



Northwest Fisheries Science Center

National Marine Fisheries Service

U.S. DEPARTMENT OF COMMERCE

**NWFSC CRUISE REPORT, CRUISE NOS.
MF2010-03 AND SH2010-01**

Results of the 2010 Pacific Hake Inter-Vessel
Calibration Between the NOAA Ships *Miller
Freeman* and *Bell M. Shimada* off the Coast of
Northern California, Oregon, and Washington

September 2012

Cruise Period, Area, and Schedule

Scientists from the U.S. Northwest Fisheries Science Center (NWFSC) at the National Marine Fisheries Service (NMFS) and the Pacific Biological Station (PBS) at the Department of Fisheries and Oceans Canada (DFO) conducted an Inter-Vessel Calibration (IVC) between the NOAA ships *Miller Freeman* and *Bell M. Shimada* on Pacific hake (*Merluccius productus*) off the coast of Northern California, Oregon, and Washington, with a primary focus on aggregations west of Newport, Oregon. The cruise began on June 26, 2010 in Seattle, Washington. However, on that date the *Miller Freeman* suffered a malfunction of generator equipment that delayed her departure from Seattle by nine days to July 5. Only when the *Miller Freeman* was repaired, left Seattle, and rendezvoused with the *Bell M. Shimada* on July 6 did true IVC operations begin. The cruise ended on July 23 with the *Bell M. Shimada* in Seattle and the *Miller Freeman* in Port Angeles.

The cruise included two legs and two calibrations of each vessel's acoustic system. The vessels' itineraries were as follows:

Before Leg 1

June 10 A pre-cruise acoustic system calibration with standard targets was conducted on the *Bell M. Shimada* in Elliott Bay, Washington.

Leg 1

June 26 Scientific personnel embarked aboard the *Bell M. Shimada* in Seattle and the vessel departed. The *Miller Freeman* remained in Seattle because of mechanical malfunctions.

June 27–July 5 The *Bell M. Shimada* scouted for and fished on Pacific hake off the Washington and Oregon coast. Scientific personnel embarked aboard the *Miller Freeman* on July 4 and conducted an acoustic system calibration with standard targets in Elliott Bay. The *Miller Freeman* departed on July 5 to rendezvous with the *Bell M. Shimada*.

July 6–8 The *Miller Freeman* and *Bell M. Shimada* began follow-the-leader IVC operations. The *Bell M. Shimada* conducted camera tows and the *Miller Freeman* conducted trawl operations for haul representativeness. Scouting for Pacific hake continued.

July 9–11 Inport Eureka, California.

Leg 2

July 12–14 Depart Eureka. The *Miller Freeman* and *Bell M. Shimada* continued with follow-the-leader IVC operations and added side-by-side IVC operations.

- July 15 The *Bell M. Shimada* conducted camera tows and the *Miller Freeman* conducted trawl operations for haul representativeness.
- July 16 Side-by-side and follow-the-leader IVC operations continued.
- July 17 The *Bell M. Shimada* conducted camera tows and the *Miller Freeman* conducted trawl operations for haul representativeness.
- July 18–21 Follow-the-leader IVC operations continued along with intermittent trawling.
- July 22–23 The *Miller Freeman* suffered a ship-wide power failure and eventually steamed/was escorted by tugboat to Port Angeles, Washington. Scientific personnel disembarked.
- July 23 An acoustic system calibration with standard targets was conducted on the *Bell M. Shimada* in Elliott Bay. Scientific personnel disembarked.
- July 25 A repaired *Miller Freeman* left Port Angeles for Seattle.
- July 26 A post-cruise acoustic system calibration with standard targets was conducted on the *Miller Freeman* in Elliott Bay.

Objectives

The primary goal of the 2010 Pacific Hake Inter-Vessel Calibration was to determine if there were differences in acoustic measurements between the current survey vessel, the NOAA Ship *Miller Freeman*, and the most recent Fishery Survey Vessel (FSV), the NOAA Ship *Bell M. Shimada*. The *Bell M. Shimada* belongs to a new class of quieted vessel that complies with the International Council for the Exploration of the Sea (ICES) vessel noise standard. The IVC is a crucial component of continuing the long-term time series of Pacific hake Integrated Acoustic and Trawl (IAT) surveys, one that allows for direct comparison of data that were collected historically to data that were collected when the *Bell M. Shimada* conducted the Pacific hake IAT survey in 2011 and 2012.

The 2010 IVC also had a number of secondary objectives, including: 1) to calibrate the 18-kHz, 38-kHz, 70-kHz, 120-kHz, and 200-kHz scientific acoustic systems using standard sphere techniques; 2) to test further an automated calibration system; 3) to sample schools of Pacific hake using a haul representativeness protocol; 4) to continue testing a net-mounted camera system; 5) to continue with attempts at acoustically differentiating Pacific hake from Humboldt squid (*Dosidicus gigas*); 6) to collect target strength measurements of Pacific hake; 7) to collect stomach samples from Pacific hake for food habits studies; 8) to jig for Humboldt squid to ground truth Humboldt squid *in situ* target strength measurements, and to collect useful biological information about Humboldt squid; 9) to collect physical oceanographic data; 10) to collect Video Plankton Recorder (VPR) data; and 11) to collect water samples for determining Harmful Algal Blooms (HAB).

Methods

Sampling Equipment

Acoustic data were collected with the Simrad EK60 scientific echo sounder system using the ER60 software system on board the NOAA Ships *Miller Freeman* and *Bell M. Shimada*. The two ships are stern trawlers equipped with a variety of scientific data acquisition systems for fisheries and oceanographic research. Simrad 18-kHz, 38-kHz, 120-kHz, and 200-kHz split-beam transducers were mounted on the bottom of retractable centerboards that, when fully extended, held the transducers approximately 9 m below the water surface (the *Bell M. Shimada* also had a 70-kHz split-beam transducer mounted on the centerboard). Raw acoustic backscatter (ER60 .raw) and Echolog 60 (Echoview .ek6) data files were logged; in Myriax (previously SonarData) Echoview the latter were used for live viewing and the former were used for scrutinizing. Event log markers and other marks, including initial judgments of Pacific hake backscattering layers, were made on the live-viewed files.

Pelagic trawling on the *Miller Freeman* was performed with an Aleutian wing trawl 24/20 (AWT). This net had a vertical opening that averaged 21 m (range = 11–25 m), a headrope and footrope of 101.8 m each, and a total length of 128 m. Mesh sizes tapered from 320.0 cm in the forward section of the net to 10.0 cm in the codend; a 3.2-cm codend liner was used. The AWT was deployed with a pair of 4-m² “Fishbuster” trawl doors (884.5 kg), 82.3-m legs, and 226.8-kg (500-lb) or 113.4-kg (250-lb) chain (“Tom”) weights on each side. Trawling on bottom was performed with a poly Nor’eastern trawl 89/121 (PNE). This net had a vertical opening of 6 m, a headrope of 27.1 m, a footrope of 36.6 m, and a total length of 42.1 m. Mesh size was 12.7 cm in the intermediate section and a 3.2-cm codend liner was used. The PNE also used the 4-m² “Fishbuster” trawl doors. To monitor and guide the fishing process on the *Miller Freeman*, a WESMAR TCS 770 third-wire trawl sonar was attached to the AWT headrope and a Furuno wireless net sounder was attached to the PNE headrope.

An AWT was also used on the *Bell M. Shimada*, but this net had been modified with a baffle to direct fish past a video camera system mounted inside the net. The camera system used two 10-cm laser length references to measure fish length, and the net was fished with the codend open or closed. A Simrad FS70 third-wire trawl sonar was attached to the AWT headrope to monitor and guide the fishing process.

Vertical profiles of temperature and salinity data were collected with a Sea-Bird Electronics, Inc. SBE 911*plus* conductivity-temperature-depth (CTD) system during calibrations of the acoustic system (to obtain a sound speed profile) and at locations along designated acoustic transects. CTD casts were conducted at night after collection of acoustic data had ceased. To obtain high-resolution optical images of plankton in the water column, a SeaScan, Inc. video plankton recorder (VPR) was mounted on the CTD rosette and deployed with CTD casts on the *Miller Freeman*. Additional temperature and depth profile data were collected by attaching a Sea-Bird SBE 39 temperature/pressure sensor to the trawl headrope during trawl hauls conducted on the *Miller Freeman*. On both vessels, ocean current velocity profile data were obtained using a Teledyne RD Instruments Ocean Surveyor 75-kHz Acoustic Doppler Current Profiler (ADCP)

system. Continuous sea surface temperature and salinity (TSG) data were collected and stored on the Scientific Computing System (SCS).

Inter-Vessel Calibration

The IVC differed in transect length, depth range, and spacing from a traditional Pacific hake IAT survey. The area covered during the IVC ranged from the northwest tip of Washington to just north of Humboldt Bay, California (Figs. 1–10). While scouting for hake, the ships ran transects in a zigzag pattern rather than traditional parallel transects. Zigzag transects were run nominally between depth contours of 100 m and 800 m, but during leg 2 offshore transects often ended at a depth of 500 m. In addition to zigzag transects, so-called “mini-grids” were run (Figs. 6-7). These grids consisted of seven or eleven transects that were oriented east-west, with an inter-transect distance of 1.0 or 1.5 nmi and a nominal length of 5 nmi. Each mini-grid was centered on an area where good Pacific hake echosign had been observed while running a zigzag transect.

When the *Miller Freeman* and the *Bell M. Shimada* were conducting IVC operations together, they ran in two different modes: follow-the-leader (FL) and side-by-side (SS). In FL mode, one ship followed the other, separated by about 0.5 nmi, along the same transect and with a slight perpendicular offset of 0.0–0.1 nmi to the transect line. In SS mode, the ships ran transects in parallel, separated by 0.5 nmi. Randomization was used to determine which ship would lead (while in FL mode) and which ship took the north parallel transect (while in SS mode). All zigzag transects were run in FL mode while the “mini-grids” were split evenly between the two modes.

For all transect operations, vessel speed averaged 5.1 m/sec (10 knots) during acoustic sounding along each transect. Acoustic operations were run only between sunrise and sunset (i.e., roughly from 0600 to 2100 PDT, about 15 hours per day) when Pacific hake formed distinct and identifiable midwater layers. Physical oceanographic data were recorded during both day and night. CTD casts were performed primarily at night after collection of acoustic echosounder data had ceased, but they also were conducted during daytime to determine sound speed during all acoustic calibrations. ADCP data were collected continuously day and night throughout the entire survey (except for acoustic calibrations) to provide information on currents at depths down to roughly 600 m. SCS sea surface data (e.g., temperature and salinity) were collected continuously day and night throughout the entire survey.

Trawling and Haul Representativeness

Trawl samples and video data were collected 1) to provide ground truthing for classifying observed backscatter layers to species; 2) to determine Pacific hake size composition; and 3) to collect specimens from Pacific hake. Distinct layers of backscatter that were observed while running zigzag transects and that were indicative of relatively high densities of Pacific hake were the highest priority for trawling.

The purpose of conducting haul representativeness operations was to test the assumption of homogeneity of patchiness of fish distribution (numerical density) within an aggregation. Once an aggregation of Pacific hake had been selected, the following trawling protocol associated with

haul representativeness was followed: A) The aggregation was fished in the manner of a normal Pacific hake IAT survey, regardless of depth and without a set time duration; B) The aggregation was fished at the top, middle, and bottom (sequence selected randomly) at the location used for haul A and with a set time duration (nominally 15 minutes); C) The aggregation was fished along the transect at the beginning, middle, and end at the depth used for haul A and with a set time duration (nominally 15 minutes); and D) While the *Miller Freeman* was conducting tows for protocol A, B, and C, the *Bell M. Shimada* conducted camera tows in the same areas targeted by the *Miller Freeman*. For all tows, average trawling speed was about 1.5 m/s (3 knots).

All trawl catches were sorted completely. Total numbers and weights were determined for most species, although invertebrates that are not efficiently caught by a trawl (e.g., jellyfish, salps, and euphausiids) could not always be counted. Aggregate weights were measured to the nearest 0.05 kg for the sorted portions of the catch using an electronic, 60-kg capacity Marel M1100 (PL4200) motion-compensated scale. Pacific hake were subsampled to determine length composition by sex, to collect otoliths for subsequent age determination, and to collect individual weight measurements and gonad condition. Pacific hake were sampled completely from a trawl catch when just a small number were caught, i.e., fewer than roughly 300 to 400 individuals. Fish lengths (fork length) were determined to the nearest centimeter using a Scantrol FM100 FishMeter board. An electronic, 15-kg capacity Marel M1100 (PL2060) motion-compensated scale was used to determine all weights of individual fish specimens to the nearest 0.02 kg. Pacific hake maturity was determined by visual inspection of gonads and classified by a 5-stage scale (ADP Code Book, 2009, RACE Division, AFSC, Seattle, Washington). Otoliths were preserved in 50% ethanol for subsequent age determination. Pacific hake stomachs were collected and preserved in 10% neutral-buffered formalin.

Preliminary Results

Calibration

Two calibrations of the acoustic systems of both vessels were conducted: the *Bell M. Shimada* on 10 June and 23 July, and the *Miller Freeman* on 4 July and 26 July. All calibrations were conducted in Elliott Bay, Washington. Results of the four calibrations were within expected levels based on factory settings and results from previous calibrations.

Inter-Vessel Calibration

While conducting the IVC, the *Miller Freeman* ran a total vessel track line of approximately 4,630 km (2,500 nmi) and the *Bell M. Shimada* ran 7,484 km (4,041 nmi). At the start of leg 1 of the IVC, the *Bell M. Shimada* (independently of the *Miller Freeman*) ran zigzag transects north to south along Washington and Oregon to scout for hake (Figure 1). When the *Miller Freeman* joined the *Bell M. Shimada*, the two ships ran one FL mini-grid of eleven transects west of Siletz Bay, Oregon and two FL zigzag transects before importing in Eureka, California (Figures 2 and 3). During leg 2, the two NOAA Ships completed additional FL zigzag transects, two SS mini-grids west of Newport, Oregon, and one FL mini-grid west of Willapa Bay, Washington (Figures 4–10). All mini-grids conducted in leg 2 consisted of seven transects.

Finding aggregations of adult Pacific hake that were extensive and dense enough for IVC operations proved challenging at times. While the *Bell M. Shimada* scouted south along Washington and Oregon at the beginning of leg 1, some areas of good Pacific hake echosign were observed, but the distribution of these areas was patchy and the corresponding echosign was consistent with that of sub-adult Pacific hake. Very little echosign of any Pacific hake was observed off Northern California. Satisfactory aggregations of Pacific hake were observed primarily off the central Oregon coast west of Newport; subsequently, most of the mini-grids and trawling conducted during the IVC occurred in this area. Toward the end of leg 2, running northbound zigzag transects and conducting one mini-grid off the Washington coast yielded little in the way of Pacific hake echosign.

The initial at-sea, visual comparison of Pacific hake aggregations as detected by the acoustics systems of the two NOAA Ships looked promising, and the aggregations appeared similar between the vessels. Preliminary results showed the *Miller Freeman* observing roughly 4.2% more echosign than did the *Bell M. Shimada* on follow-the-leader transects (Figure 11A). The coefficient of variance (CV) was 0.13. For side-by-side transects, the *Miller Freeman* observed roughly 25.9% less than the *Bell M. Shimada* did during one set (Figure 11B), while during another set (Figure 11C) the *Miller Freeman* observed roughly 7.3% more. The CV for side-by-side was 0.31, more than twice that of follow-the-leader. Quantitative analysis of the acoustic data is in progress.

Biological and Optical Sampling

A total of 62 trawls were successfully conducted by the two NOAA Ships: 25 on the *Miller Freeman* (Table 1, Figure 12) and 37 camera trawls on the *Bell M. Shimada* (Table 2, Figure 13). Catch weights on the *Miller Freeman* ranged from 0.0 kg to 11,482 kg (mean = 1,223 kg). Midwater trawls caught Pacific hake almost exclusively (~99% by weight), with two salmon shark (*Lamna ditropis*) caught incidentally on separate occasions (Table 3). The only bottom trawl conducted caught a more evenly distributed mix of species (Table 4); the top five species (by weight) were Pacific hake, darkblotched rockfish (*Sebastes crameri*), roughey rockfish (*Sebastes aleutianus*), Pacific ocean perch (*Sebastes alutus*), and Dover sole (*Microstomus pacificus*). Midwater camera trawls conducted on the *Bell M. Shimada* observed and caught Pacific hake almost exclusively; small numbers of lanternfish (Myctophidae), yellowtail rockfish (*Sebastes flavidus*), Pacific ocean perch, squid (Teuthida), and a few other incidental species were either observed or caught. Because a primary goal of the *Bell M. Shimada* was to collect underwater video data and not to process trawl catches thoroughly, the vessel had not been equipped with appropriate catch and fish processing software nor had sufficient personnel on board to process all trawl catches using a customary protocol. Hence, some of the trawl catch data were incomplete.

