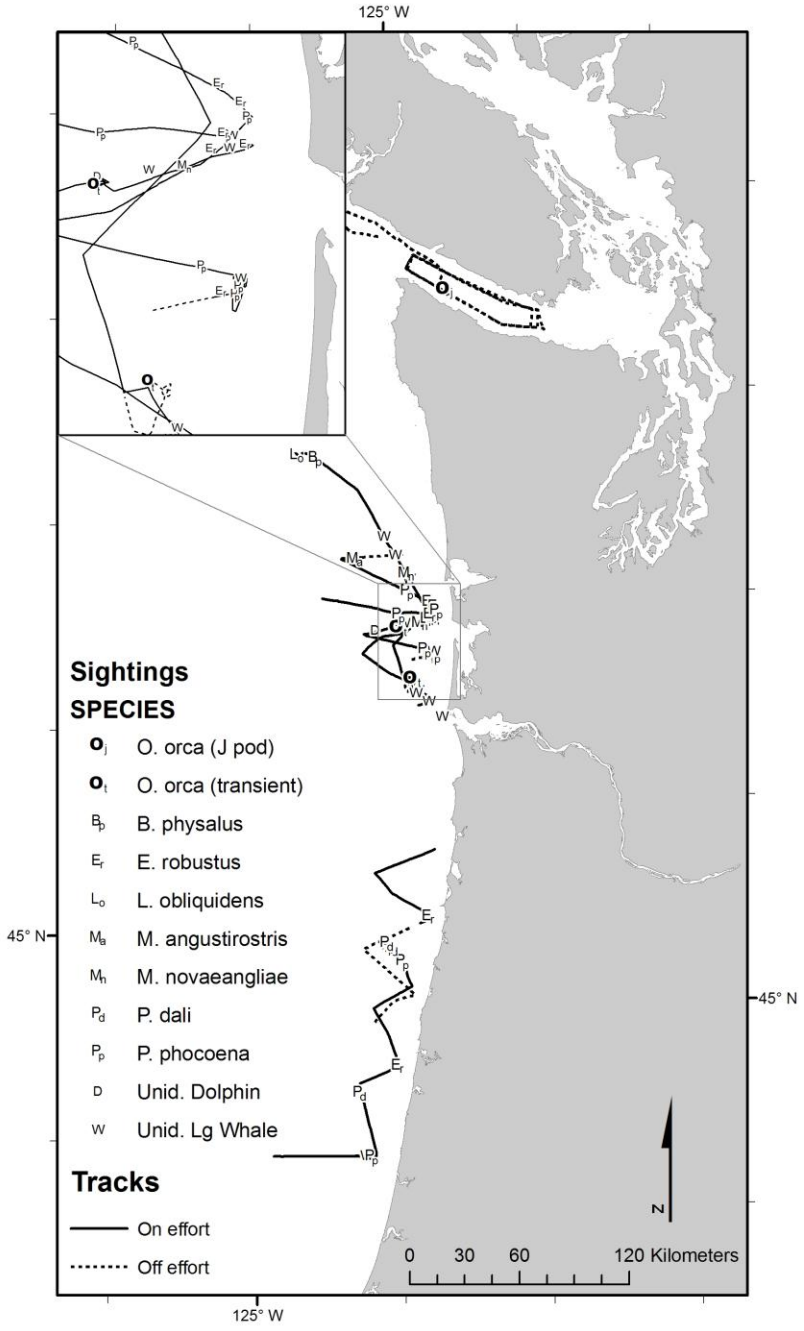

Figure 3. On and Off- effort sightings of marine mammals from 17 - 26 March 2008.

