PRELIMINARY CRUISE RESULTS
NOAA Ship *Miller Freeman*, Cruise No. 98-10

Echo Integration-Trawl Survey Of Pacific Whiting Along The West Coasts Of The United States And Canada

CRUISE PERIOD, AREA, AND SCHEDULE

Scientists from the Alaska Fisheries Science Center (AFSC) investigated the population distribution and characteristics of Pacific whiting (*Merluccius productus*) along the U.S. and Canadian west coasts from July 6 to August 27, 1998 (a total of 52 sea days) using echo integration-trawl (EIT) survey techniques aboard the NOAA ship *Miller Freeman*. The cruise began and ended in Seattle, Washington. The EIT survey portion began near Monterey, California and progressed north to just south of the Queen Charlotte Islands, British Columbia.

The itinerary for the *Miller Freeman* was as follows:

Leg 1

July 6-9	Embark portion of scientific party in Seattle. Depart Seattle for Monterey. Offshore reconnaissance and acoustic system noise collection.
July 9	Begin EIT survey of west coast. Touch and go at Monterey to exchange personnel.
July 10	Touch and go at Santa Cruz, California to debark personnel.
July 22	Touch and go at Port Orford, Oregon to embark personnel.
July 27-28	Overnight at Newport, Oregon for engine repair.
July 30	Fish avoidance research with acoustic buoy.
Aug 1	Fish avoidance research with acoustic buoy.
Aug 3	Inport Astoria, Oregon.

Leg 2

Aug 4	Continue EIT survey of west coast.

Aug 11	Touch and go at Neah Bay, Washington to exchange personnel.
Aug 21	Sphere calibration in Howe Bay, Kunghit Island (Queen Charlotte Islands), British Columbia.
Aug 21-23	Intership calibration with Canadian research vessel *W. E. Ricker*.
Aug 25	Finish EIT survey. Transit to area west of Cape Flattery, Washington.
Aug 26	Fish avoidance research with acoustic buoy.
Aug 27	Arrive Seattle. End of cruise.

OBJECTIVES

The primary objective of the cruise was to collect echo integration data and midwater and demersal trawl data necessary to determine the distribution, biomass, and biological composition of Pacific whiting in the survey area.

Secondary objectives were to:

1) collect Pacific whiting target strength data for use in scaling echo integration data to estimates of absolute abundance;

2) calibrate the 38 kHz and 120 kHz scientific acoustic systems using standard sphere techniques;

3) conduct an intership calibration of acoustic systems between the *Miller Freeman* and the Canadian research vessel *W. E. Ricker*;

4) collect acoustic data with a buoy to determine the behavior of Pacific whiting in response to ship noise;

5) collect echo integration data and midwater trawl data necessary to determine the distribution and biological composition of common macrozooplankton species (e.g., euphausiids) in the survey area;

6) collect physical oceanographic data by determining water column profiles of temperature (and salinity, on occasion) at selected sites and by continuously monitoring near-surface currents, temperature, salinity, and ambient light level;

7) calculate density factors for volumetric catch weight estimation of Pacific whiting;

8) collect Pacific whiting stomach samples for food habits studies;

9) collect one year-old and adult hake for a parasite/stock structure study;

10) continuously filter water with a submerged pumping system to identify and map the horizontal egg distribution of epipelagic fishes;

11) collect near-shore water samples for a bio-toxin study; and

12) conduct noise tests of the vessel's acoustic system.

VESSEL, ACOUSTIC EQUIPMENT, AND TRAWL GEAR

Acoustic data were collected with a Simrad EK500[1] quantitative echo-sounding system on board the NOAA ship *Miller Freeman*,
a 66 m (216 ft) stern trawler equipped for fisheries and oceanographic research. Simrad 38 kHz and 120 kHz split-beam transducers were mounted on the bottom of the vessel's centerboard. With the centerboard fully extended, the transducers were 9 m below the water surface. System electronics were housed in a permanent laboratory space dedicated to acoustics. Data from the Simrad EK500 echo sounder/receiver were processed on a SUN workstation using Simrad BI500 echo integration and target strength data analysis software. Results presented in this document are based on the 38 kHz data.