Of the twenty-five trawls conducted on the *Miller Freeman*, just under two-thirds (N = 16/25) were associated with the haul representativeness investigation that was conducted on three days: 7 July (five trawls, Figure 14), 15 July (five trawls, Figure 15), and 17 July (six trawls, Figure 16). Length-frequency plots of Pacific hake measured from haul representativeness tows displayed a variation among tows within an aggregation (Figures 17–19). However, there was

no evidence of a systematic bias with regard to trawl depth or lateral position within an aggregation. Further analysis of the haul representativeness trawls is ongoing.

During the cruise, biological sampling of Pacific hake on the *Miller Freeman* included 7,748 length measurements and 1,133 collected pairs of otoliths (Table 5). On the *Bell M. Shimada*, 2,470 Pacific hake lengths were measured and 300 pairs of otoliths were collected (Table 6). Overall length-frequency distributions of Pacific hake measured on both ships displayed a trimodal distribution that correlated with ages of 1, 2, and 3+ (Figures 20 and 21).

During the IVC, even scarcer than the Pacific hake were Humboldt squid, a target species that was abundant during the 2009 Pacific hake acoustic survey but which in 2010 was not observed at all. Several attempts were made on the *Bell M. Shimada* during leg 1 to jig for squid, but none were caught.

Oceanographic Data Sampling

Seven CTD temperature and salinity profiles were collected on the *Miller Freeman* (Table 7, Figure 22) and 102 were collected on the *Bell M. Shimada* (Table 8, Figure 22) at selected locations. Additional temperature profiles were collected from twenty-five SBE casts that were collected at *Miller Freeman* trawl stations. Both ships collected ADCP and TSG data throughout the cruise. Analysis of oceanographic data is ongoing.

Observed Problem

At intermittent times during the cruise, acoustic dropouts were observed on the *Bell M. Shimada* (Figure 23). Initial analysis examined if any correlation existed between the presence of dropouts and vessel speed and/or meteorological conditions (e.g., wind speed, wind direction relative to ship direction, sea wave height, and height of wave swells), but none was immediately apparent or conclusive. Further analysis will be ongoing.

Scientific Personnel

<u>Name</u>	<u>Sex/Nationality</u>	<u>Position</u>	<u>Organization</u>
<u>Before Leg 1 <i>Bell M. Shimada</i> (6/10)</u>			
Dezhang Chu	M/USA	Chief Scientist	NWFSC
Lisa Bonacci	F/USA	Acoustician	NWFSC
Stephen de Blois	M/USA	Acoustician	NWFSC
Larry Hufnagle	M/USA	Acoustician	NWFSC
John Pohl	M/USA	Fish. Biologist	NWFSC
Rebecca Thomas	F/USA	Acoustician	NWFSC
Stan Tomich	M/USA	Engineer	NWFSC

Leg 1 Bell M. Shimada (6/26–7/8)

Larry Hufnagle	M/USA	Chief Scientist	NWFSC
Sarikka Attoe	F/USA	Graduate Student	OSU
Matthew Biddle	M/USA	Volunteer	HSU
Lisa Bonacci	F/USA	Acoustician	NWFSC
Jack Brown	M/USA	Volunteer	OCZMA
Dezhang Chu	M/USA	Acoustician	NWFSC (6/26–7/5)
Chris Grandin	M/Canada	Acoustician	DFO
Kate Merrick	F/USA	Volunteer	NWFSC
Stephen Pierce	M/USA	Oceanographer	OSU
Waldo Wakefield	M/USA	Fish. Biologist	NWFSC

Leg 1 Miller Freeman (7/4–7/8)

Rebecca Thomas	F/USA	Chief Scientist	NWFSC
Stephen de Blois	M/USA	Acoustician	NWFSC
Julia Clemons	F/USA	Oceanographer	NWFSC
John Pohl	M/USA	Fish. Biologist	NWFSC

Leg 2 Bell M. Shimada (7/12–7/23)

Lisa Bonacci	F/USA	Chief Scientist	NWFSC
Stephen Pierce	M/USA	Oceanographer	OSU
John Pohl	M/USA	Fish. Biologist	NWFSC

Leg 2 Miller Freeman (7/12–7/23)

Larry Hufnagle	M/USA	Chief Scientist	NWFSC
Matthew Biddle	M/USA	Volunteer	HSU
Stephen de Blois	M/USA	Acoustician	NWFSC
Julia Clemons	F/USA	Oceanographer	NWFSC
Jake Minich	M/USA	Lab. Technician	SWFSC

After Leg 2 Miller Freeman (7/26)

Dezhang Chu	M/USA	Acoustician	NWFSC
Rebecca Thomas	F/USA	Acoustician	NWFSC

DFO – Department of Fisheries and Oceans Canada, Nanaimo, British Columbia

NWFSC – Northwest Fisheries Science Center, Seattle, Washington

HSU – Humboldt State University, Arcata, California

OCZMA – Oregon Coastal Zone Management Association, Depoe Bay

OSU – Oregon State University, Corvallis

SWFSC – Southwest Fisheries Science Center, La Jolla, California

Table 1. Trawl station and catch data summary from the NOAA Ship *Miller Freeman* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Haul no.	Date	Time (PDT)	Duration (min.) ^a	Gear type ^b	Start position		Depth (m)		Temp. (°C)		Catch				
					Latitude	Longitude	Gear ^c	Bottom	Gear ^d	Surface	Pacific hake (kg)	Number	Other (kg)		
1	6 Jul	20:48	10	AWT	44	52.64	124	39.00	338	360	6.01	15.03	1,135.0	6,503	2.3
2	7 Jul	7:04	6	AWT	44	53.12	124	39.01	332	357	6.0	14.46	144.4	515	0.3
3	7 Jul	9:39	--	AWT	trawl unsuccessful		--	--	--	--	14.52	--	--	--	--
4	7 Jul	11:50	15	AWT	44	52.82	124	38.86	289	365	6.18	14.81	0.2	1	0.3
5	7 Jul	13:49	15	AWT	44	52.73	124	38.52	338	373	5.82	14.98	841.2	4,208	0.3
6	7 Jul	15:33	--	AWT	trawl aborted because of marine mammal(s)		--	--	--	--	--	--	--	--	--
7	7 Jul	17:27	15	PNE	44	53.17	124	38.82	364	365	5.61	15.27	158.0	410	273.2
8	7 Jul	20:40	15	AWT	44	52.66	124	36.02	329	392	5.93	14.64	282.7	1,489	0.0
9	8 Jul	13:56	2	AWT	43	16.80	124	43.00	168	221	6.79	11.31	1,866	14,225	0.0
10	14 Jul	11:22	9	AWT	44	35.29	124	36.70	182	193	6.63	13.50	3,570	28,207	0.0
11	15 Jul	8:10	10	AWT	44	33.82	124	36.81	148	193	7.12	12.59	50.5	341	0.9
12	15 Jul	10:01	16	AWT	44	33.76	124	36.79	173	194	6.81	12.34	906.7	9,168	0.2
13	15 Jul	14:12	15	AWT	44	33.74	124	37.09	172	206	6.59	11.24	0.0	4	1.1
14	15 Jul	16:12	15	AWT	44	33.54	124	38.68	252	273	6.19	11.32	709.7	2,670	201.6
15	15 Jul	18:55	15	AWT	44	34.80	124	35.36	141	156	7.08	10.96	0.0	0	0.0
16	16 Jul	10:38	5	AWT	44	46.66	124	36.00	244	275	6.39	11.40	456.3	2,963	1.1
17	16 Jul	19:44	15	AWT	44	43.63	124	34.78	194	208	6.89	11.62	542.2	4,944	0.0
18	17 Jul	7:48	11	AWT	44	43.84	124	34.88	184	208	6.79	11.01	2,070	22,898	0.0
19	17 Jul	10:25	15	AWT	44	43.67	124	36.00	223	239	6.55	11.41	475.9	3,594	8.0
20	17 Jul	12:39	15	AWT	44	43.60	124	34.82	194	206	6.58	11.25	11,482	105,786	0.0
21	17 Jul	16:15	15	AWT	44	43.66	124	34.73	189	205	6.60	11.62	1,019.3	9,589	1.1
22	17 Jul	18:41	10	AWT	44	43.75	124	34.11	181	192	6.62	11.52	1,420	13,581	200.0
23	17 Jul	20:39	14	AWT	44	43.62	124	34.79	188	206	6.65	11.38	427.8	3,317	0.0
24	19 Jul	19:13	15	AWT	46	14.38	124	27.27	269	521	6.08	--	331.1	1,335	3.9
25	20 Jul	11:25	8	AWT	46	25.77	124	33.16	212	382	6.59	12.06	1,290	6,576	0.0
26	20 Jul	13:56	--	AWT	trawl unsuccessful		--	--	--	--	12.18	--	--	--	--
27	20 Jul	19:22	15	AWT	46	25.73	124	33.78	322	560	5.87	12.23	460.4	1,645	8.2
28	21 Jul	14:30	20	AWT	46	45.71	124	49.55	181	194	6.69	12.56	236.6	1,002	4.2

^a Duration is the time during trawling between "Target Depth" and "Haul Back."

^b AWT = Aleutian wing midwater trawl, PNE = poly Nor'eastern bottom trawl

^c Gear depths were measured at the foot rope.

^d Gear temperatures were measured at the head rope.

Table 2. Trawl station summary from the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Haul no.	Date	Time (PDT)	Duration (min.) ^a	Start position			Bottom Depth (m)	Surface Temp. (°C)	Codend Open/Closed
				Latitude	Longitude				
1	27 Jun	20:55	7	47 55.66	125 24.56	771	13.87	Open	
2	28 Jun	13:37	--	trawl aborted			--	--	--
3	28 Jun	17:31	13	47 31.82	125 4.57	675	13.82	Open	
4	29 Jun	10:01	64	47 18.37	124 54.50	829	13.95	Open	
5	29 Jun	14:29	14	47 13.24	125 1.53	196	14.90	Open	
6	29 Jun	20:18	42	47 10.30	124 58.61	477	14.30	Open	
7	30 Jun	13:09	1	46 43.10	124 31.84	104	12.62	Closed	
8	1 Jul	20:46	9	45 41.05	124 44.46	529	15.15	Closed	
9	2 Jul	14:56	<1	45 6.31	124 24.86	332	15.50	Closed	
10	2 Jul	18:52	15	45 6.14	124 25.45	344	15.56	Closed	
11	3 Jul	9:52	8	44 57.27	124 34.10	444	15.44	Closed	
12	3 Jul	12:56	21	44 56.83	124 37.04	446	15.51	Closed	
13	3 Jul	15:51	14	44 54.99	124 35.08	445	15.78	Closed	
14	4 Jul	12:56	14	44 13.63	124 59.56	602	15.63	Closed	
15	6 Jul	21:04	34	44 52.65	124 38.32	375	15.11	Open	
16	7 Jul	7:35	51	44 53.31	124 38.04	419	14.73	Open	
17	7 Jul	10:47	53	44 52.59	124 38.24	392	14.95	Open	
18	7 Jul	14:32	30	44 52.72	124 35.29	392	15.01	Open	
19	7 Jul	17:14	15	44 53.07	124 39.69	356	15.58	Open	
20	7 Jul	19:42	23	44 53.58	124 36.99	439	15.12	Open	
21	8 Jul	15:21	15	43 16.50	124 42.33	205	11.63	Open	
22	14 Jul	10:58	21	44 35.43	124 36.91	212	13.75	Open	
23	15 Jul	8:38	18	44 33.34	124 37.65	233	12.77	Open	
24	15 Jul	11:10	34	44 34.28	124 36.96	205	12.23	Open	
25	15 Jul	15:11	21	44 33.85	124 35.99	176	11.51	Open	
26	15 Jul	17:39	33	44 33.84	124 37.57	220	11.65	Open	
27	15 Jul	20:16	16	44 34.06	124 39.04	285	11.58	Open	
28	16 Jul	10:09	20	44 47.25	124 35.37	272	11.69	Open	
29	16 Jul	19:35	21	44 44.31	124 35.24	219	11.91	Open	
30	17 Jul	8:25	45	44 44.29	124 36.63	281	11.53	Open	
31	17 Jul	11:25	21	44 43.94	124 33.95	189	11.35	Open	
32	17 Jul	13:41	20	44 43.73	124 34.80	208	11.63	Open	
33	17 Jul	15:45	22	44 43.60	124 34.02	192	11.69	Open	
34	17 Jul	19:21	22	44 43.98	124 36.52	263	12.00	Open	
35	19 Jul	19:40	26	46 14.59	124 27.32	492	12.22	Open	
36	20 Jul	11:42	14	46 25.76	124 33.96	565	12.79	Open	
37	20 Jul	14:23	--	trawl aborted			--	--	--
38	20 Jul	19:14	22	46 25.92	124 34.41	730	12.83	Open	
39	21 Jul	14:42	24	46 45.52	124 48.55	182	12.77	Open	

^a Duration is the time during trawling between "Target Depth" and "Haul Back."

Table 3. Catch by species from 24 Aleutian wing (AWT) midwater trawl hauls conducted aboard the NOAA Ship *Miller Freeman* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Common name	Scientific name	Weight (kg)	(%)	Numbers
Pacific hake	<i>Merluccius productus</i>	29,718	98.6	244,561
salmon shark	<i>Lamna ditropis</i>	400	1.3	2
king salmon	<i>Oncorhynchus tshawytscha</i>	6.4	<0.1	1
lanternfish	Myctophidae	6.3	<0.1	--
rougheye rockfish	<i>Sebastes aleutianus</i>	5.4	<0.1	3
yellowtail rockfish	<i>Sebastes flavidus</i>	3.6	<0.1	2
north Pacific armhook squid	<i>Gonatopsis borealis</i>	3.2	<0.1	5
egg-yolk jellyfish	<i>Phacellophora camtschatica</i>	2.3	<0.1	3
jack mackerel	<i>Trachurus symmetricus</i>	1.7	<0.1	1
California market squid	<i>Loligo opalescens</i>	1.1	<0.1	38
salps	Thaliacea	1.1	<0.1	--
widow rockfish	<i>Sebastes entomelas</i>	1.1	<0.1	1
squid	Teuthida	0.5	<0.1	--
euphausiid	Euphausiacea	0.3	<0.1	3,255
pandalid shrimp	Pandalidae	0.3	<0.1	181
Pacific viperfish	<i>Chauliodus macouni</i>	0.1	<0.1	8
blackchin	<i>Scopelogys tristis</i>	<0.1	<0.1	2
shining tubeshoulder	<i>Sagamichthys abei</i>	<0.1	<0.1	1
deepwater eelpout	<i>Lycodapus endemoscotus</i>	<0.1	<0.1	1
--	<i>Abraliopsis</i> sp.	<0.1	<0.1	2
herrings	Clupeidae	<0.1	<0.1	1
Pacific sergestid	<i>Sergestes similis</i>	<0.1	<0.1	31
slender barracudina	<i>Lestidiops ringens</i>	<0.1	<0.1	1
octopus	Octopodidae	<0.1	<0.1	5
fish larvae	--	<0.1	<0.1	1

Table 4. Catch by species from one poly Nor'eastern (PNE) bottom trawl haul conducted aboard the NOAA Ship *Miller Freeman* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Common name	Scientific name	Weight (kg)	(%)	Numbers
Pacific hake	<i>Merluccius productus</i>	158.0	36.6	410
darkblotched rockfish	<i>Sebastes crameri</i>	127.5	29.6	137
rougeye rockfish	<i>Sebastes aleutianus</i>	24.8	5.7	24
Pacific ocean perch	<i>Sebastes alutus</i>	24.4	5.7	37
Dover sole	<i>Microstomus pacificus</i>	24.2	5.6	40
shortspine thornyhead	<i>Sebastolobus alascanus</i>	17.9	4.2	82
rex sole	<i>Glyptocephalus zachirus</i>	16.7	3.9	82
sablefish	<i>Anoplopoma fimbria</i>	16.4	3.8	9
splitnose rockfish	<i>Sebastes diploproa</i>	9.5	2.2	25
arrowtooth flounder	<i>Atheresthes stomias</i>	3.5	0.8	2
bigfin eelpout	<i>Lycodes cortezianus</i>	2.6	0.6	24
sea anemone	Actiniaria	2.3	0.5	93
sandy sea cucumber	<i>Pseudostichopus mollis</i>	1.4	0.3	24
rosethorn rockfish	<i>Sebastes helvomaculatus</i>	0.8	0.2	3
starfish	Asteroidea	0.6	0.1	--
redbanded rockfish	<i>Sebastes babcocki</i>	0.3	<0.1	1
aurora rockfish	<i>Sebastes aurora</i>	0.3	<0.1	2
lanternfish	Myctophidae	0.2	<0.1	15
squid	Teuthida	<0.1	<0.1	6
slender sole	<i>Lyopsetta exilis</i>	<0.1	<0.1	2
fleshy sea pen	<i>Anthoptilum grandiflorum</i>	<0.1	<0.1	1
Pacific viperfish	<i>Chauliodus macouni</i>	<0.1	<0.1	3
snail	Gastropoda	<0.1	<0.1	4
salps	Thaliacea	<0.1	<0.1	--
lampshells	Brachiopoda	<0.1	<0.1	1
flatfish larvae	Pleuronectiformes	<0.1	<0.1	3

Table 5. Numbers of Pacific hake biological samples and measurements collected on the NOAA Ship *Miller Freeman* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Haul	Length	Otoliths	Fish Weight	Maturity	Stomachs
1	267	40	40	0	10
2	315	86	86	0	10
3 *	--	--	--	--	--
4	0	1	1	1	0
5	448	50	50	50	10
6 *	--	--	--	--	--
7	260	50	50	50	9
8	401	52	52	52	10
9	239	50	50	50	10
10	320	50	50	50	10
11	288	49	50	50	11
12	409	50	50	50	10
13	4	0	0	0	0
14	348	50	50	50	10
15	0	0	0	0	0
16	261	51	51	51	10
17	372	53	53	53	10
18	526	48	48	48	10
19	355	51	51	51	10
20	400	51	51	51	11
21	453	50	50	50	10
22	406	51	51	51	11
23	326	50	50	50	10
24	392	50	50	50	11
25	300	50	50	50	10
26 *	--	--	--	--	--
27	337	50	50	50	11
28	321	50	50	50	10
Totals	7,748	1,133	1,134	1,008	224

* Hauls 3 and 26 were unsuccessful and haul 6 was aborted.

