Catchability coefficient for rockfish estimated from trawl and submersible surveys

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Abstract.–A bottom-trawl catchability coefficient was estimated for rockfish by comparing trawl catch rates to densities estimated from a manned submersible. A total of 16 comparisons were completed in 1989 and 1991 at depths of 180–283 m. Pacific ocean perch, *Sebastes alutus*, was the target species and accounted for 72% of the rockfish caught in the trawl. The seafloor area sampled by the trawl was calculated from the distance between the wingtips of the net and the distance the net traveled across the seafloor. The seafloor area sampled from the submersible was calculated from the distance the submersible traveled and the lateral range of visibility. A larger volume of water was sampled from the submersible because counts of rockfish included fish to 7 m above the seafloor, whereas the vertical opening of the trawl was 1.8 m; approximately 50% of the rockfish observed from the submersible were >1.8 m above the seafloor. Even though a larger volume of water was sampled from the submersible, catchability coefficients of 0.97 and 1.27 were estimated for minimum and maximum detection probabilities of rockfish from the submersible. Apparently, rockfish dove or were herded horizontally into the opening of the net. Density estimates of rockfish and other groundfish species are feasible from a submersible, and these estimates can be used to determine bottom-trawl catchability coefficients.

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Bottom-trawl surveys are used to estimate absolute abundance of most groundfish species in Alaska. The method is founded on the basic assumption that catch per unit of effort (CPUE) is a function of stock density. CPUE is converted to biomass from the area swept by the trawl and the sampling efficiency of the gear (catchability coefficient) (Alverson and Pereyra, 1969). The basic equation relating population size to CPUE is

$$P_{ij} = C_{ij} / qf_{ij},$$

where i = time period;
j = location or area;
P = exploitable population size in weight;
C = catch in weight;
q = catchability coefficient; and
f = fishing effort (Alverson and Pereyra, 1969).

Because there is no simple method of measuring catch efficiency, a catchability coefficient of 1.0 is used to convert CPUE data to biomass in bottom-trawl surveys (assuming a 100% catch efficiency across the horizontal spread of the net [wingtip to wingtip]). However, if fish are distributed above the headrope, are buried in the substrate, swim out of the path of the trawl, or escape through the net, the catchability coefficient is <1.0 and abundance is underestimated. Conversely, if fish are herded into the trawl by the bridles and trawl doors and do not escape above or under the net, the catchability coefficient is >1.0 and abundance is overestimated. Catchability coefficients depend on biological factors such as sensory capabilities as well as behavioral responses of the target species, and environmental factors such as light, temperature, and bottom type (see Gunderson, 1993, for an overview). A wide range of catchability coefficients were estimated in studies that monitored efficiency of bottom trawls: Harden-Jones et al. (1977) attached acoustic tags to flatfish and monitored their behavior in response to trawl gear; 61% of the fish in the path of the net were captured. Main and Sangster (1981) observed the catch process of several groundfish species from a towed underwater vehicle; each species responded differently with regard to net avoidance, escapement, and herding by the bridles and doors. Korotkov[1] observed groundfish behavior in front of a bottom trawl from an underwater towed apparatus; catchability coefficients of 0.1 to 0.4 were estimated, depending on trawl rigging and trawl orientation to the bottom. These studies relied on species that could be tagged or on species located at shallow depths where ambient

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[1] Korotkov, V. K. 1984. Fish behaviour in a catching zone and influence of bottom trawl rig elements on selectivity. Int. Counc. Explor. Sea, Council Meeting 1984, paper/B:15, 14 p.

light was available for observations. In this study catchability coefficients are estimated for rockfish that inhabit deep depths where ambient light is minimal and that cannot be tagged because of gas bladder expansion when sampled. Catchability coefficients are estimated by comparing trawl catch rates with counts from a manned submersible.