Midwater echosign was sampled with an Aleutian Wing 30/26 trawl (AWT), a full-mesh wing trawl constructed of nylon except for polyethylene toward the aft section of the body and the codend. The headrope and footrope each measured 81.7 m (268 ft). Mesh sizes tapered from 3.25 m (128 in) in the forward section of the net to 8.9 cm (3.5 in) in the codend. A 3.2 cm (1.25 in) codend liner was used. The net was fished with 82.3 m (270 ft)
of 1.9 cm (0.75 in) diameter 8x19 non-rotational
dandylines, 340 kg (750 lb) or 227 kg (500 lb) tom weights on each side, and 5 m^2 (53.8 ft^2) "Fishbuster" doors (1,247 kg [2,750 lb.])

Fish on and near bottom were sampled with a polyethylene Nor'eastern (PNE) high-opening bottom trawl equipped with roller gear. The trawl was constructed with stretch mesh sizes ranging from 12.7 cm (5 in) in the forward portion of the net to 8.9 cm (3.5 in) in the codend. It was fitted with a nylon codend liner with a mesh size of 3.2 cm (1.25 in). The 27.2 m (89.1 ft) headrope held 21 floats [30.5 cm (12 in) diameter]. A 24.7 m
(81 ft) chain fishing line was attached to a 24.9 m (81.6 ft) footrope constructed of 1 cm (3/8 in) 6 x 19 wire rope wrapped with polypropylene rope. The 24.2 m (79.5 ft) roller gear was constructed with 35.6 cm (14 in) rubber bobbins spaced 1.5-2.1 m (5-7 ft) apart. A solid string of 10.2 cm (4 in) rubber disks separated some of the bobbins in the center section of the roller gear.

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[1] Reference to trade names or commercial firms does not constitute U.S. Government endorsement.

Two 5.9 m (19.5 ft) wire rope extensions with 10.2 cm
(4 in) and 20.3 cm (8 in) rubber disks were used to span the two lower flying wing sections and were attached to the roller gear. The roller gear was attached to the fishing line using chain toggles [2.9 kg (6.5 lb.) each] which comprised five links and one ring. The trawl was rigged with triple 54.9 m (180 ft) galvanized wire rope dandylines. The net was fished with the "Fishbuster" doors.

A Methot trawl was used to sample macrozooplankton (oblique tows to 250 m [820 ft] depth). This trawl had a rigid square frame with 2.3 m (7.5 ft) sides forming the mouth of the net. A 1.8 m (6 ft) dihedral depressor modified from an Isaacs-Kidd midwater trawl was suspended from the square frame. Mesh sizes were 2 mm x 3 mm (0.08 in x 0.12 in) in the main part of the net and 1 mm (0.04 in) in the codend. The Methot trawl was attached to a single cable that was fed through the ship's stern-mounted A-frame. A calibrated General Oceanics flow meter was attached to the mouth of the net and used to determine the volume of water filtered. The Methot trawl was lost at sea on July 21 when the cable parted. Until a replacement Methot trawl was obtained on August 3, a 0.5 m Bongo net (333 ?m mesh size) was used (oblique tows, 250 m [820 ft] maximum depth).

The AWT and PNE trawl hauls were monitored with a WesMar third wire or a Furuno wireless net sounder system attached to the head rope; vertical net opening, depth, and water temperature were measured. Vertical net openings averaged 22.4 m (73.5 ft) for the AWT and 6.4 m (21.0 ft) for the PNE. The Methot was monitored using a Scanmar or Netmind sounder system.

Conductivity-temperature-depth (CTD) data were collected with a Seabird CTD system at calibration sites and selected locations. Expendable bathythermographs (XBTs) were used north of 41°N to collect water temperature data every 0.5 degree of latitude along transects at their offshore endpoints, and over bottom depths
of 150 m (492 ft) and 400 m (1,312 ft), as well as at several haul sites. Sea surface temperature and salinity data, as well as other environmental (e.g., meteorological, sea state) and operational (Marine Operations Abstract [MOA]) data were collected using the *Miller Freeman*'s Scientific Collection System (SCS). Velocity data to describe ocean currents were obtained using the vessel's acoustic Doppler current profiler system whose transducer was mounted in the centerboard. Temperature and depth profile data were collected during most trawl hauls by attaching a micro bathythermograph (MBT) to the trawl headrope or the Methot frame. When no MBT data were available to determine gear temperature during a trawl, recording real-time temperature readouts from the WesMar system was the preferred substitute, followed by temperature data from an XBT or CTD cast if located within about one nmi (1.9 km) of the trawl site.