Table 6. Numbers of Pacific hake biological samples and measurements collected on the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Haul	Length	Otoliths	Fish Weight
1	2	0	0
2 *	--	--	--
3	94	0	0
4	3	0	0
5	0	0	0
6	9	0	0
7	0	0	22
8	40	50	50
9	315	50	50
10	206	50	50
11	226	50	50
12	0	0	0
13	234	50	50
14	243	50	50
15	34	0	0
16	6	0	0
17	4	0	0
18	24	0	0
19	37	0	0
20	28	0	0
21	260	0	0
22	98	0	0
23	0	0	0
24	116	0	0
25	2	0	0
26	0	0	0
27	78	0	0
28	82	0	0
29	7	0	0
30	42	0	0
31	0	0	0
32	6	0	0
33	79	0	0
34	37	0	0
35	71	0	0
36	58	0	0
37 *	--	--	--
38	27	0	0
39	2	0	0
Totals	2,470	300	322

* Hauls 2 and 37 were aborted.

Table 7. Summary of conductivity-temperature-depth (CTD) casts conducted aboard the NOAA Ship *Miller Freeman* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

CTD Number	Date	Drop Time (GMT)	Latitude (°N)	Longitude (°W)	Bottom Depth (m)
1	4 Jul	21:18	47 37.74	122 25.03	97
2	5 Jul	4:07	47 37.74	122 25.01	99
3	8 Jul	23:07	43 16.75	124 43.00	226
4	8 Jul	23:58	43 17.28	124 41.61	196
5	9 Jul	3:08	43 11.14	124 52.55	352
6	26 Jul	14:47	47 37.95	122 24.99	52
7	26 Jul	19:37	47 37.96	122 24.97	48

Table 8. Summary of conductivity-temperature-depth (CTD) casts conducted aboard the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

CTD Number	Date	Drop Time (GMT)	Latitude (°N)		Longitude (°W)		CTD Depth (m)	Bottom Depth (m)
1	28 Jun	7:39	48	4.55	125	21.15	188	193
2	28 Jun	9:43	48	2.67	124	57.92	98	103
3	28 Jun	11:00	48	0.04	125	8.13	140	145
4	29 Jun	6:13	47	24.31	124	47.85	217	222
5	29 Jun	7:18	47	25.17	124	51.19	502	732
6	29 Jun	8:46	47	27.60	124	59.64	503	701
7	29 Jun	10:07	47	30.00	125	7.93	502	594
8	30 Jun	5:36	47	12.57	125	5.19	501	827
9	30 Jun	6:36	47	11.51	125	2.65	503	732
10	30 Jun	7:32	47	10.58	124	59.96	502	540
11	30 Jun	8:25	47	9.38	124	57.59	337	342
12	30 Jun	10:26	47	2.33	124	39.90	99	104
13	1 Jul	7:17	46	55.66	124	51.87	171	176
14	1 Jul	8:09	46	54.29	124	54.14	501	506
15	1 Jul	9:02	46	52.62	124	56.72	503	738
16	1 Jul	9:57	46	51.50	124	53.56	197	202
17	1 Jul	12:08	46	42.77	124	29.14	95	100
18	2 Jul	5:27	45	41.95	124	50.66	500	777
19	2 Jul	6:27	45	41.77	124	47.52	502	587
20	2 Jul	7:25	45	41.85	124	44.30	476	481
21	2 Jul	8:34	45	42.00	124	37.32	245	250
22	2 Jul	9:30	45	41.58	124	30.78	196	201
23	3 Jul	7:12	44	52.66	124	57.83	503	755
24	3 Jul	8:23	44	53.85	124	51.64	370	375
25	3 Jul	9:27	44	55.23	124	45.22	445	450
26	3 Jul	10:29	44	56.50	124	39.05	449	454
27	4 Jul	6:24	44	56.67	124	37.23	444	449
28	4 Jul	7:24	44	57.39	124	34.66	443	448
29	4 Jul	8:29	44	58.30	124	29.90	389	394
30	4 Jul	9:28	44	59.21	124	25.37	272	277
31	4 Jul	10:21	45	0.17	124	20.81	186	191
32	5 Jul	6:48	43	52.18	124	57.47	503	970
33	6 Jul	5:32	45	7.37	124	30.60	351	356
34	6 Jul	6:40	45	9.16	124	37.55	463	468
35	6 Jul	7:50	45	10.86	124	44.16	501	592
36	6 Jul	9:58	45	17.37	124	29.98	398	403
37	6 Jul	11:16	45	15.51	124	37.34	473	478

Table 8 continued. Summary of conductivity-temperature-depth (CTD) casts conducted aboard the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

CTD Number	Date	Drop Time (GMT)	Latitude (°N)		Longitude (°W)		CTD Depth (m)	Bottom Depth (m)
38	7 Jul	7:00	44	52.83	124	39.08	346	351
39	7 Jul	9:15	44	35.60	124	47.04	327	332
40	7 Jul	10:21	44	37.34	124	41.62	242	247
41	8 Jul	7:05	44	39.00	124	35.48	182	187
42	8 Jul	8:52	44	30.26	124	38.48	191	196
43	8 Jul	10:12	44	22.47	124	37.54	96	101
44	9 Jul	0:13	43	16.53	124	42.21	195	200
45	14 Jul	4:11	43	53.65	124	12.92	56	61
46	14 Jul	5:15	43	52.48	124	16.90	96	101
47	14 Jul	5:54	43	50.92	124	20.94	109	114
48	14 Jul	6:28	43	49.55	124	24.71	118	123
49	14 Jul	7:07	43	47.92	124	28.95	131	136
50	14 Jul	7:47	43	46.33	124	33.14	186	191
51	14 Jul	8:19	43	45.43	124	35.48	240	245
52	15 Jul	5:59	44	12.23	124	12.28	55	60
53	15 Jul	6:36	44	12.60	124	16.61	71	76
54	15 Jul	7:20	44	12.54	124	22.92	86	91
55	15 Jul	8:04	44	12.55	124	29.03	98	103
56	15 Jul	8:53	44	15.00	124	34.64	98	103
57	15 Jul	9:42	44	17.53	124	40.11	82	87
58	15 Jul	10:29	44	20.03	124	45.57	136	141
59	16 Jul	7:28	44	52.54	124	7.10	57	62
60	16 Jul	8:04	44	52.50	124	12.08	97	102
61	16 Jul	8:46	44	50.84	124	18.92	131	136
62	16 Jul	9:31	44	49.24	124	25.64	149	154
63	16 Jul	10:16	44	47.58	124	32.19	193	198
64	16 Jul	11:08	44	45.86	124	39.02	282	287
65	17 Jul	7:22	45	12.54	124	4.01	63	68
66	17 Jul	7:55	45	12.60	124	7.80	98	103
67	17 Jul	8:32	45	11.33	124	12.48	147	152
68	17 Jul	9:16	45	9.86	124	17.45	184	189
69	17 Jul	9:52	45	9.03	124	21.40	302	307
70	18 Jul	5:48	44	32.70	124	11.20	52	57
71	18 Jul	6:31	44	32.35	124	15.33	72	77
72	18 Jul	7:11	44	32.56	124	20.69	68	73
73	18 Jul	7:54	44	32.56	124	26.81	72	77
74	18 Jul	8:25	44	32.57	124	30.48	99	104

Table 8 continued. Summary of conductivity-temperature-depth (CTD) casts conducted aboard the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

CTD Number	Date	Drop Time (GMT)	Latitude (°N)		Longitude (°W)		CTD Depth (m)	Bottom Depth (m)
75	18 Jul	9:09	44	35.10	124	35.81	160	165
76	19 Jul	6:42	45	32.51	124	2.58	58	63
77	19 Jul	7:22	45	32.62	124	8.19	95	100
78	19 Jul	8:16	45	34.61	124	15.81	144	149
79	19 Jul	9:15	45	36.67	124	23.29	170	175
80	19 Jul	10:11	45	38.69	124	30.97	208	213
81	19 Jul	11:12	45	40.74	124	38.40	297	302
82	20 Jul	5:08	46	17.40	124	14.07	55	60
83	20 Jul	5:49	46	15.01	124	17.44	89	94
84	20 Jul	6:26	46	12.47	124	21.56	117	122
85	20 Jul	7:06	46	13.97	124	26.13	313	318
86	20 Jul	8:00	46	15.14	124	30.46	501	534
87	20 Jul	9:22	46	16.37	124	35.25	167	172
88	20 Jul	11:01	46	17.73	124	39.83	494	499
89	21 Jul	6:25	46	44.97	124	18.24	53	58
90	21 Jul	7:01	46	44.48	124	22.97	72	77
91	21 Jul	7:42	46	43.80	124	28.61	89	94
92	21 Jul	8:36	46	43.31	124	34.38	117	122
93	21 Jul	9:19	46	42.63	124	40.18	141	146
94	21 Jul	10:03	46	44.39	124	45.33	160	165
95	22 Jul	5:50	47	12.52	124	27.59	49	54
96	22 Jul	6:27	47	11.91	124	32.31	67	72
97	22 Jul	7:13	47	12.53	124	37.12	79	84
98	22 Jul	7:47	47	12.57	124	41.42	101	106
99	22 Jul	8:37	47	12.58	124	46.11	124	129
100	22 Jul	9:34	47	12.66	124	50.62	146	151
101	22 Jul	10:39	47	15.12	124	52.30	198	203
102	22 Jul	11:23	47	17.57	124	52.54	375	380

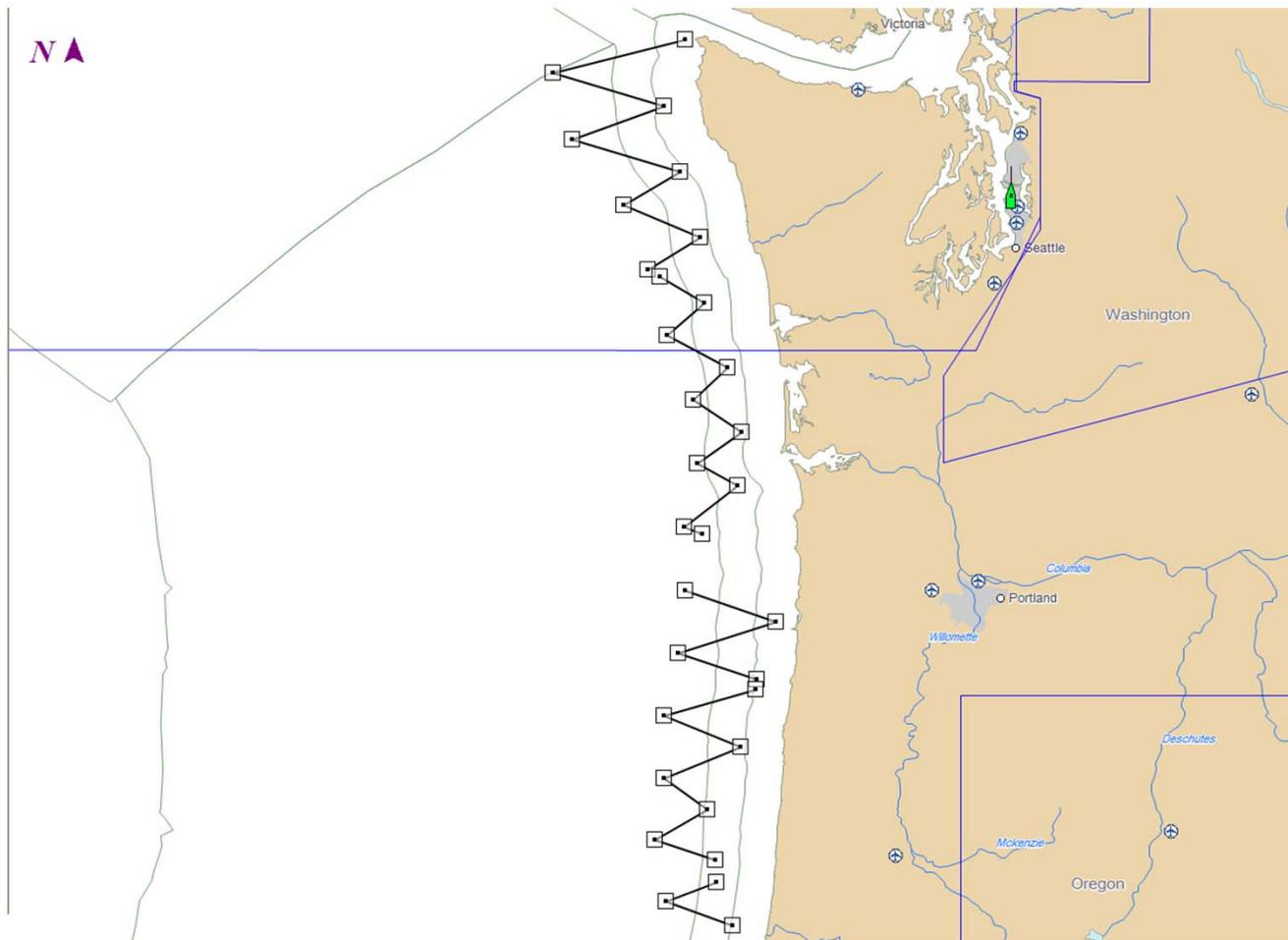


Figure 1. Cruise track design used by the NOAA Ship *Bell M. Shimada* prior to rendezvous with the NOAA Ship *Miller Freeman* during leg 1 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader Transects, 6 July 2010

