NPAFC
Doc. 1180
Rev.
Rev. Date:

Calibration of Juvenile Salmon Catches using Paired Comparisons between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeastern Alaska, July 2008

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Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

the United States of America

October 2009

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Wertheimer, A.C., J.A. Orsi, E.A. Fergusson, and M.V. Sturdevant. 2009. Calibration of Junveile Salmon Catches using Paired Comparisons between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeastern Alaska, July 2008. NPAFC Doc. 1180. 18 pp. (Available at http://www.npafc.org).

Calibration of Juvenile Salmon Catches using Paired Comparisons between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeastern Alaska, July 2008

Abstract

Juvenile salmon (*Oncorhynchus* spp.) catches were compared from 26 pairs of surface trawl hauls fished by two research vessels in marine waters of the northern region of southeastern Alaska in July 2008. This calibration study was initiated to develop fishing efficiency measures and calibration factors to adjust trawl catches from the long-term Southeast Coastal Monitoring (SECM) data set for consistency with catches using different vessels. The Alaska Department of Fish and Game research vessel *Medeia* fished concurrently with the chartered research vessel *Steller* in Icy and Chatham Straits. The vessels fished Nordic 264 rope trawls for 20 minutes synoptically at the surface along adjacent, staggered trawl paths. Trawl speed, distance trawled, catch rates (total and individual species), species compositions, and sizes of juvenile salmon were compared between vessels. In paired-difference tests, trawl paths were significantly longer (17%, $P < 0.001$) for the *Medeia* compared to the *Steller*. The total number of juvenile salmon caught was also greater for the *Medeia* than the *Steller* (3,486 vs. 3,184). In the paired comparisons, the *Medeia* caught significantly ($P < 0.05$) more total juvenile salmon and juvenile coho salmon (*O. kisutch*), but no significant difference ($P > 0.1$) was found between vessel catches of pink (*O. gorbuscha)*, chum (*O. keta)*, or sockeye (*O. nerka*) salmon. Numbers of Chinook salmon (*O. tshawytscha*) caught were too low for statistical comparisons to be made. Overall species composition was significantly different (Chi-square, $P < 0.01$) between the two vessels. Size of juvenile salmon was significantly ($P < 0.01$) larger for fish captured by the *Medeia.* The ratios of average log-transformed (Ln[catch +1]) catches between the *Medeia* and the *Steller* for each species of juvenile salmon were used to develop calibration factors for adjusting the *Steller* catches relative to the 2007 comparisons between the *Medeia* and the NOAA ship *John N. Cobb*. Thus, this study maintains the consistency of the 12-year time series of SECM juvenile salmon abundance data. The consistency in average trawl distances between 2007 and 2008 for the *Medeia* and the correspondence of the ratio of trawl distance to the ratio of average log-transformed juvenile salmon catches indicate that trawl distance may provide a reasonable calibration factor for adjusting catches of future SECM sampling vessels to the long-term data series.

Introduction

The Southeast Coastal Monitoring (SECM) project is a coastal monitoring study of the National Oceanic and Atmospheric Administration (NOAA) Auke Bay Laboratories (ABL) conducted in the marine waters of the northern region of southeastern Alaska. The SECM project was initiated to annually study the early marine ecology of Pacific salmon (*Oncorhynchus* spp.) and associated epipelagic ichthyofauna and to better understand effects of environmental change on salmon production. From 1997 to 2007, SECM used the NOAA ship *John N. Cobb* to accrue an 11-yr time series of catches with a Nordic 264 rope trawl fished at the surface along established stations within the SECM sampling area (Orsi et al. 2000, 2008). Surface rope trawls have also been used to estimate abundance of juvenile coho salmon (*O. kisutch*) in the Strait of Georgia (Beamish et al. 2000) and to compare regional abundances of juvenile salmon and co-occurring epipelagic fish species in the Alaska and California Currents (Orsi et al. 2007). Juvenile pink salmon (*O. gorbuscha*) catches from the SECM time series are a key parameter in forecast models for pink salmon harvests in Southeast Alaska (Orsi et al. 2006; Heinl 2008; Wertheimer et al. 2008a). The Alaska Department of Fish and Game (ADF&G) research vessel *Medeia* has also deployed the surface trawl gear for specific projects for ABL (Orsi et al. 2006). In 2007, in anticipation of the decommissioning of the *John N. Cobb* in the fall of 2008, the *Medeia* and the *John N. Cobb* fished synoptically for 28 pairs of trawl hauls to develop calibration factors in the event of differential catch rates between the two vessels (Wertheimer et al. 2008b). In early June of 2008, the *John N. Cobb* was disabled by a broken crankshaft, and was unable to sample the SECM transects. The research vessel *Steller* was chartered to sample the northern transects in place of the *John N. Cobb* in June and July. During the July sampling, the *Medeia* fished synoptically with the *Steller* to determine relative fishing efficiency so that *Steller* catches could then be compared and calibrated to the SECM data series from the *John N. Cobb*. The objectives of this project in 2008 were to: (1) compare species compositions, catch rates, and sizes of juvenile salmon caught by the two vessels in 2008 and determine if significant differences in these indices existed between the vessels; (2) develop appropriate calibration factors between the *Steller* and the *Medeia*; and (3) use the relative fishing efficiency of the *Medeia* to the *John N. Cobb* and the *Steller* to calibrate the *Steller* catches to the *John N. Cobb*.