Pacific ocean perch, *Sebastes alutus*, was the target species of this study. Biomass estimates of Pacific ocean perch in the Gulf of Alaska, based on bottom-trawl surveys conducted triennially, were 214,827, 138,003, and 460,755 metric tons for 1987, 1990, and 1993 (Heifetz et al.[2]). These extreme changes in biomass are unlikely, given the slow growth and low mortality rates of *Sebastes* spp. (Heifetz et al.[2]). To improve Pacific ocean perch biomass estimates from bottom-trawl surveys, manned submersibles and bottom trawls have been used since 1988 to study their substrate association and spatial distribution, and the efficiency of bottom trawls for sampling them. Most Pacific ocean perch observed from a submersible were concentrated on smooth substrates in groups of 2–200 fish (Krieger, 1993). Counts of Pacific ocean perch from a manned submersible in 1989 were compared with catch rates from trawl hauls, and a catchability coefficient of 2.1 (SE=0.4) was estimated for the distance between the wingtips of the net. This catchability coefficient was considered preliminary for three reasons: 1) only nine submersible-trawl comparisons were made; 2) no fish were assumed captured while the trawl was retrieved; and 3) all fish were assumed counted within the viewing range from the submersible (Krieger, 1993). The catchability coefficient estimated in this study is based on an increased number of submersible versus trawl comparisons and on improved density estimates from trawl catch rates and submersible counts.

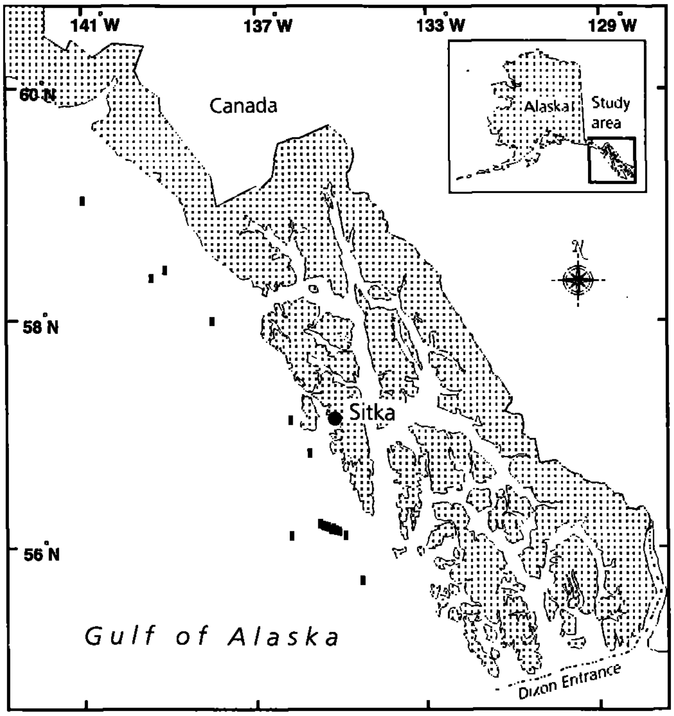

Figure 1

Locations of submersible dive sites that were sampled with bottom trawls in the eastern Gulf of Alaska, 1989 and 1991.

Materials and methods

Sampling of submersible counts and trawl catch rates for Pacific ocean perch were conducted in August 1989 and 1991 on the outer continental shelf in the eastern Gulf of Alaska (Fig. 1). The sampling strategy was to count rockfish from the submersible along four parallel transects, and then intersect the four transects with a bottom trawl. Each transect was determined by following a compass heading for 15 min, and there were 5 min of travel between transects. Trawl hauls were considered successful only if the gear was retrieved intact (no tears in the net or broken cables) and the trawl intersected at least three of the four submersible transects. Submersible dives and bottom trawling were completed during daylight at 180–283 m depths. The time between dives and trawls was <4 h for 13 of the 16 comparisons. Substrates consisted of pebble or sand, interspersed with cobble <0.5 m in diameter and boulders 0.5–5.0 m in diameter.

Submersible

We used the two-man submersible *Delta* chartered by the National Oceanic and Atmospheric Administration, National Undersea Research Center. This battery-powered submersible is 4.7 m long, dives to 365 m, and travels 2–6 km/h for 2–4 h. It is equipped with halogen lights and internal and external video cameras. In addition, it has a magnetic compass, directional gyro compass, underwater telephone, and transponder that allow tracking of the submersible from a surface vessel. The pilot maintained the submersible within 0.5 m of the bottom, while a scien-

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[2] Heifetz, J., D. M. Clausen, and J. N. Ianelli. 1994. Slope rockfish. *In* Plan Team for the Groundfish Fisheries of the Gulf of Alaska (eds.), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 1995, Sect. 5. North Pac. Fish. Manage. Counc., P.O. Box 103136, Anchorage AK 99510.