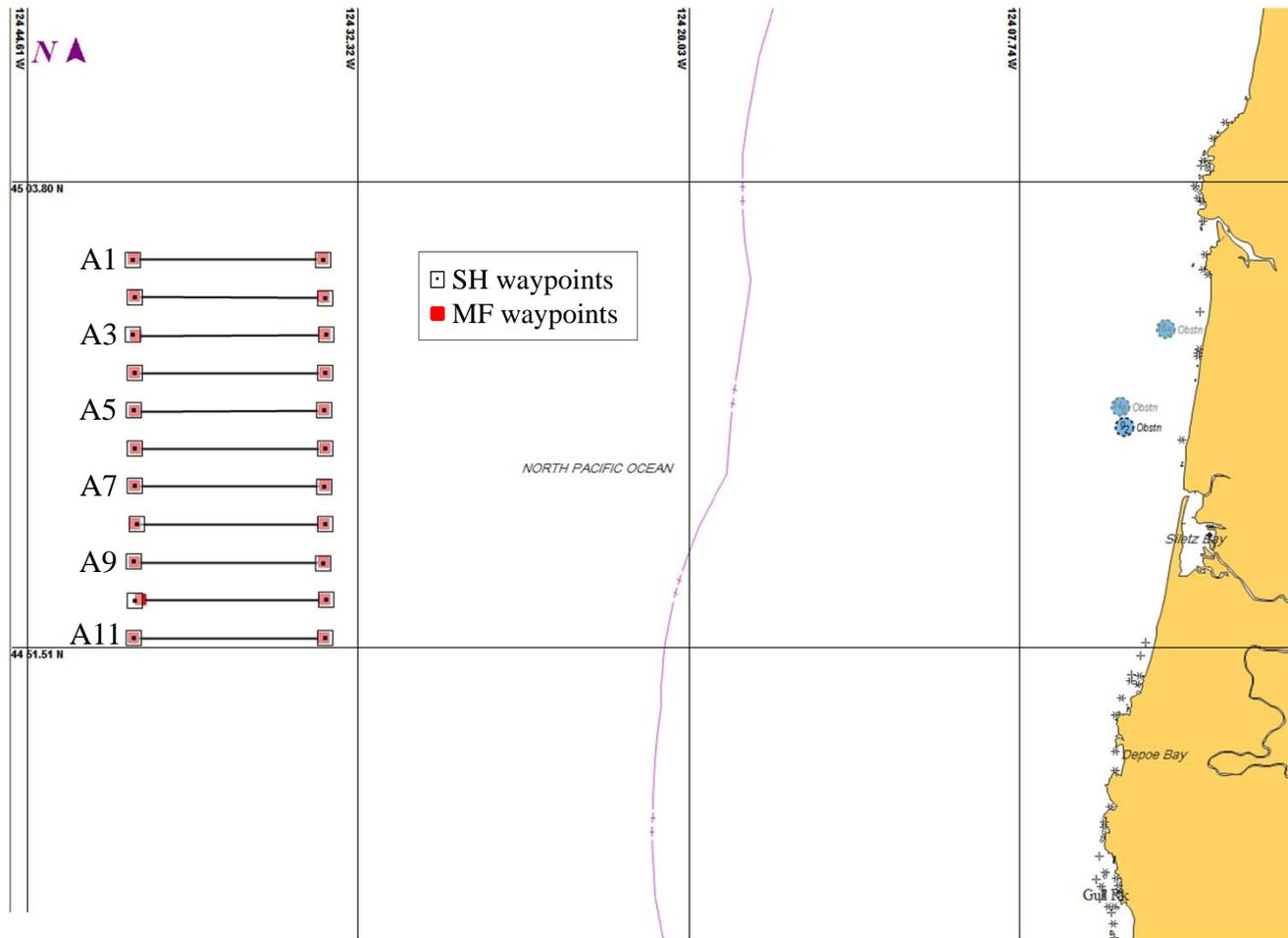


Figure 2. Cruise track design used during leg 1 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader Transects, 8 July 2010

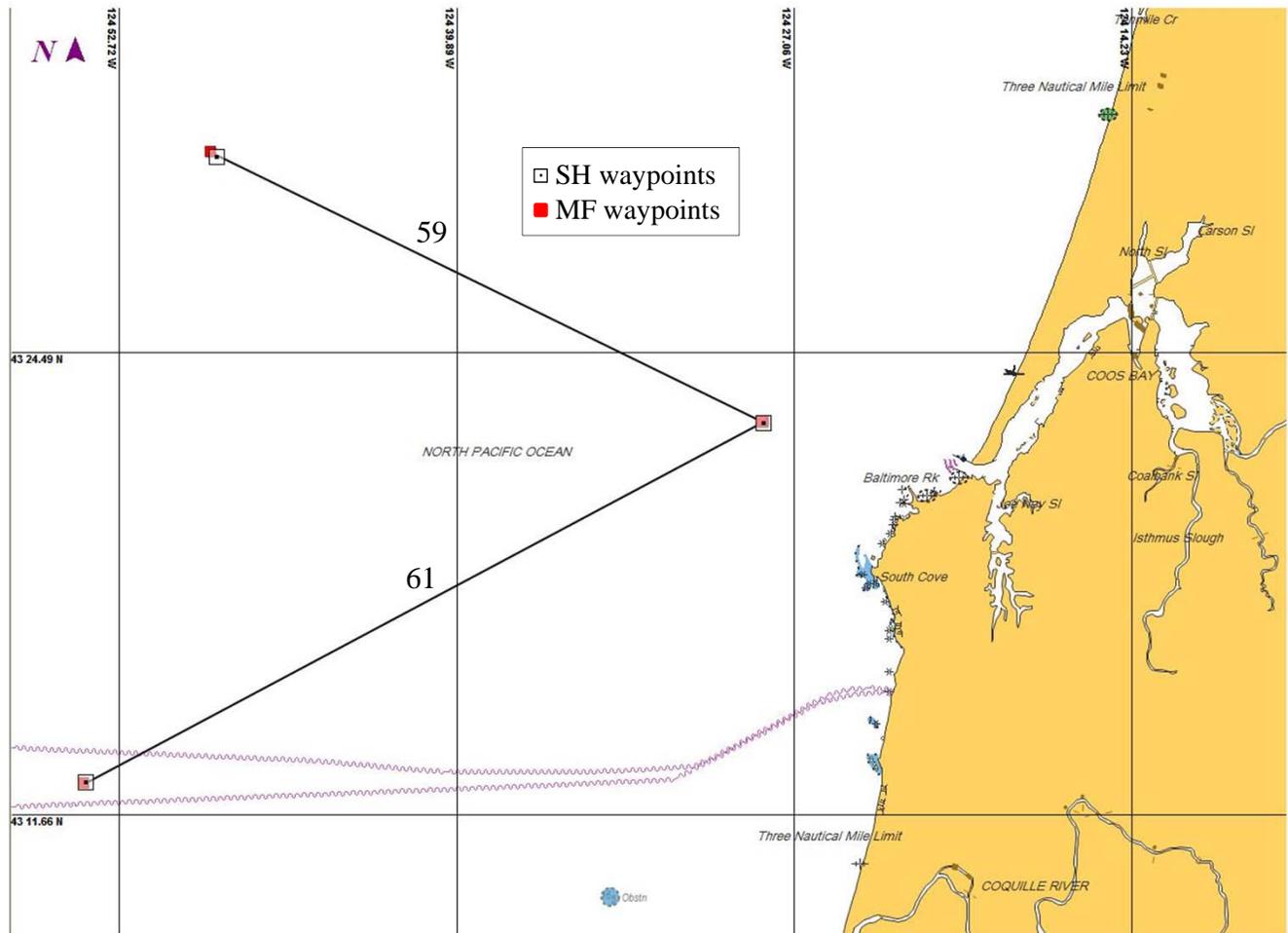


Figure 3. Cruise track design used during leg 1 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader Transects, 12 July 2010

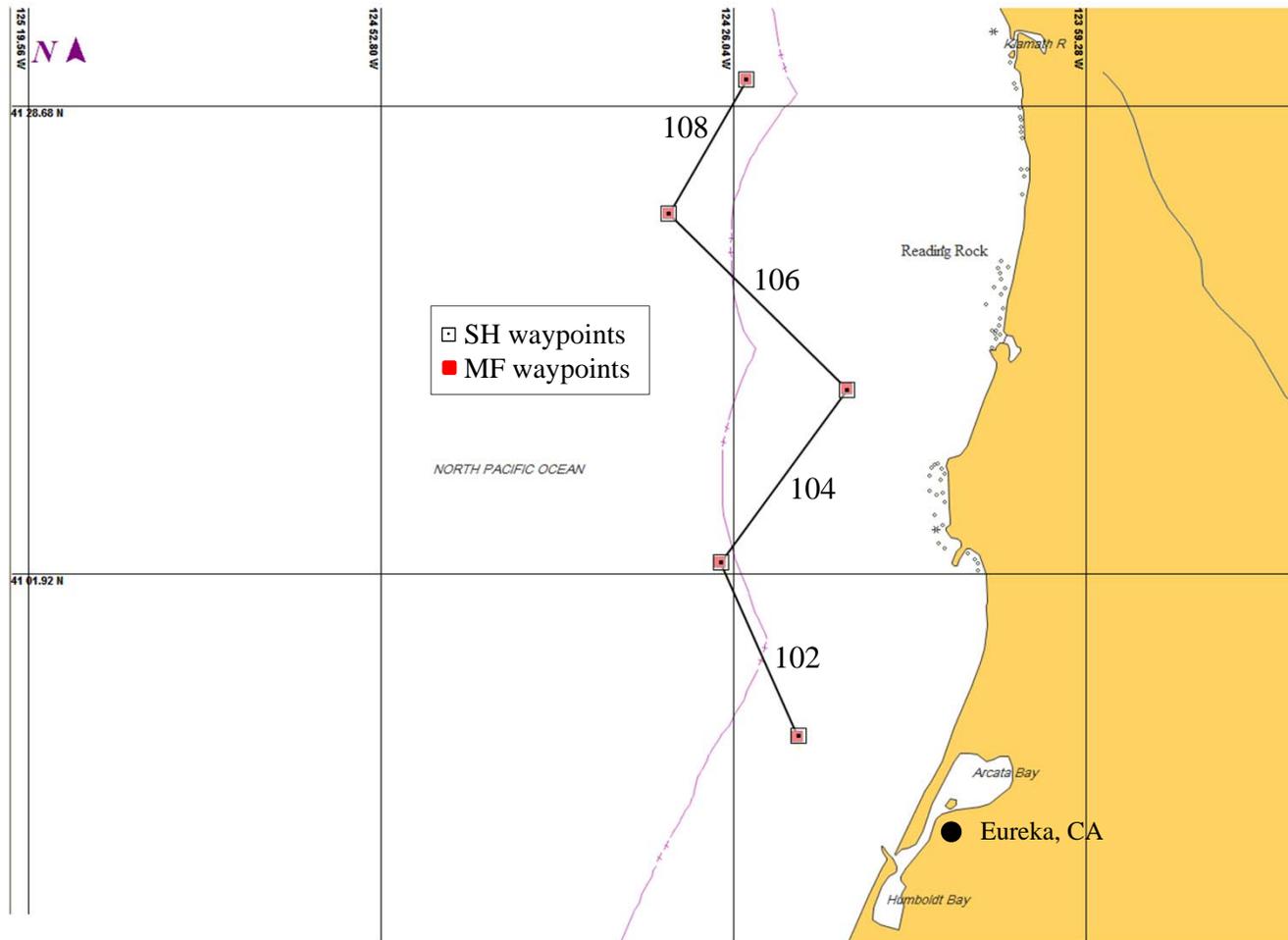


Figure 4. Cruise track design used during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader Transects, 13 July 2010

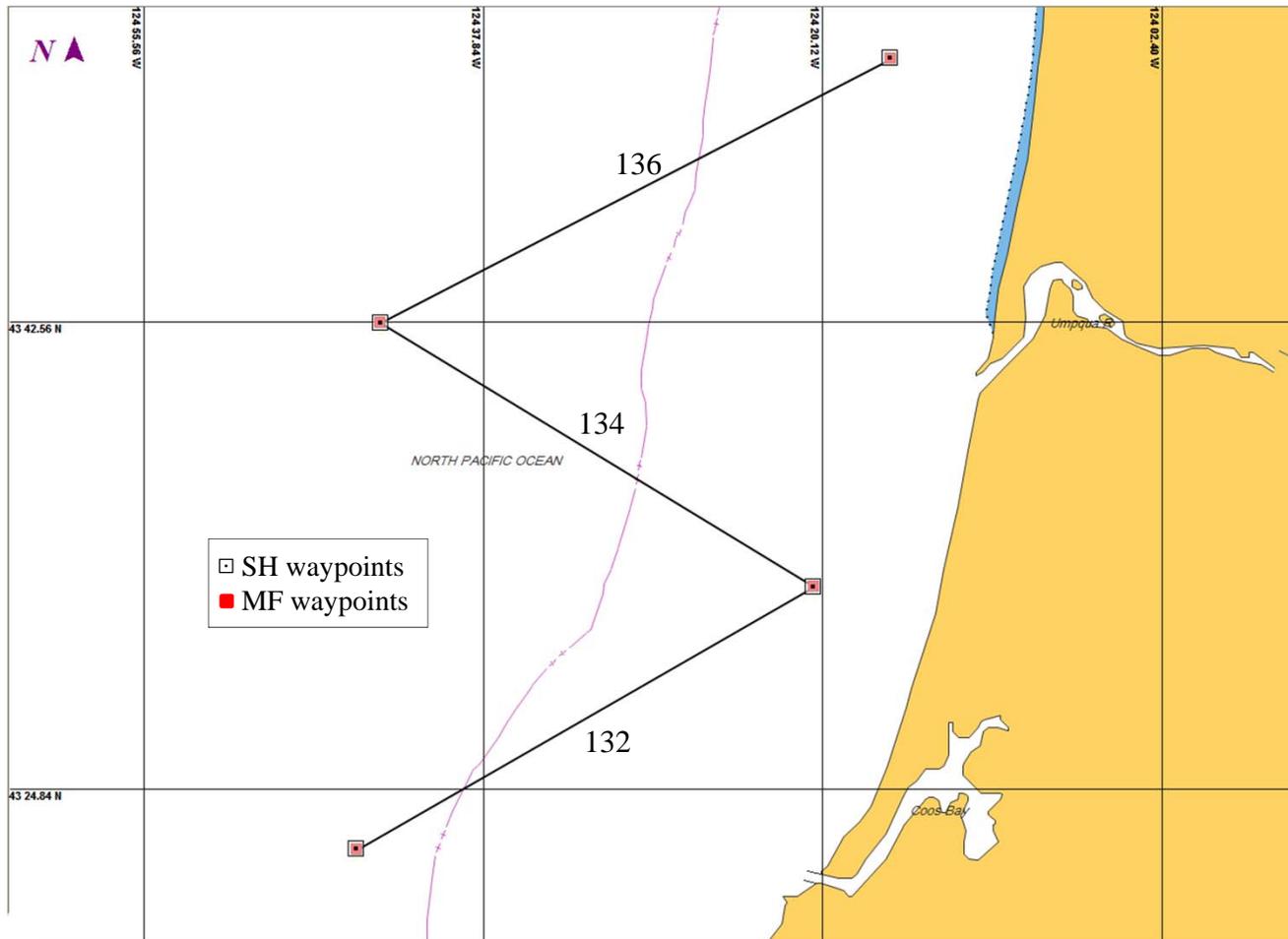


Figure 5. Cruise track design used during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader and Side-by-Side Transects, 14 July 2010

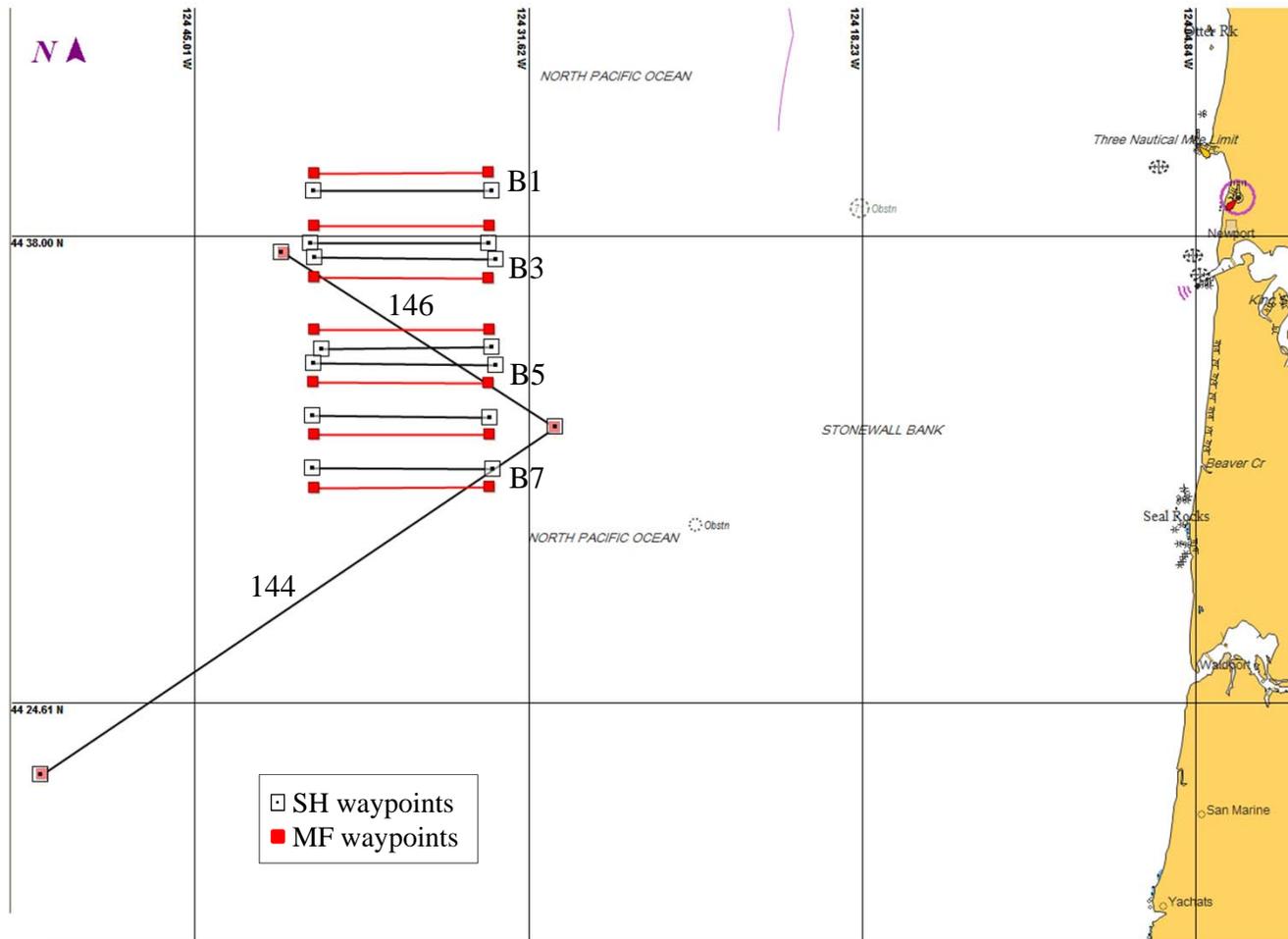


Figure 6. Cruise track design used during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader and Side-by-Side Transects, 16 July 2010