The acoustic buoy consisted of an aluminum cylinder (length 130 cm [51.2 in]) with a "donut" Ionomer foam floatation collar and mast at one end. A bulkhead inside the cylinder separated the cylinder into an upper (i.e., instrument) and lower (i.e., battery) watertight compartment which was accessed by removing an aluminum end cap. The acoustic-buoy electronic components included a Simrad EY500 echosounder operating at 38 kHz, communications hardware, and other instrumentation. Data were stored onboard the buoy and telemetered directly to the *Miller*

Freeman. A UHF radio link between the buoy and vessel was used to control the echosounder, receive buoy positions based on GPS, and remotely generate echograms in real time. The GPS data from the buoy were also transmitted via an Argos satellite system to the vessel to locate the buoy in the event that visual, radar, and direct radio contact were lost. A split-beam transducer and heading sensor were suspended 6.5 m (21.3 ft) below the buoy, and a copper sphere was suspended about 25 m (82 ft) below the transducer. Transducer heading data from the buoy were collected and used in analyses to assess the direction of fish response (i.e., movement relative to vessel). Four 100 ampere-hour gel cell batteries powered the buoy; one battery powered the GPS/Argos transceiver while three powered the remaining instruments. The total weight of the buoy was about 300 kg (661 lb).

SURVEY METHODS

The EIT survey consisted of 102 parallel, east-west transects that started near Monterey (Fig. 1) and proceeded north along the U.S. and Canadian west coasts to just south of the Queen Charlotte Islands. Average transect length was about 37 nmi (69 km) and ranged from about 15 nmi (28 km) to 92 nmi (170 km). Transect spacing was about 10 nmi (18.5 km) apart except inshore near the U.S./Canada border where spacing was reduced to 5 nmi (9.3 km). Transects were generally run between the 50 m (164 ft) and 1,500 m (4,921 ft) depth contours, although sometimes a transect was extended to deeper water when fish sign was found at or near its predetermined offshore endpoint. About 3,615 nmi (6,695 km) of transect lines were run.

Standard survey operations occurred only during daylight hours; night operations were used to collect Pacific whiting target strength data, conduct trawl hauls on echosign observed during daytime survey operations, trawl on aggregations of macrozooplankton and other midwater fishes, or sample areas outside the daytime survey trackline for epipelagic fish eggs and bio-toxins. Vessel speeds during daytime transecting were usually around 11-12 knots (6 m/s). Acoustic data from the 38 kHz system were collected from 14 m (46 ft) below the surface to within 0.5 m (1.6 ft) of the bottom except in deeper waters where data were collected to maximum depths of 500-1,000 m (1,640-3,281 ft). Acoustic data from the 120 kHz system were collected no deeper than 250 m (820 ft). Only the 38 kHz data were scrutinized by one or more scientists and then stored in an INGRES database. When properly scaled, these data were used to provide estimates of Pacific whiting density.

Midwater and bottom trawl hauls were made at selected locations to identify echosign and to provide biological data and Pacific whiting samples. Haul duration was kept to the minimum necessary to ensure an adequate sample. Average trawling speed was about 3 kts (1.5 m/s). Each trawl catch was completely sorted unless it exceeded about 1,000 kg (2,200 lb), at which point representative splits of the catch were sorted instead. Total weights and numbers of individuals, by species, were determined for each catch. Individual Pacific whiting were further sampled to determine sex, length (standard length for fish <80 mm, fork length for fish >80 mm), body weight, sexual maturity, and to collect otoliths for age determination. Both otoliths were removed and stored in a solution of 50% ethanol. Electronic

scales were used to determine all weights. Fish fork lengths were determined to the nearest cm with a polycorder measuring device (a combination of a bar code reader and a hand-held computer). Standard lengths of age-0 Pacific whiting were measured to the nearest mm and recorded onto a tally sheet before being transferred to a personal computer. Sexual maturities were determined by visual inspection of gonads based initially on an 8-stage scale, then later consolidated into a 5-stage scale. Stages were categorized as immature, developing, pre-spawning, spawning, and post-spawning. Pacific whiting stomachs and macro-zooplankton samples were preserved in a 10% formalin solution. Whole Pacific whiting were frozen.