tist counted rockfish through a starboard porthole 0.5 m above the bottom of the submersible. Rockfish counts and behavior were audio- and video-recorded for subsequent analysis. Rockfish densities were derived from the number of fish counted and the seafloor area searched. This area was calculated from the distance the submersible traveled and the estimated lateral range of visibility from the starboard porthole. The observer estimated that lateral visibility ranged from 3 to 7 m, depending on water clarity. The ability of the observer to estimate distance was tested by three methods: 1) a length of pipe marked at meter intervals was laid on the seafloor and observed on two dives; 2) a hand-held sonar gun provided distance readouts to rock formations located at the maximum visibility range on six dives; and 3) the submersible's sonar provided distance readouts when the seafloor became visible during descents and when the seafloor disappeared from view during ascents. Observer estimates of distance were consistently within 1 m of actual distances. Accuracy to within 1 m was possible because constant illumination was provided entirely by the submersible lights, and water clarity was consistent at each site. The pilot assisted in counting fish >4 m above the seafloor from a panoramic view 2 m above the scientist. The pilot could see at least 10 m above the seafloor.

Identification of Pacific ocean perch from the submersible was not always possible because they look similar to three other red rockfish species: redstripe rockfish, *S. proriger*; sharpchin rockfish, *S. zacentrus*; and harlequin rockfish, *S. variegatus*. Therefore, rockfish density estimates from submersible counts and from trawling include these three species in addition to Pacific ocean perch. Most rockfish observed from the submersible, however, were identified as Pacific ocean perch by their symphyseal knob and body shape. Trawl sampling confirmed their dominance: 72% of the rockfish caught were Pacific ocean perch.

A detection probability (DP) from the submersible was estimated by measuring angles to targets with a clinometer. Clinometer readings were collected from a fixed height above the seafloor to red sea stars, *Luidiaster* spp., on the seafloor; sea stars were selected as targets because their color was similar to red rockfish and they were abundant, stationary targets. The DP was assumed to equal 1.0 near the submersible and to decrease to zero at some distance from the submersible. The DP was computed as the ratio of the observed and expected density of targets. The observed population density was computed as

$$P_i = N_i / D_i,$$

where N_i is the observed count in angle interval i, and D_i is the distance along the seafloor corresponding to angle interval i. The expected density was computed as the average observed density within the full-detection range (the range where the observed density did not decrease).

Bottom trawling

Trawl gear consisted of a 400-mesh Eastern otter trawl equipped with 55-m bridles between the net and 1.5 × 2.1-m doors weighing 386 kg each. The average distance between the wingtips (15.8 m) and the trawl doors (45.0 m) was determined during four trawl hauls by using mensuration gear. Krieger (1993) used a wingtip spread of 14 m, based on previous net measurements of the 400 Eastern trawl, to estimate the preliminary catchability coefficent (NMFS, 1993). A net height (foot-rope to head-rope) of 1.8 m is based on previous mensuration gear measurements of 1.4–1.8 m (NMFS, 1993).

Trawl catches were processed for total number and weight by species. Rockfish density estimates were derived from the number of rockfish captured and the seafloor area swept by the net. The seafloor area swept was the distance trawled multiplied by the horizontal spread of the net. Trawl distances (0.93–1.74 km/haul) and trawl speeds (5.0–6.5 km/h) were calculated from position fixes with a global positioning system (GPS). Trawl periods ranged from 10 to 18 min, depending on trawl speed and trawl distance needed to intersect the submersible transects. At the completion of the 10–18 min trawl period, vessel speed was reduced while the trawl was retrieved. To determine the sampling capabilities of the trawl during retrieval, catch rates from six "standard" trawl hauls were compared with catch rates from seven "retrieval" trawl hauls. A "standard" trawl haul was followed by a "retrieval" trawl haul at randomly selected sites separated by <3 km distance by using the same trawl depths, cable ratios, and vessel speeds as those for trawling at the submersible sites. "Standard" trawl hauls consisted of the net sweeping the seafloor for 10 min at 5.5–6.0 km/h and then being retrieved at reduced vessel speed. "Retrieval" trawl hauls consisted of the net sinking to the seafloor and then being retrieved immediately at reduced vessel speed. A sonar net-sounder was used to determine when the net departed the seafloor. GPS fixes and the rate of cable retrieval were used to determine the speed of the trawl during retrieval.