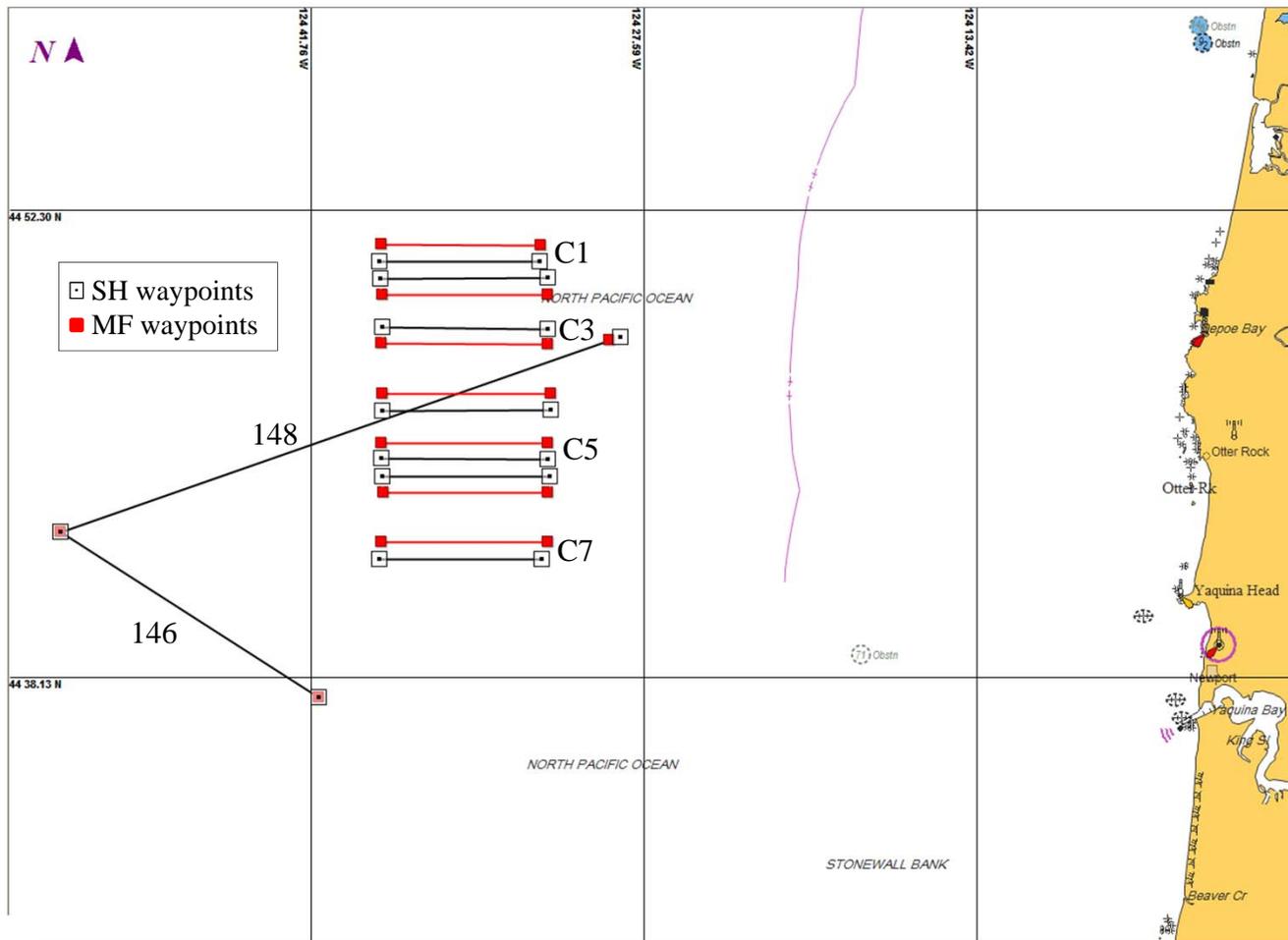


Figure 7. Cruise track design used during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader Transects, 18-19 July 2010

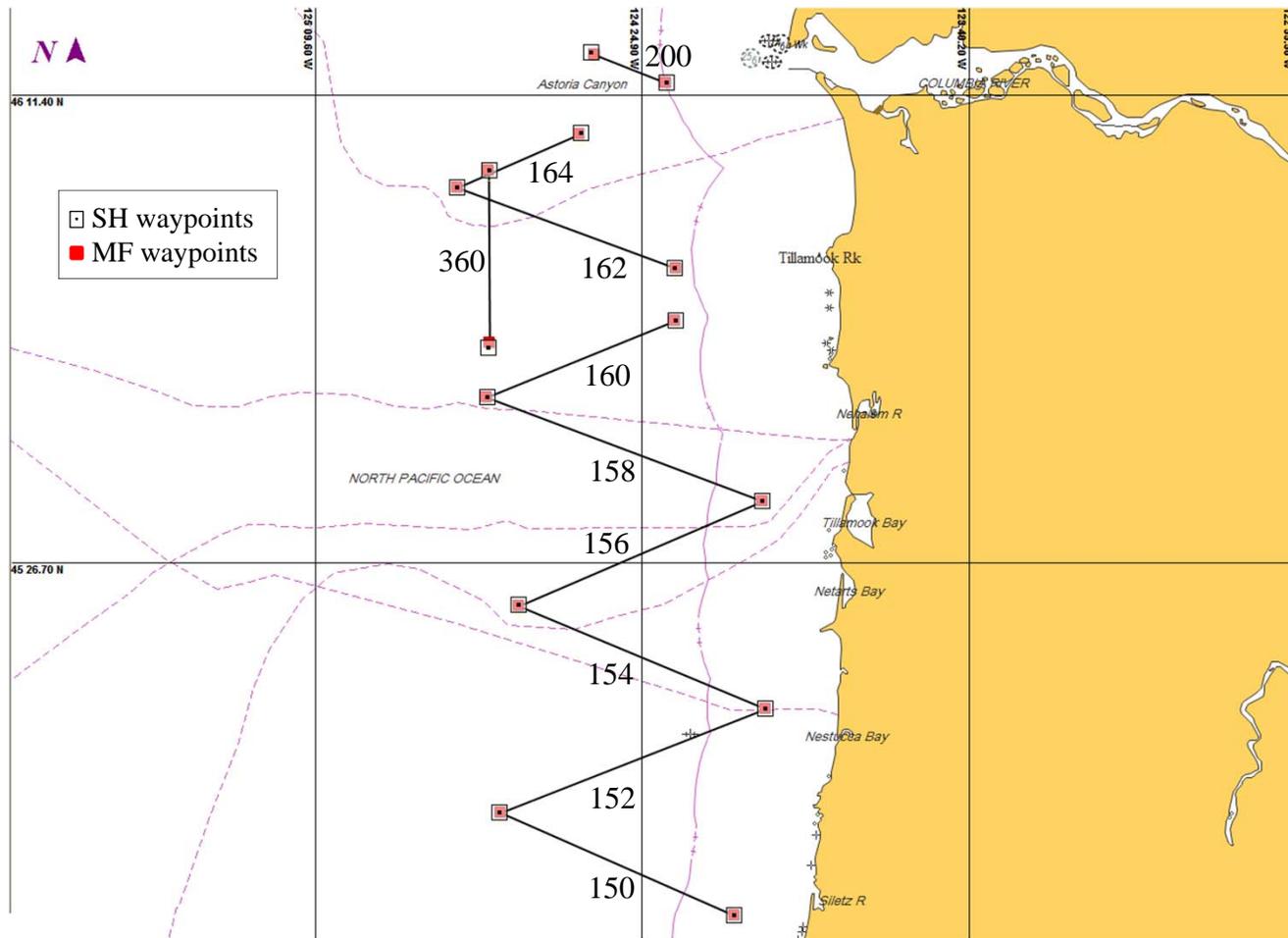
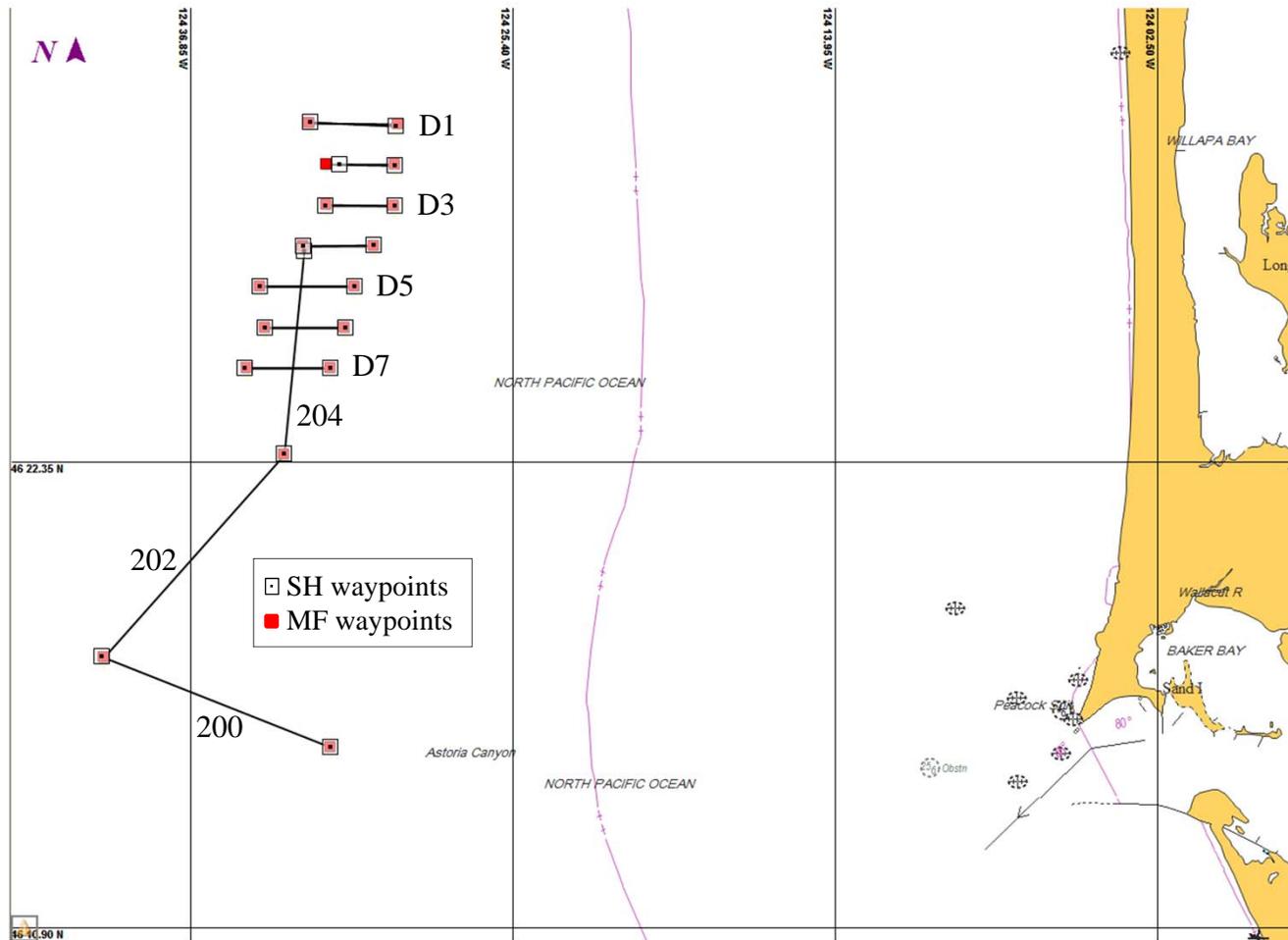


Figure 8. Cruise track design used during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader Transects, 20 July 2010



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Figure 9. Cruise track design used during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

Follow-the-Leader Transects, 21 July 2010

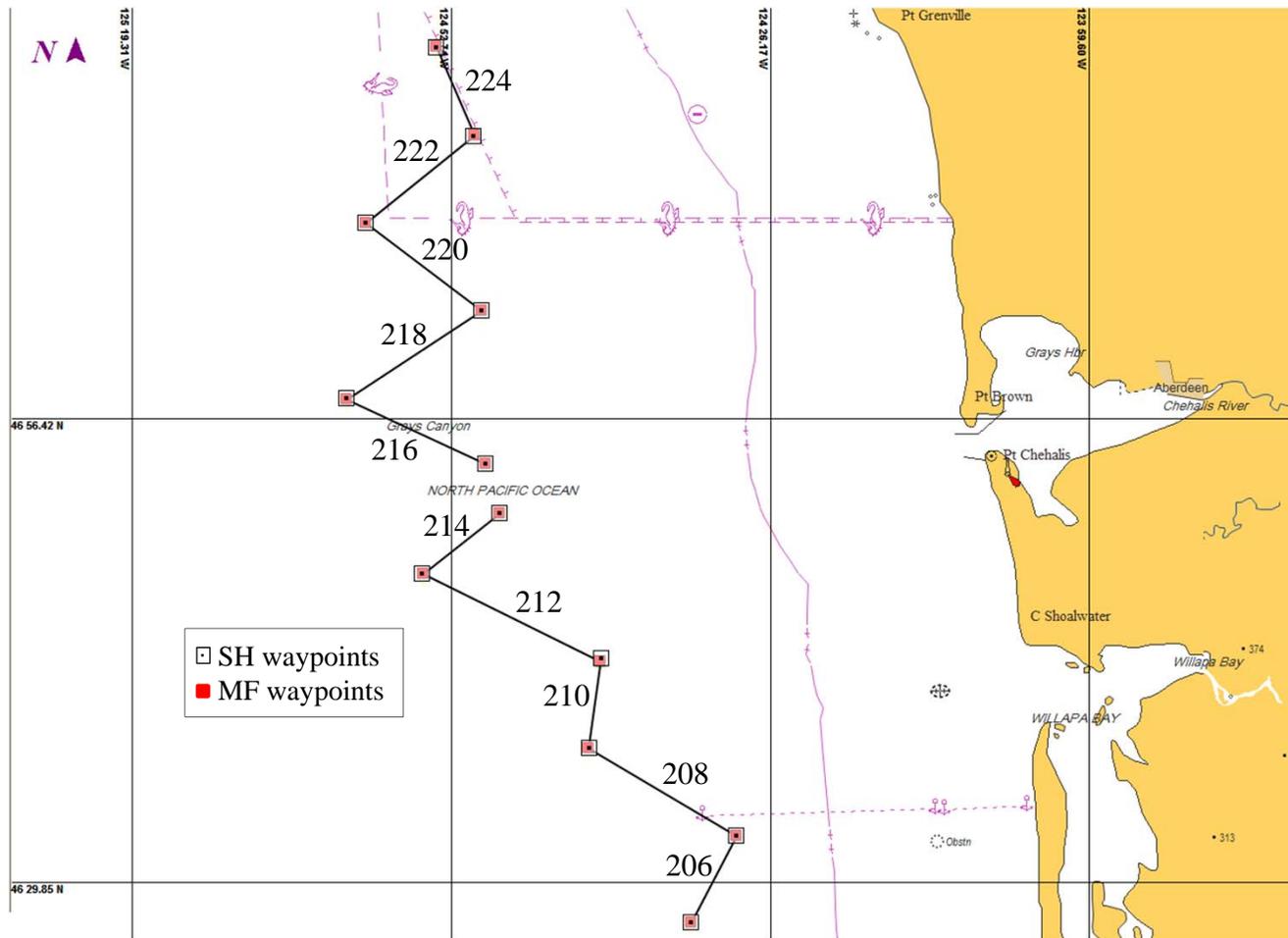


Figure 10. Cruise track design used during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