Collection of target strength data required suitable conditions (e.g., low fish density, single-species aggregations, unimodal size distribution, and calm seas) and involved passing repeatedly over an aggregation of Pacific whiting at speeds of less than 4 kts (2 m/s) and then collecting biological data from trawl hauls conducted in conjunction with the collection of acoustic data.

A second method of collecting target strength data was used when echosign was deeper than about 150 m (492 ft). The vessel was stopped and a 38 kHz transducer was lowered to a depth just above the fish sign for data collection using a lowered-transducer winch assembly. A CTD unit mounted onto the transducer housing measured tilt angles of the transducer.

The primary acoustic buoy objective during the survey was to determine if a change occurred in the total water-column area back-scattering coefficient (S_A) attributed to Pacific whiting as a result of vessel noise generated while free-running at normal survey vessel speed (i.e., 12 knots). Acoustic data were collected by the buoy while the vessel steamed as close as possible past the buoy after starting from a distance of 1-2 miles away. The vessel maintained its speed and direction until it was 1-2 miles past the buoy where it remained until beginning another pass 10-15 minutes later. The vessel path during each pass was conducted perpendicular to the buoy drift-trajectory to minimize the disturbance to fish that were in the path of the buoy and might be encountered during subsequent passes.

PRELIMINARY RESULTS

Standard Sphere Calibrations

Two standard sphere calibrations of the 38 kHz and 120 kHz acoustic systems were conducted in conjunction with the survey (Table 1), one of which was completed prior to the cruise on June 30 in Puget Sound, WA. No significant differences in system parameters were observed between the two calibrations.

Intership Calibration

The *Miller Freeman* and the Canadian research vessel *W. E. Ricker* conducted an intership calibration of their acoustic data collection systems on August 21-23 to enable comparison of

density estimates derived from the two systems. Acoustic data were collected in Queen Charlotte Sound along 20 transects which were about 7-11 nm (13-20 km) long. One vessel followed directly astern of the other along each transect. Inter-ship spacing was 0.5 nm (0.9 km) for the first four transects, then 1.0 nm (1.9 km) thereafter. The vessel taking the lead position changed after each pair of transects. Vessel speeds were about 9-10 knots (5 m/s). Preliminary analysis suggested that acoustic densities measured by the Canadian system were slightly higher than those measured by the U. S. system.

EIT Survey

Biological data and specimens were collected from 95 midwater and 13 bottom trawl hauls (Fig. 1). Trawl station and catch data are summarized in Table 2. Pacific whiting was the dominant fish species captured in the midwater trawl hauls by weight and by numbers, followed by Pacific herring (*Clupea pallasi;* Table 3). The next most abundant species -- yellowtail rockfish (*Sebastes flavidus*), jack mackerel (*Trachurus symmetricus*), widow rockfish (*S. entomelas*), and redstripe rockfish (*S. proriger*) -- contributed a total of about five percent by weight to the catch. Pacific whiting was the most dominant species by weight caught in bottom trawl hauls, but shortbelly rockfish (*S. jordani*) were more numerous (Table 4). Spiny dogfish (*Squalus acanthias*) and redstripe rockfish were the next most common species numerically and by weight. Types of biological data and numbers of samples and measurements collected from midwater and bottom trawls are listed in Table 5. Haul statistics for 18 Methot trawls (Fig. 2) are presented in Table 6. Catches from these hauls appeared dominated by euphausiids and mesopelagic fishes.

The size composition of Pacific whiting differed over the survey area (Fig. 3). Nearly all fish off California (38°-42°N) comprised a dominant mode at 25-35 cm (primarily 2 year-olds) although a few fish occurred between 35-50 cm. Fish off Oregon and most of Washington (42°-48°N) were generally larger with dominant modes between 30-50 cm. Fish north of 48°N exhibited a strong mode centered around 45 cm. A second, smaller mode at 25 cm (1 year-olds) was also observed north of 49°N. Modal lengths of the adult fish generally increased from south to north.