Data analysis

Rockfish density estimates from submersible counts and trawl catch rates were based on the total seafloor area sampled, but were not adjusted for the larger water column sampled from the submersible; submersible personnel surveyed to 10 m above the seafloor, whereas the net sampled to 1.8 m above the seafloor. A catchability coefficient was estimated by comparing the average density from trawl catch rates to the average density from submersible counts. The bootstrap resampling method (Efron, 1982; Efron and Tibshirani, 1986) was used to test the statistical significance of the difference and to estimate a confidence interval for the catchability coefficient. A bootstrap sample was created by sampling 1,000 times with replacement. The statistical significance of the difference (*P*) between submersible and trawl comparisons was computed by tallying how many of the 1,000 bootstrap replicates were greater than zero; *P* is for a two-sided test.

Results

Sampling during trawl retrieval

During trawl retrieval, the net remained in contact with the seafloor an additional 7–9 min. The speed of the net along the seafloor during retrieval was 4–5 km/h—a combination of the vessel moving slowly forward and retrieval of the cable. Catch rates for Pacific ocean perch averaged 34.9/1,000 m^2 during "standard" trawling and 29.8/1,000 m^2 during "retrieval" trawling (Table 1) and were not significantly different (2-sided *t*-test, $P>0.5$). Apparently, the net continued to sample effectively during retrieval; therefore, trawl catch rates included the seafloor area swept during trawl retrieval.

Detection probability from submersible

Observed densities of sea stars began decreasing 3.4 m from the submersible; therefore, the expected density was the average density of targets within the 3.4-m full-detection range. Assuming DP = 1.0 within 3.4 m, we calculated a DP of 0.77 for the entire 5.3-m range of visibility, which implies that about 3/4 of the sea stars were counted within the range of visibility. Sea stars were more difficult to detect than were rockfish because of differences in body shape; the flat bodies of sea stars blended into the seafloor, but the fusiform bodies of rockfish extended above the seafloor. Therefore, the 0.77 DP for sea stars is considered a minimal DP for rockfish and catchability coefficients are calculated for both a 0.77 DP and a 1.0 DP.

Comparison of submersible counts with trawling catch rates

Sixteen dive sites were successfully sampled by bottom trawling (Table 2). The average rockfish densities were 21.7/1,000 m^2 from trawling, and 22.4/1,000 m^2 (DP=0.77) and 17.1/1,000 m^2 (DP=1.0) from submersible counts, resulting in catchability coefficients of 0.97 (95% confidence interval: 0.70–1.32) and 1.27 (95% confidence interval: 0.91–1.73) for the area swept between the trawl wingtips. No significant difference was detected between density estimates from the submersible and trawl for either the 0.77 DP (P=0.95) or the 1.0 DP (P= 0.13).

Discussion

The 0.97 and 1.27 catchability coefficients are considerably less than the 2.1 (SE=0.4) catchability coefficient reported by Krieger (1993), mainly because they include the area sampled during trawl retrieval. The 0.77 DP from the submersible and the increased estimate of net width also contributed to lower estimates of catchability coefficients.

If rockfish did not react to the trawl gear, density estimates from submersible counts would have exceeded those from trawl catch rates because approxi-

Table 1

Number of rockfish caught, distance trawled, and estimated catch rates during standard (10 min + retrieval) and retrieval trawling using a 400 Eastern otter trawl at depths of 180–283 m in the eastern Gulf of Alaska.

	Distance (km)		
Number caught	Trawling (10 min)	Retrieval (7–9 min)	Catch rate (number/1,000 m^2)
2,263	1.10	0.63	82.53
1,267	0.96	0.74	47.02
778	0.93	0.63	31.46
660	1.06	0.65	24.35
416	1.02	0.78	14.58
274	1.15	0.69	9.40
Standard trawling mean = 34.89			
686		0.62	69.81
677		0.74	57.72
304		0.69	27.80
240		0.78	19.41
204		0.63	20.43
131		0.74	11.17
21		0.63	2.10
Retrieval trawling mean = 29.78			

Table 2

Density (number/1,000 m^2) of rockfish estimated from submersible counts and trawl catch rates at 16 sites in the eastern Gulf of Alaska, 1989 and 1991. Submersible densities are for detection probabilities (DP) of 1.0 and 0.77.