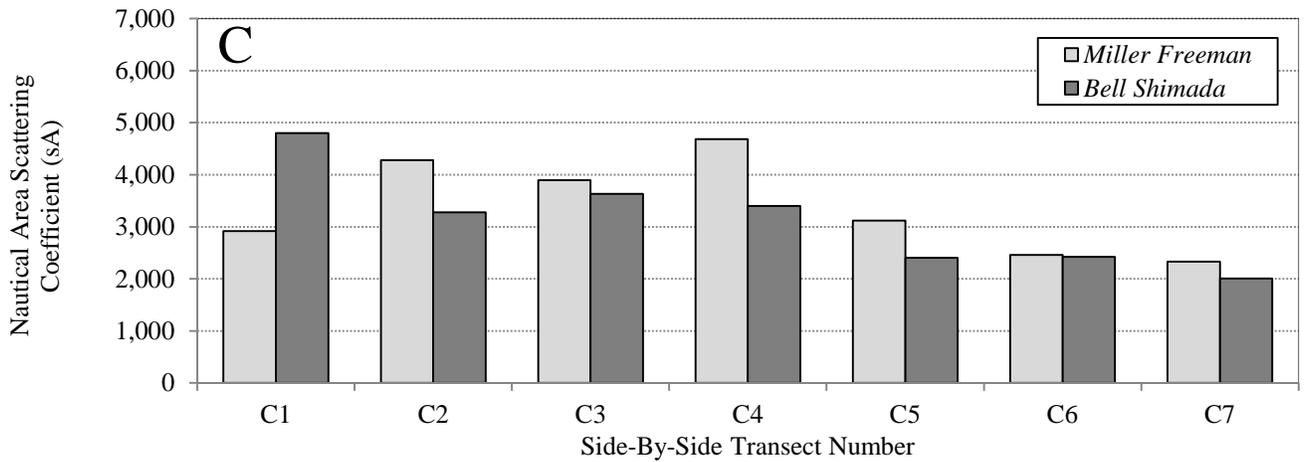
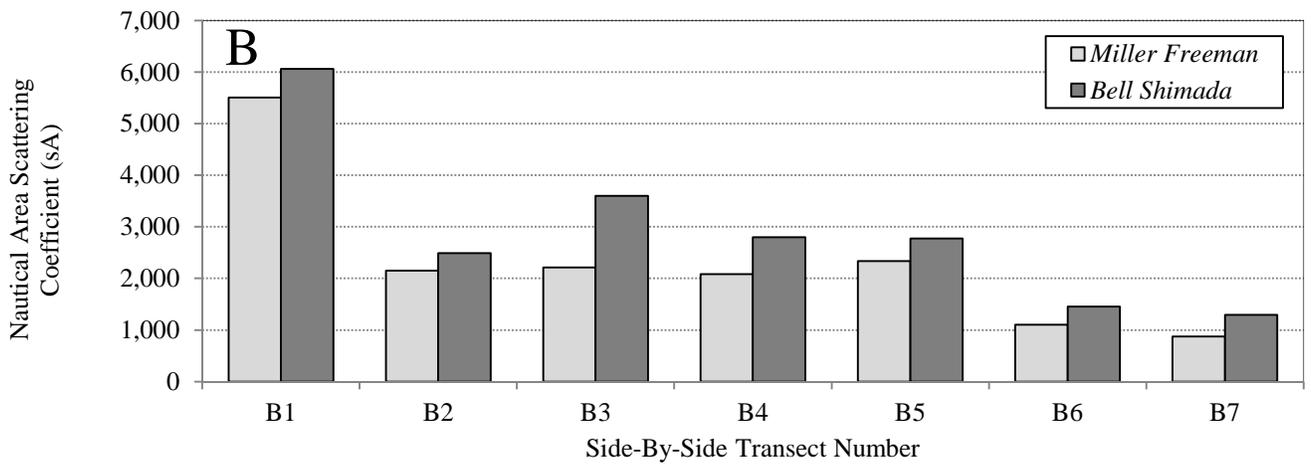
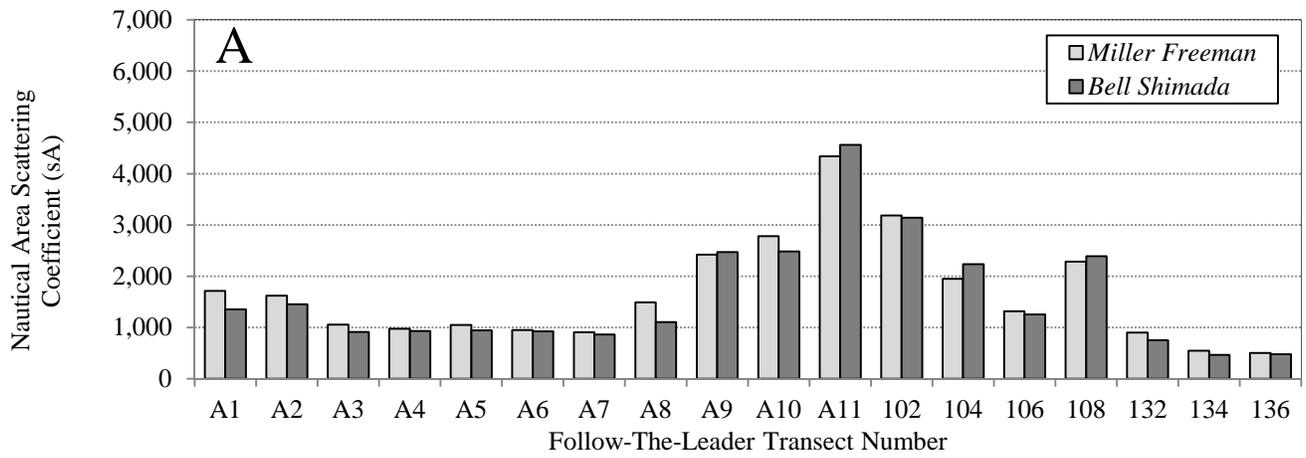


Figure 11. Total Nautical Area Scattering Coefficient (sA) values observed by the NOAA Ships *Miller Freeman* and *Bell M. Shimada* from selected transects during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

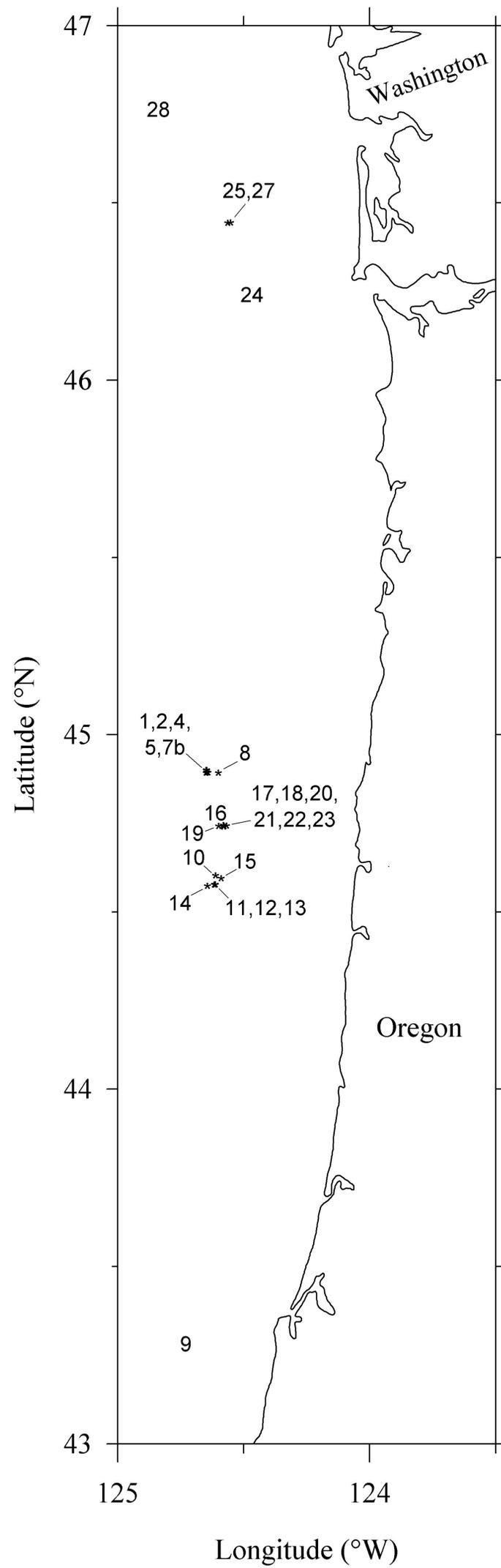


Figure 12. Haul sequence of midwater trawls (one bottom trawl is denoted by the suffix "b") conducted by the NOAA Ship *Miller Freeman* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

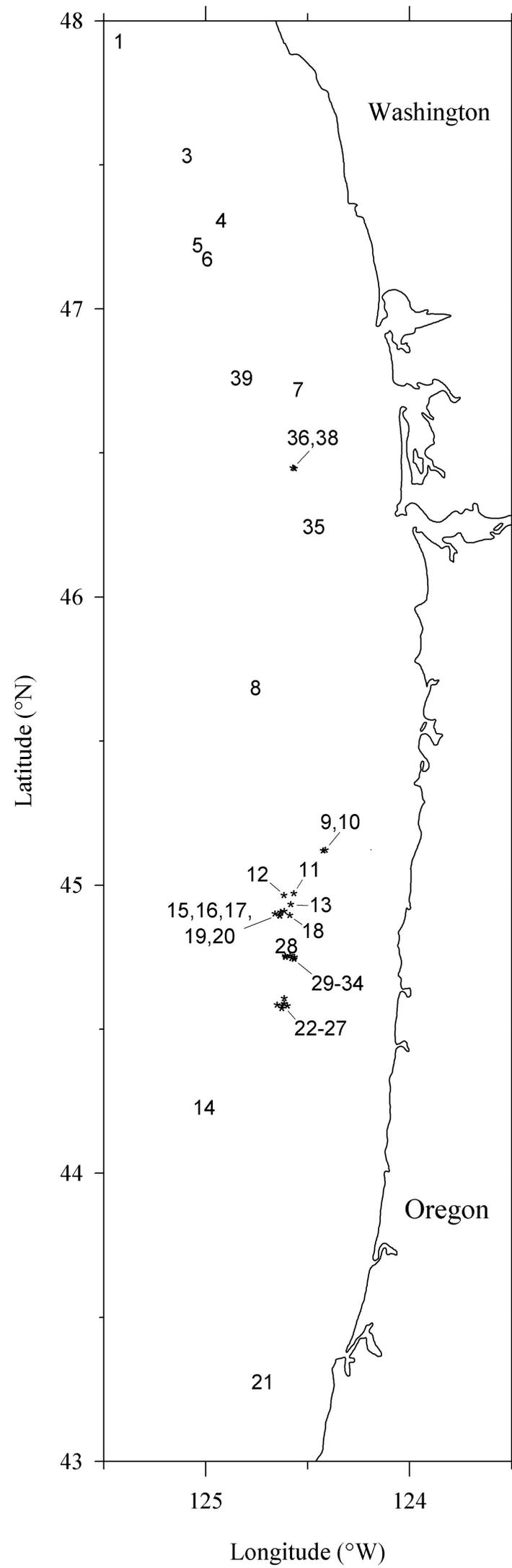


Figure 13. Haul sequence of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

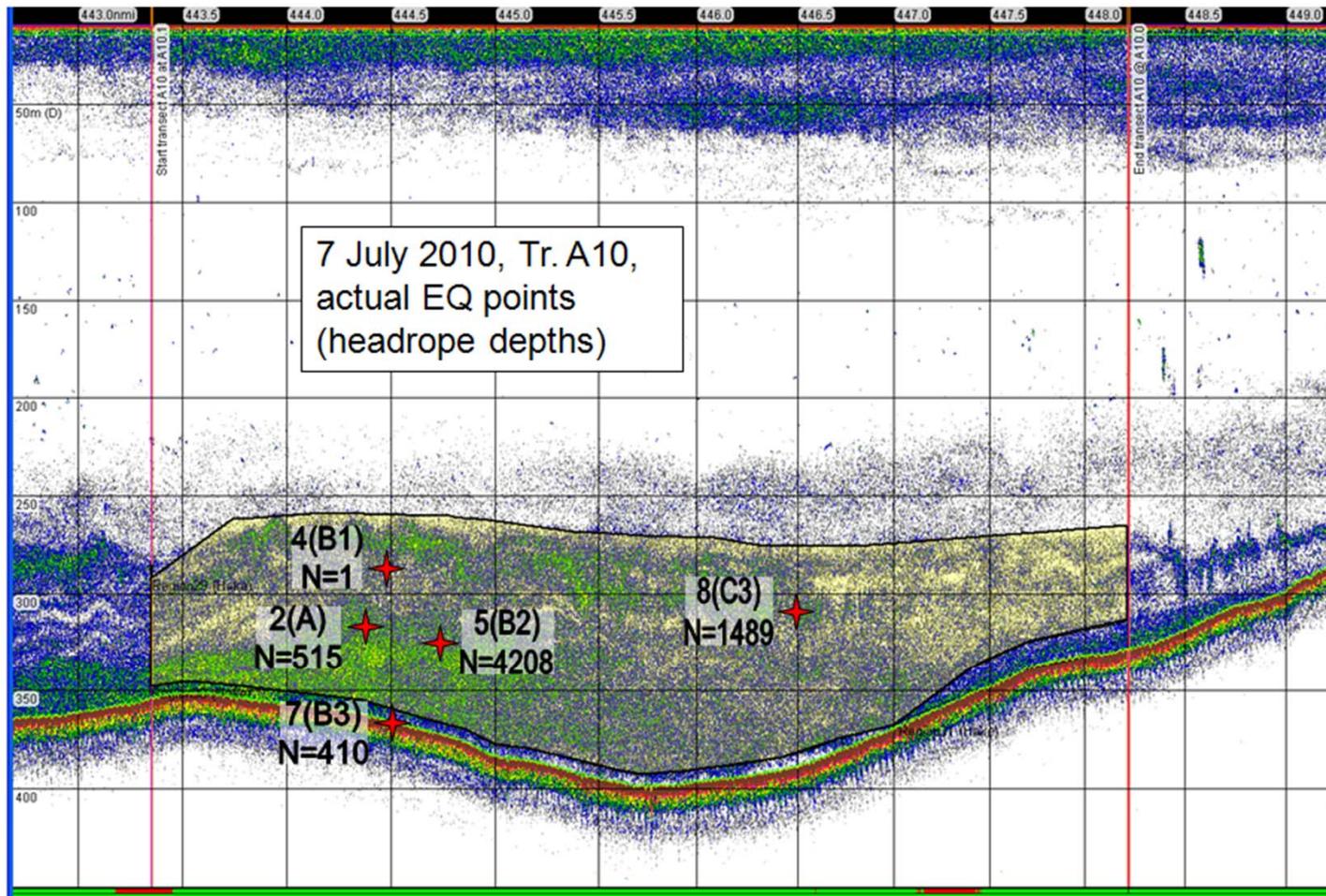


Figure 14. Location in the water column of trawl hauls conducted on the NOAA Ship *Miller Freeman* for haul representativeness during leg 1 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington. Haul number is indicated, as is sample size of Pacific hake caught.