Relatively dense Pacific whiting echosign was observed off northern California/southern Oregon (near 42°N), off central Oregon (43°-44°N), over Juan de Fuca Canyon near Cape Flattery, and north of 50° along Vancouver Island and in Queen Charlotte Sound (Fig. 4). Low densities of Pacific whiting were observed off California south of about 41°N.

Temperature profile data (MBT) were collected at most trawl haul locations (Tables 2 and 6). Additional vertical temperature profile data were successfully collected from 38 CTD and 95 XBT casts (Tables 7 and 8) conducted throughout the study area (Figure 5).

Target Strength Data Collection

Pacific whiting target strength data were collected on seven occasions. Target strength data were collected five times using only the hull-mounted transducer (July 19, 30; August 8, 9, 12) and twice using the lowered transducer assembly (August 19, 20). Ten hauls were conducted in

association with the target strength work. Analysis of target strength data is in progress.

Acoustic Buoy Deployment

The acoustic buoy was deployed six times during the survey (Table 9). During each deployment, the vessel made repeated passes within 2-20 m (6-66 ft) of the buoy. A total of 44 passes were conducted over adult Pacific whiting during daylight periods. Analysis of the data is in progress.

SCIENTIFIC PERSONNEL

Name	Sex/ Nationality	Position	Organization	Dates Aboard
		Leg 1		
Chris Wilson	M/USA	Chief Scientist	AFSC	7/6-8/2
Dan Twohig	M/USA	Instrument Chief	AFSC	7/6-7/9
Mike Guttormsen	M/USA	Fish. Biologist	AFSC	7/9-8/2
Steve de Blois	M/USA	Fish. Biologist	AFSC	7/6-8/2
Kevin Landgraf	M/USA	Fish. Biologist	AFSC	7/9-8/2
Bob Clark	M/USA	Computer Specialist	AFSC	7/6-7/9, 7/22-8/2
Michiyo Shima	F/Japan	Fish. Biologist	UW	7/9-8/2
Elaine Acuna	F/USA	Fish. Biologist	SWFSC	7/9-7/10, 7/22-8/2
Dave Griffith	M/USA	Fish. Biologist	SWFSC	7/6-8/2
Justine Stohler	F/USA	Fish. Biologist	NWFSC	7/6-8/2
Mariya Sweetwyne	F/USA	Fish. Biologist	NWFSC	7/6-8/2
Mildred Chamblee	F/USA	Teacher-At-Sea	OLA	7/6-8/2
		Leg 2		
Neal Williamson	M/USA	Chief Scientist	AFSC	8/4-8/27
Taina Honkalehto	F/USA	Fish. Biologist	AFSC	8/4-8/27
Steve de Blois	M/USA	Fish. Biologist	AFSC	8/4-8/27
Kevin Landgraf	M/USA	Fish. Biologist	AFSC	8/4-8/27
Bob Clark	M/USA	Computer Specialist	AFSC	8/4-8/11
Yoshimi Takao	M/Japan	Fish. Acoustician	NRIFE	8/4-8/27
Martin Dorn	M/USA	Fish. Biologist	AFSC	8/4-8/27
Sherry Charter	F/USA	Fish. Biologist	SWFSC	8/4-8/27
Ron Dotson	M/USA	Fish. Biologist	SWFSC	8/4-8/27
Mike Smith	M/Canada	Fish. Biologist	DFO	8/11-8/27

AFSC - Alaska Fisheries Science Center, Seattle, WA
DFO - Department of Fisheries and Oceans, Nanaimo, BC, Canada
NRIFE - National Research Institute of Fisheries Engineering, Hasake, Japan
NWFSC - Northwest Fisheries Science Center, Seattle, WA
OLA - NOAA Office of Legislative Affairs, Teachers at Sea Program, Washington, DC
SWFSC - Southwest Fisheries Science Center, La Jolla, CA
UW - University of Washington, Seattle, WA

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