Site	Submersible				Trawl		
	Count	Area (1,000 m^2)	Density (number/1,000 m^2)		Caught	Area (1,000 m^2)	Density (number/1,000 m^2)
			DP=1.0	DP=0.77			
1	1,040	12.0	86.7	113.0	2,902	26.3	110.3
2	747	12.3	60.7	79.2	884	26.3	33.6
3	380	13.9	27.3	35.6	1,134	30.2	37.6
4	391	17.3	22.6	29.5	1,419	37.6	37.7
5	230	12.1	19.0	24.8	848	30.2	28.1
6	187	15.3	12.2	15.9	339	30.8	11.0
7	222	16.8	13.2	17.2	1,244	33.4	37.2
8	117	13.7	8.5	11.1	658	35.8	18.4
9	136	12.9	10.5	13.7	426	29.2	14.6
10	79	13.6	5.8	7.6	352	32.9	10.7
11	55	14.4	3.8	5.0	31	34.4	0.9
12	38	13.6	2.8	3.6	158	37.6	4.2
13	16	17.6	0.9	1.2	115	38.3	3.0
14	1	7.1	0.1	0.2	10	33.3	0.3
15	1	5.1	0.2	0.3	6	39.2	0.2
16	0	14.1	0.0	0.0	0	26.3	0.0
Mean			17.1	22.4			21.7

mately 50% of the rockfish were distributed above the 1.8-m height sampled by the net. The similar density estimates imply that rockfish dove to within 1.8 m of the seafloor or were herded horizontally into the net opening by the bridles and doors. Herding of fish by trawl doors and bridles has been documented for several semidemersal species by using acoustic tags (Harden-Jones et al., 1977), direct observations from a towed submersible (Main and Sangster, 1981), and underwater video (Glass and Wardle, 1989). For Pacific ocean perch, herding and diving in response to trawl gear was indicated in studies using sonar and variable bridle lengths. Sonar recordings of Pacific ocean perch indicated that the fish were diving as a fishing vessel passed over them (Kieser et al., 1992) and were diving in response to trawl gear (Nunnallee[3]). Herding was indicated in two studies where increased bridle lengths resulted in increased catch rates of Pacific ocean perch: catch rates increased 2.79- and 3.24-fold when 36.6-m bridles were increased 27.4 m and 54.9 m (Harling and Davenport, 1977), and catch rates were about 2.5 times higher for a net with 33% longer bridles, even though its vertical and horizontal opening was smaller (Wilkins and Weinberg, 1987).

This study demonstrates that estimates of fish density are feasible from a submersible and that these estimates can be used to determine bottom-trawl catchability coefficients. Rockfish were ideal for counting within the illuminated area because they were brightly colored, solitary or loosely grouped, not hidden by rugged habitat, usually motionless, and generally distributed within 7 m of the seafloor (Krieger, 1993). Most rockfish remained oriented into the current while the submersible passed, indicating minimal response to the submersible. The only movements observed were those of individual fish moving out of the direct path of the submersible and those of a few groups moving toward the submersible. Counts of fish within these groups were not hindered, because the fish swam slowly and maintained their spacing and orientation. The pilot observed similar behavior on all sides of the submersible. In addition to rockfish, density estimates appear feasible for numerous invertebrate species and groundfish species, including shortspine thornyhead, *Sebastolobus alascanus*, and several flatfish species.

The value of comparing in situ observations of groundfish with trawl catches has been documented

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[3] Nunnallee, E. P. 1991. An investigation of the avoidance reactions of Pacific whiting (*Merluccius productus*) to demersal and midwater trawl gear. ICES Council Meeting 1991, paper/B:5, Sess. U., Fish Capture Committee, 17 p.

in other studies. Uzman et al. (1977) compared submersible counts with trawl catches of fish and invertebrates and concluded that continuous visual assessment of the benthos provides the best approximation of species abundance and diversity. Adams et al. (1995) compared remotely operated vehicle counts with trawl catches of groundfish and concluded that for strongly bottom-associated groundfish, ROV abundance estimates were significantly higher and were less variable than bottom-trawl abundance estimates.

Application to stock assessment

The catchability coefficient estimated in this study with a 400 Eastern trawl may not be directly applicable to Alaska trawl surveys that use a Nor'eastern trawl. The main differences between the Nor'eastern trawl and 400 Eastern trawl are net height and footrope design: the Nor'eastern net height is 6–10 m and roller gear (36–cm rubber bobbins separated by 10-cm rubber disks) is attached to the footrope, whereas the 400 Eastern has a maximum 1.8-m net height with no roller gear on the footrope. The 15–17 m wingtip spread of the Nor'eastern is similar to the 15.8 m average spread of the 400 Eastern trawl, whereas the 47–57 m door spread of the Nor'eastern is wider than the average 45-m door spread of the 400 Eastern. The Nor'eastern trawl is assumed to be more efficient for capturing rockfish because of its higher vertical opening. Roller gear attached to the Nor'eastern trawl may either increase or decrease catch efficiency of rockfish. A repeat of this study using the Nor'eastern trawl is recommended for determining a catchability coefficient for Alaska trawl survey data.