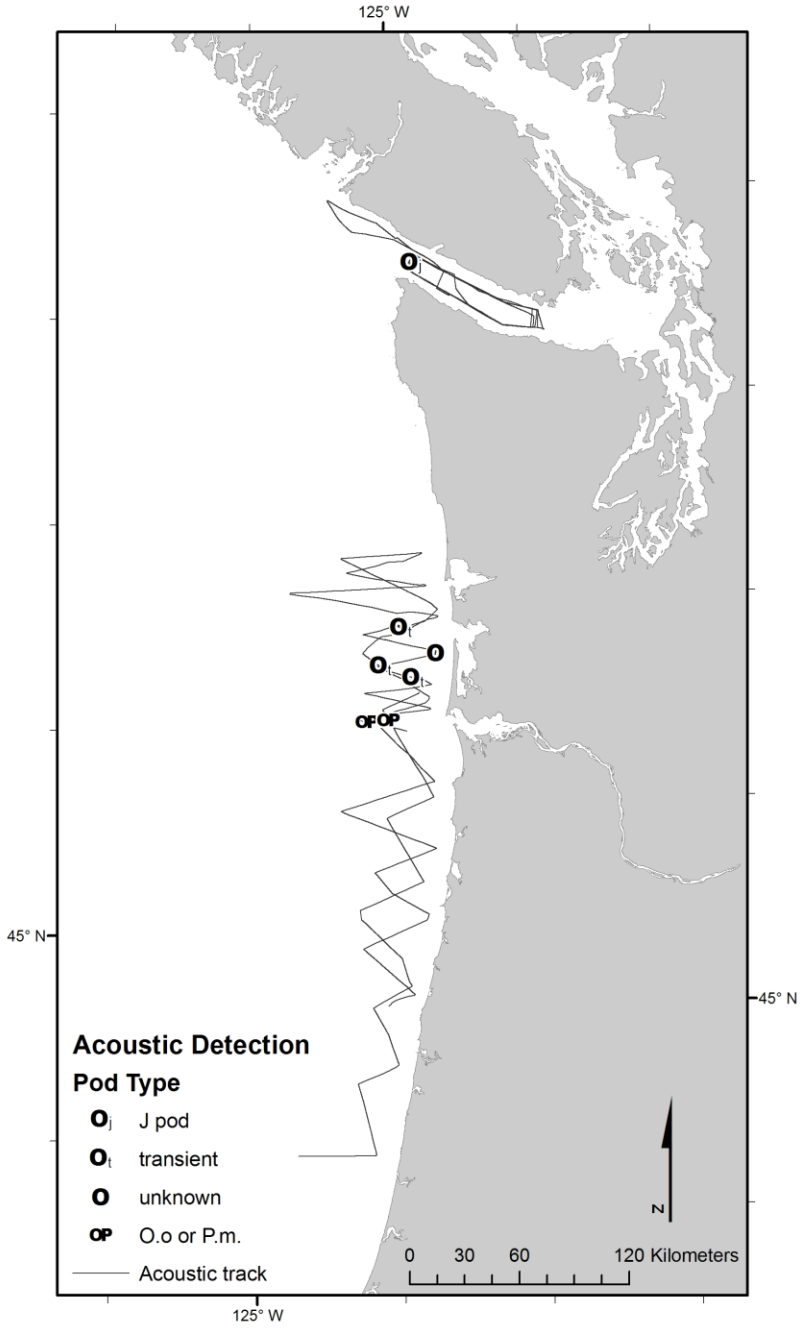

Figure 4. Acoustic detections of marine mammals from 17 - 26 March 2008.

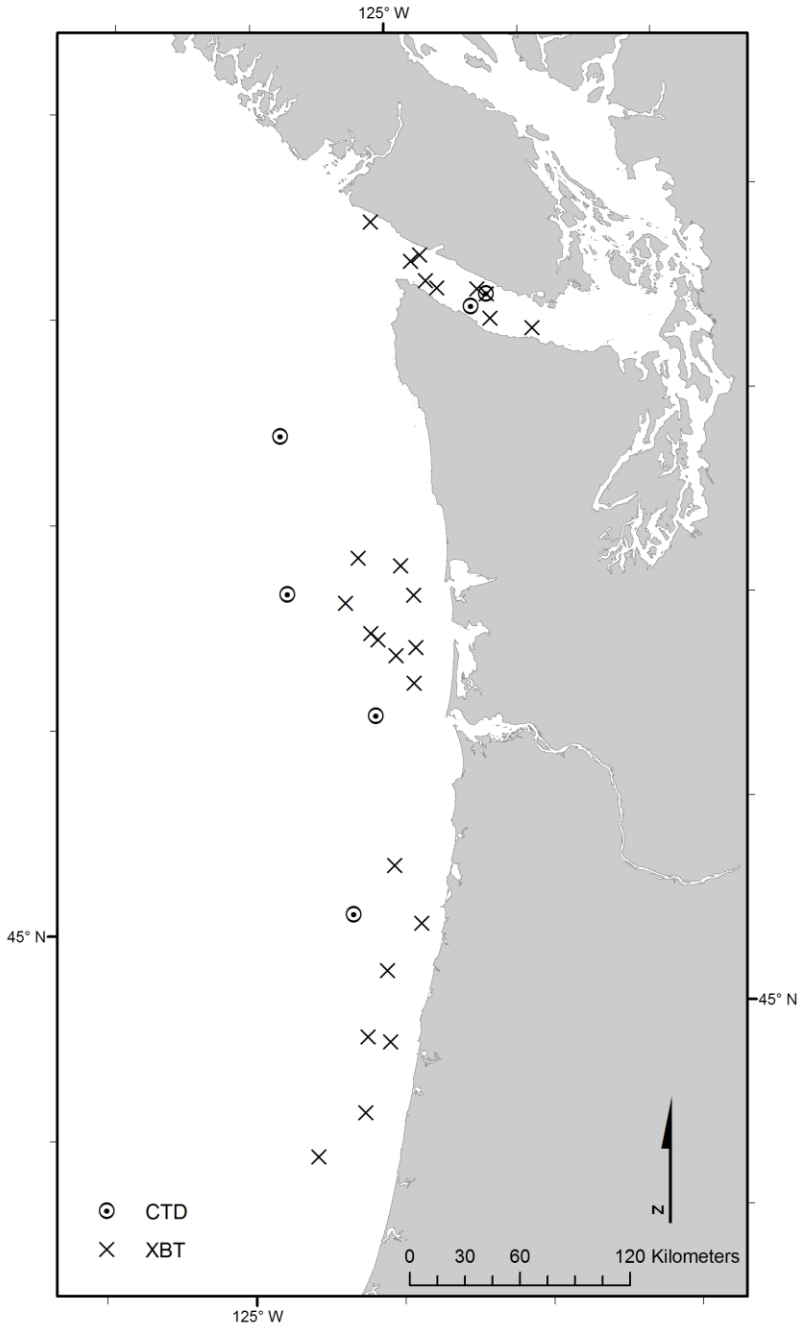

Figure 5. XBT and CTD deployments from 17 - 26 March 2008.