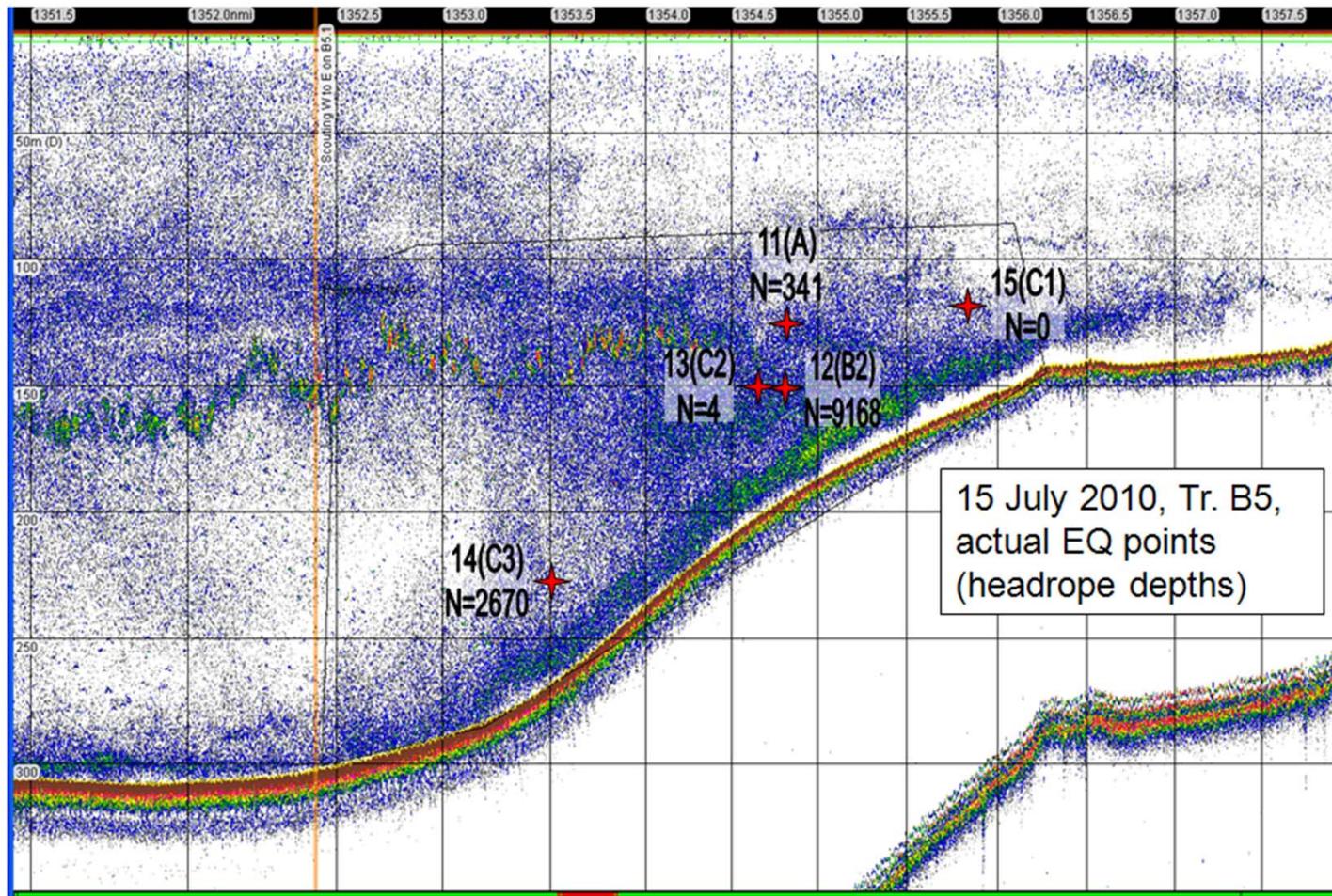


Figure 15. Location in the water column of trawl hauls conducted on the NOAA Ship *Miller Freeman* for haul representativeness during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington. Haul number is indicated, as is sample size of Pacific hake caught.

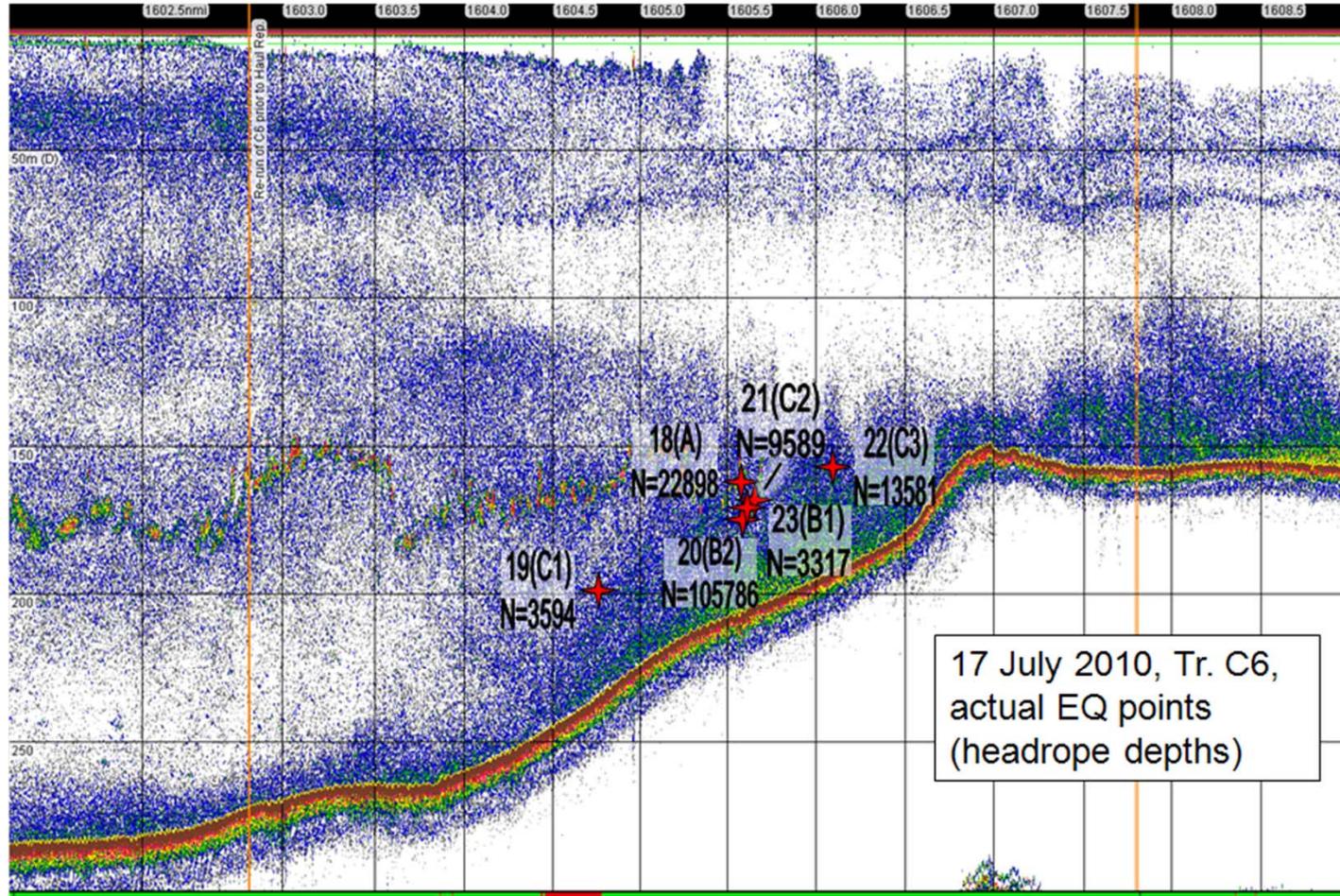


Figure 16. Location in the water column of trawl hauls conducted on the NOAA Ship *Miller Freeman* for haul representativeness during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington. Haul number is indicated, as is sample size of Pacific hake caught.

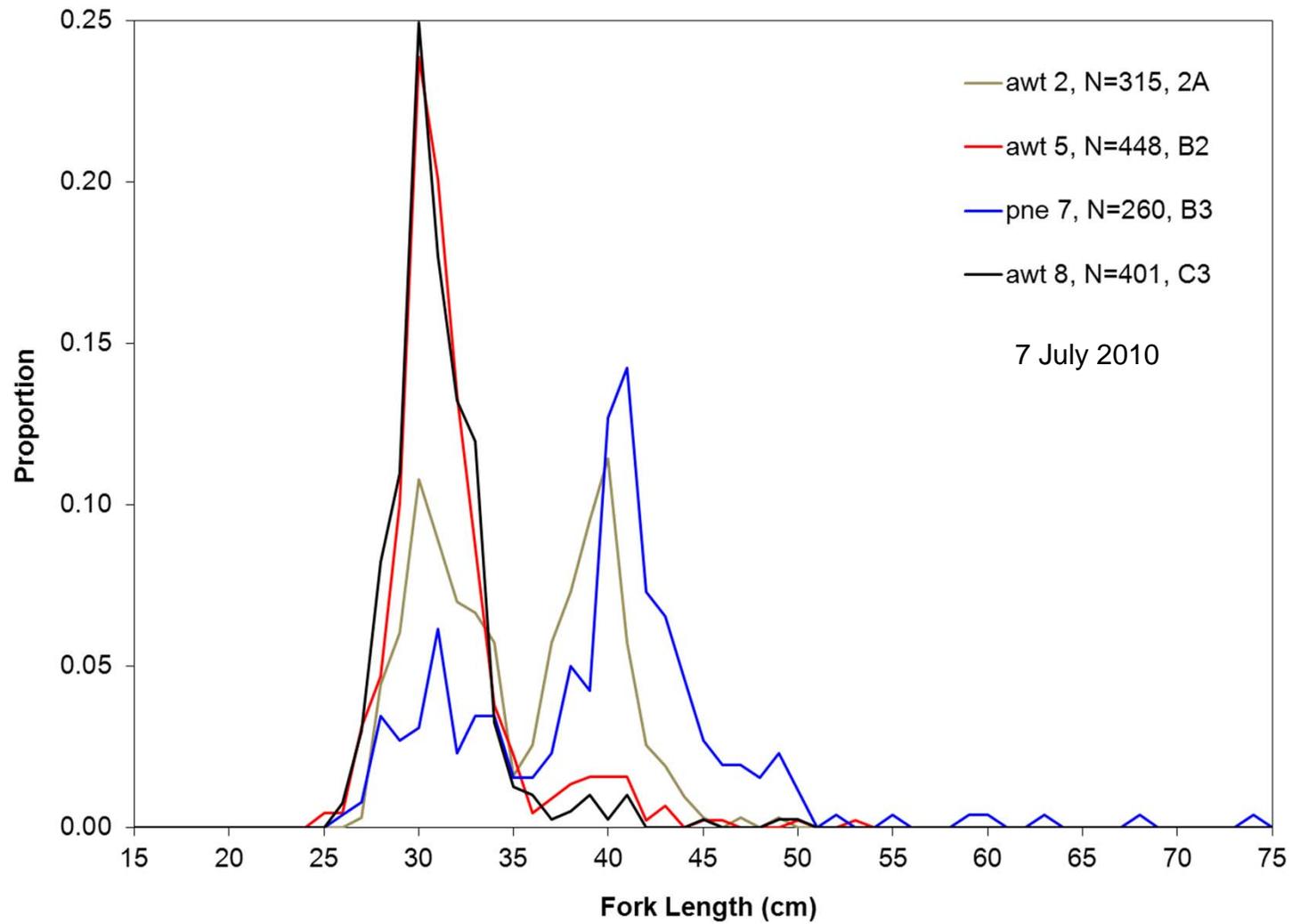


Figure 17. Length frequency distribution of Pacific hake caught in trawl hauls conducted on the NOAA Ship *Miller Freeman* for haul representativeness during leg 1 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington. Haul number is indicated, as is the number of Pacific hake lengthed.

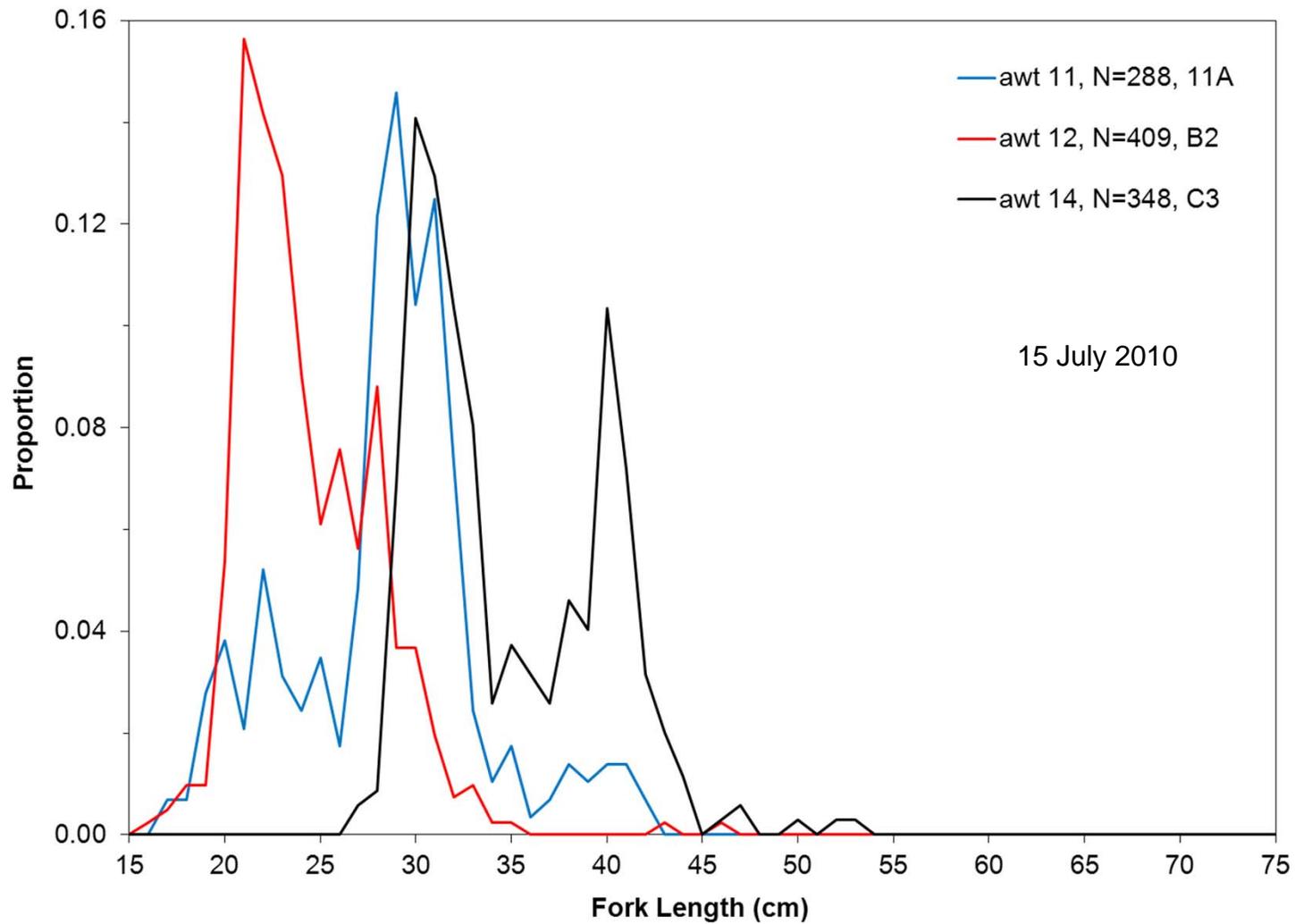


Figure 18. Length frequency distribution of Pacific hake caught in trawl hauls conducted on the NOAA Ship *Miller Freeman* for haul representativeness during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington. Haul number is indicated, as is the number of Pacific hake lengthed.

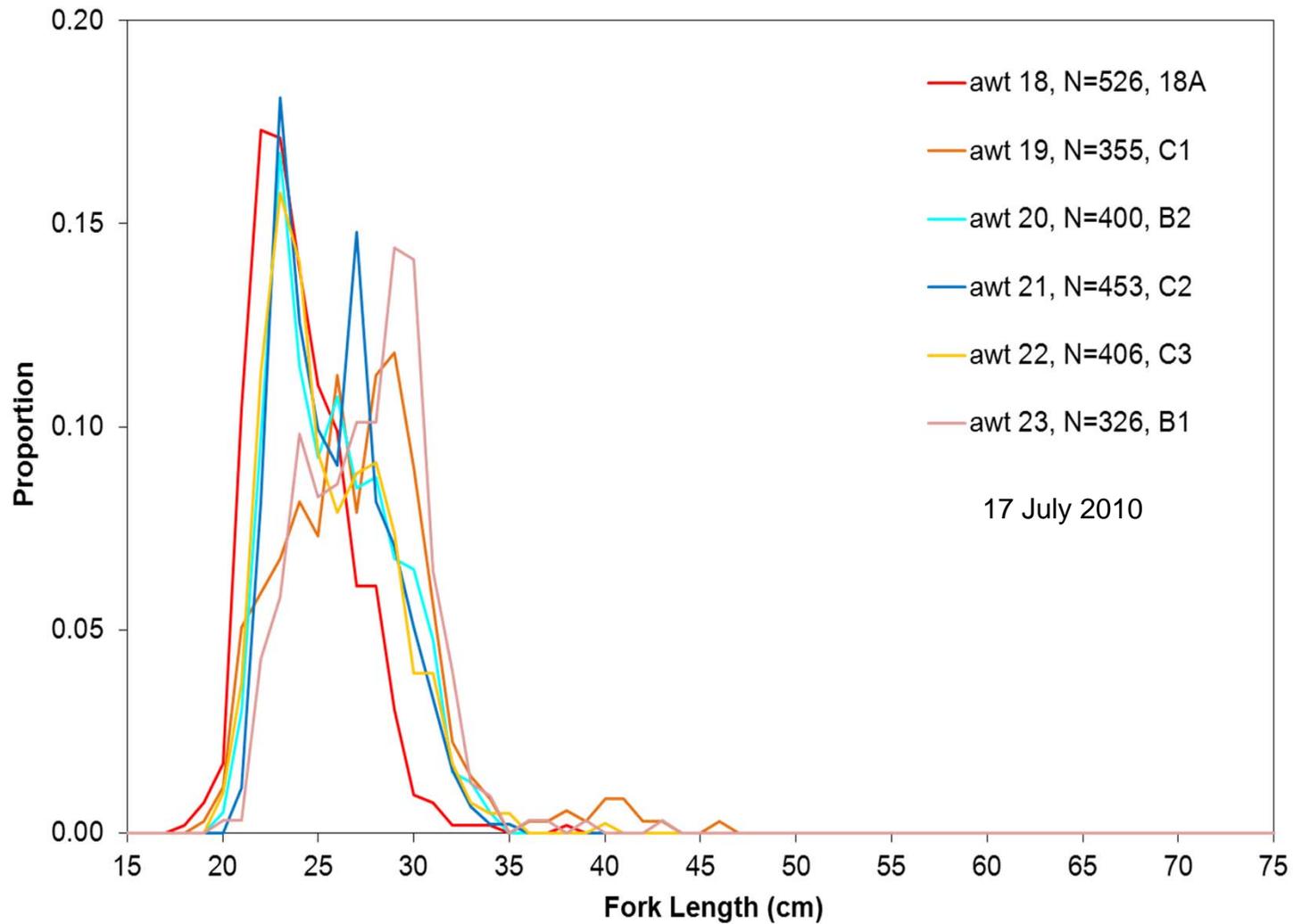


Figure 19. Length frequency distribution of Pacific hake caught in trawl hauls conducted on the NOAA Ship *Miller Freeman* for haul representativeness during leg 2 of the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington. Haul number is indicated, as is the number of Pacific hake lengthed.