Accurate indexing of Pacific ocean perch seems possible from bottom-trawl surveys because of their substrate preference and susceptibility to bottom-trawl gear. Pacific ocean perch concentrate on trawlable substrates (Krieger, 1993) and were effectively sampled in this study. Assuming that fish occupy the water column above the opening of the trawl and inhabit untrawlable areas, Balsiger et al. (1985) reported that CPUE data from bottom-trawl surveys probably underestimate Pacific ocean perch biomass. Submersible studies, however, indicate Pacific ocean perch biomass may be overestimated from bottom-trawl surveys for two reasons: 1) the catchability coefficient of the survey trawl may exceed 1.0 for the distance between the wingtips; and 2) only trawlable substrates where Pacific ocean perch are concentrated are sampled during surveys, but CPUE from trawlable substrates is applied to untrawlable substrates.

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Literature cited

Adams, P. B., J. L. Butler, C. H. Baxter, T. E. Laidig, K. A. Dahlin, and W. W. Wakefield.
1995. Population estimates of Pacific coast groundfishes from video transects and swept-area trawls. Fish. Bull. 93:446–455.

Alverson, D. L., and W. T. Pereyra.
1969. Demersal fish explorations in the northeastern Pacific Ocean—an evaluation of exploratory fishing methods and analytical approaches to stock size and yield forecasts. J. Fish. Res. Board Can. 26:1985–2001.

Balsiger, J. W., D. H. Ito, D. K. Kimura, D. A. Somerton, and J. M. Terry.
1985. Biological and economic assessment of Pacific ocean perch (*Sebastes alutus*) in waters off Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-72, 210 p.

Efron, B.
1982. The jackknife, the bootstrap and other resampling plans. Society for Industrial and Applied Mathematics, Philadelphia, PA, 92 p.

Efron, B., and R. Tibshirani.
1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Stat. Sci. 1:54–77

Glass, C. W., and C. S. Wardle.
1989. Comparison of the reactions of fish to a trawl gear, at high and low light intensities. Fish. Res. 7:249–266.

Gunderson, D. R.
1993. Surveys of fisheries resources. John Wiley & Sons, New York, NY, 221 p.

Harden-Jones, F. R., A. R. Margetts, W. M. Greer, and G. P. Arnold.
1977. The efficiency of the Granton otter trawl determined by sector-scanning sonar and acoustic transponding tags. Rapp. P.-V. Reun. Cons. Int. Explor. Mer 170:45–51.

Harling, W. R., and D. Davenport.
1977. *G. B. Reed* groundfish cruise no. 77-3, August 22 to September 8, 1977. Can. Fish. Mar. Serv. Data Rep. 42, 36 p.

Kieser, R., B. M. Leaman, P. K. Withler, and R. D. Stanley.
1992. *W. E. Ricker* and *Eastward Ho* cruise to study the effect of trawling on rockfish behaviour, October 15–27, 1990. Can. Manuscr. Rep. Fish. Aquat. Sci. 2161, 84 p.

Krieger, K. J.
1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull. 91:87–96.

Main, J., and G. I. Sangster.
1981. A study of the fish capture process in a bottom trawl

by direct observations from a towed underwater vehicle. Scott. Fish. Res. Rep. 23, 23 p.

NMFS (National Marine Fisheries Service).
1993. ADP Code Book. U.S. Dep. Commer., Resour. Assess. and Conserv. Eng. Div., NMFS, Alaska Fish. Sci. Cent., Seattle, 82 p.

Uzmann, J. R., R. A. Cooper, R. B. Theroux, and R. L. Wigley.
1977. Synoptic comparison of three sampling techniques for estimating abundance and distribution of selected megafauna: submersible versus camera sled versus otter trawl. Mar. Fish. Rev. 39(11):11–19.

Wilkins, M. E., and K. L. Weinberg.
1987. Results of a bottom trawl survey of Pacific ocean perch off Washington and Oregon during 1985. *In* B. R. Melteff (coordinator), Proceedings of the international rockfish symposium, p. 241–265. Alaska Sea Grant Rep. 87-2, University of Alaska.