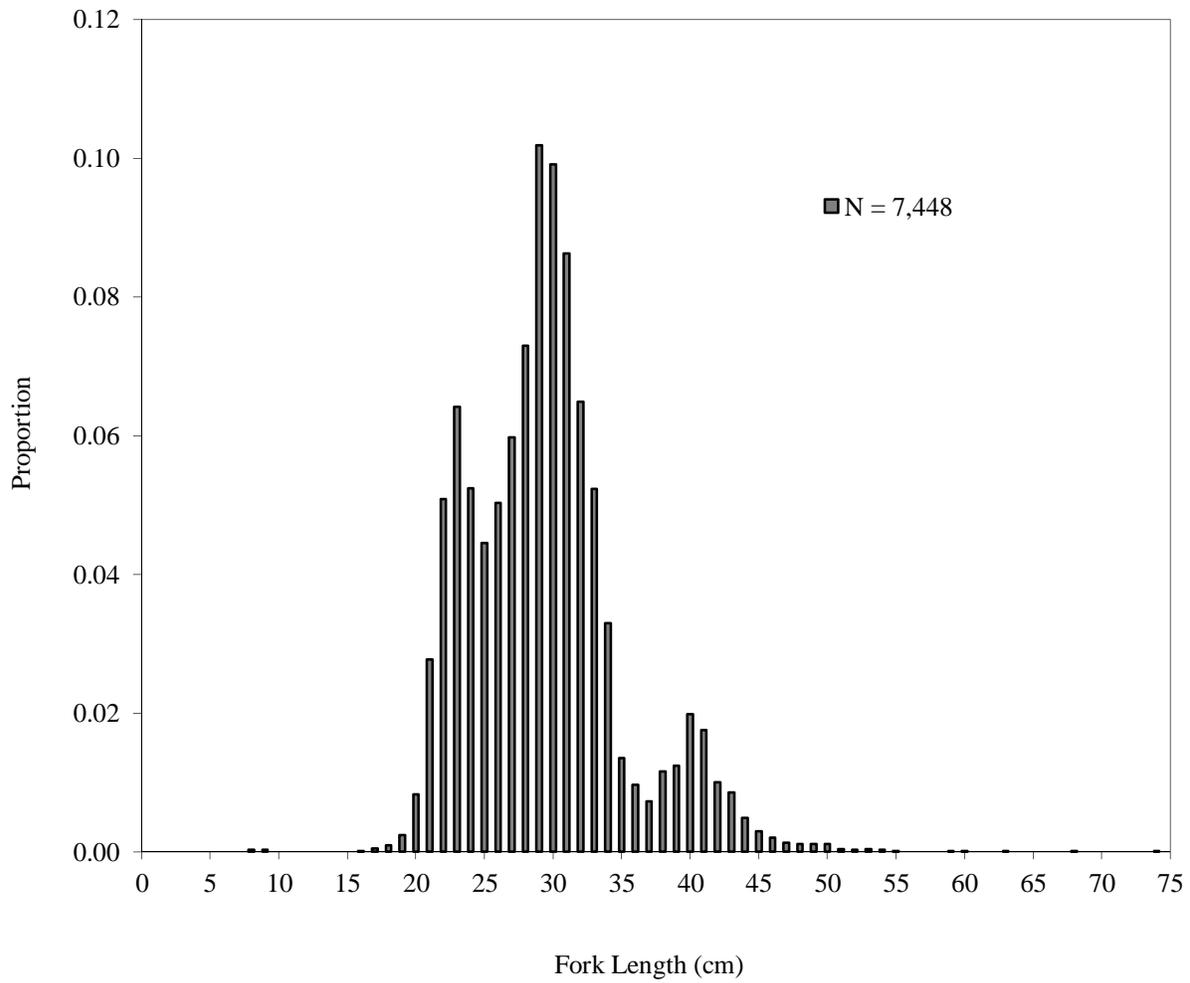


Figure 20. Length-frequency distribution of Pacific hake from specimens collected by the NOAA Ship *Miller Freeman* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

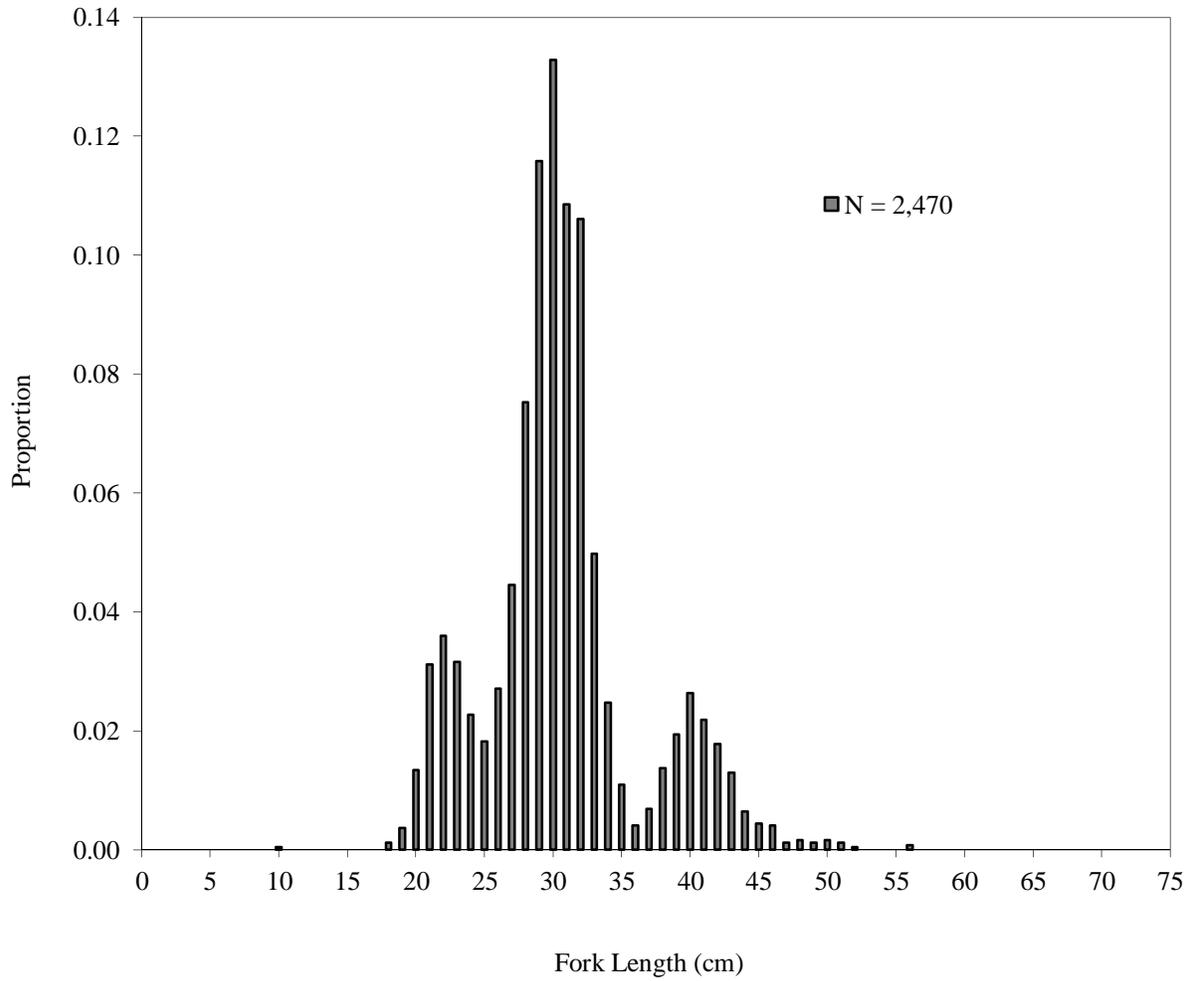


Figure 21. Length-frequency distribution of Pacific hake from specimens collected by the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.

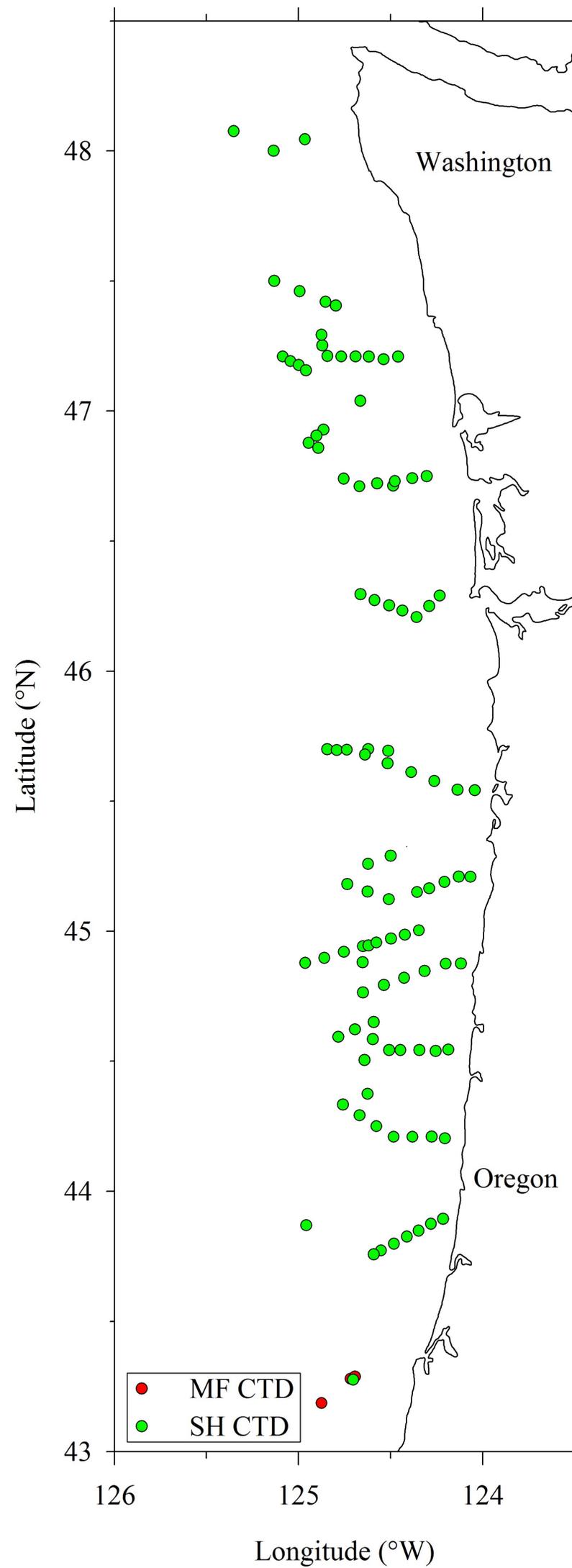


Figure 22. Locations of conductivity-temperature-depth (CTD) profile measurements taken during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington. CTDs conducted during calibration of the NOAA Ships' acoustic systems in Elliott Bay, Washington are not displayed.

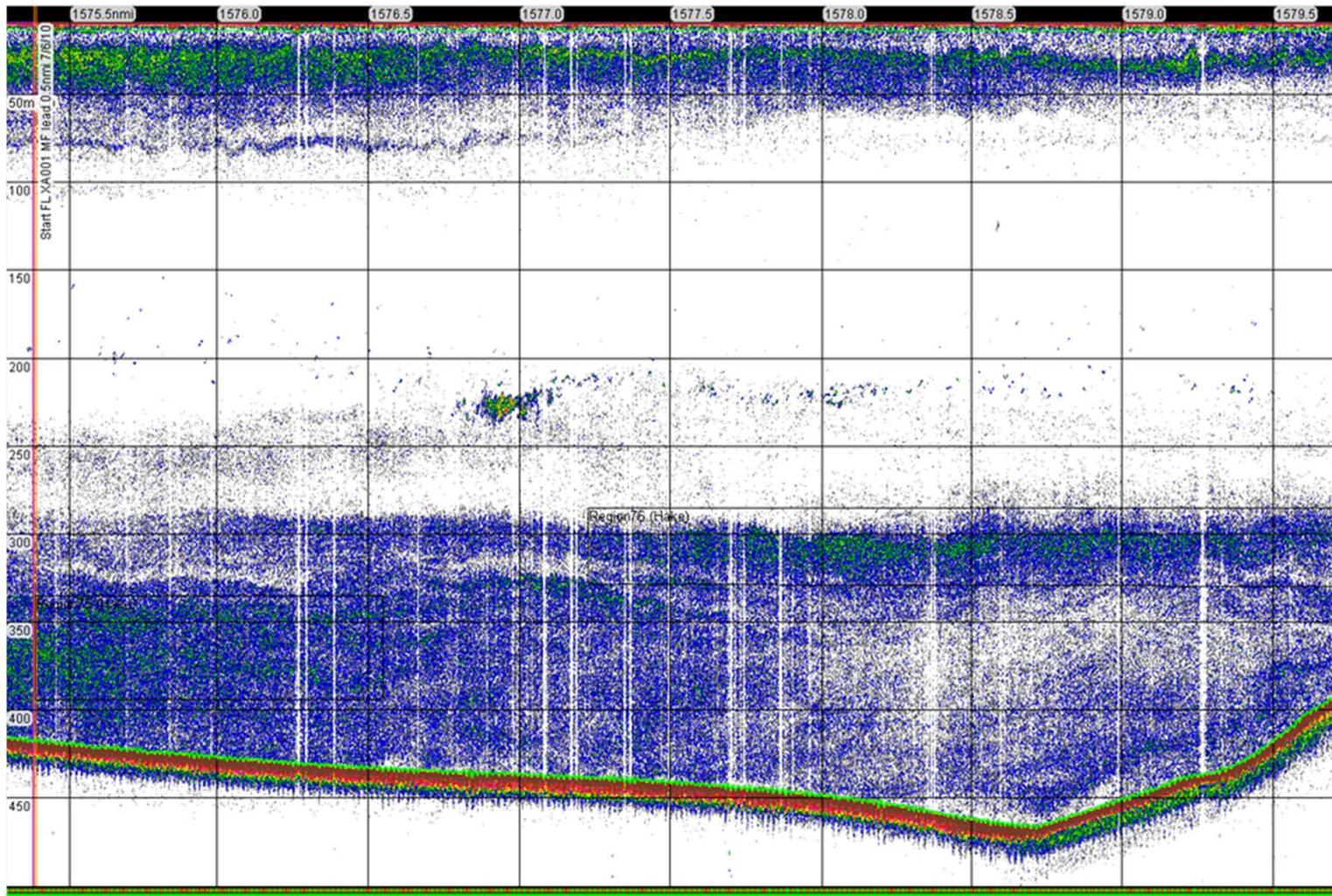


Figure 23. Example of acoustic dropouts observed on the NOAA Ship *Bell M. Shimada* during the 2010 Pacific hake inter-vessel calibration (IVC) off the coast of Northern California, Oregon, and Washington.