Methods

The *Medeia* and the *Steller* are research vessels rigged for stern trawling. The *Medeia* is 33 m in length and has two main engines producing 1250 hp. The *Steller* is 21 m in length and has a single main engine producing 425 hp. Each vessel fished a Nordic 264 rope trawl, modified to fish the surface water directly astern. The trawl was 184 m long and had a mouth opening of 24 m by 30 m (depth by width). A pair of 3-m foam-filled NETS Lite[1] trawl doors, each weighing 544 kg (91 kg submerged), was used to spread the trawl open. Trawl mesh sizes from the jib lines aft to the cod end were 162.6 cm, 81.3 cm, 40.6 cm, 20.3 cm, 12.7 cm, and 10.1 cm over the 129.6-m meshed length of the rope trawl. A 6.1 m long, 0.8-cm knotless liner mesh was sewn into the cod end. The trawl also contained a small mesh panel of 10.2-cm mesh sewn along the jib lines on the

[1] Reference to trade names does not imply endorsement by the Auke Bay Laboratories, National Marine Fisheries Service, NOAA Fisheries.

top panel between the head rope and the 162.6-cm mesh to reduce loss of small fish. To keep the trawl headrope at the surface, two clusters of three A-4 Polyform buoys (each inflated to 0.75 m diameter and encased in a knotted mesh bag), were clipped to opposing corner wingtips of the headrope, and one A-3 Polyform float (inflated to 0.5 m diameter), was clipped into a mesh kite pocket in the center of the headrope. The trawl was fished with a 9.1 m length of 1.6-cm wire trailing off the top and bottom of each trawl door (back strap), and each back strap was connected with a "G" hook and flat link to a 70.1-m wire swiveled bridle. The head rope bridles were 1.0-cm wire and the footrope bridles were 1.3-cm wire. The *Steller* deployed the trawl with 150 m of 1.6-cm wire main warp attached to each door, and typically averaged 2.4 kt while fishing. The *Medeia* deployed the trawl with 75 m of 1.6-cm wire main warp attached to each door, and typically averaged 3.0 kt while fishing. Start and stop trawling times were recorded as the time in which the doors were set in full fishing position and the time the door haul back was initiated.

A SCANMAR acoustic system was used to determine the average realized spread of the net while fishing, and the depth from the middle of the head rope to the middle of the foot rope. Because only one set of acoustic monitoring gear was available, the gear was deployed from each trawler on alternate days.

Sampling was conducted along two SECM transect lines (encompassing four stations each) located in Icy and Chatham Straits in the northern region of southeastern Alaska (Table 1, Figure 1). For each pair of trawls, the *Steller* initiated the trawling and the *Medeia* fished a parallel track in the same direction, starting about 10 min later. The *Medeia* trawl track was off-set from the *Steller* trawl track for each haul by 200-250 m, alternating between port and starboard. Trawl duration, between when the trawl doors were fully deployed and retrieval of the doors and net was initiated, was 20 min.

After each trawl haul, the fish were anaesthetized with tricaine methanesulfonate (MS-222), identified, enumerated, measured, labeled, bagged, and frozen. After the catch was sorted, juvenile salmon were measured to the nearest mm fork length (FL) with a Limnoterra FMB IV electronic measuring board (Chaput et al. 1992). In general, up to 50 of each species of juvenile salmon per haul were individually bagged and frozen, up to 100 were measured, and any in excess of 100 were counted only.

The distance traveled per trawl haul and the number and size of juvenile salmon caught were evaluated for statistical differences between the two vessels. Distance traveled was computed from GPS coordinates as the straight-line distance between the starting point and ending point of the 20-min fishing period. Paired-difference t-tests were used to compare distance traveled, the total number of juvenile salmon caught, and the number of juvenile pink, chum (*O. keta*), sockeye (*O. nerka*), and coho salmon caught. Chinook salmon (*O. tshawytscha*) catches were not analyzed statistically because of the small number captured. Prior to testing, numbers caught per trawl haul were transformed by Ln(catch+1) to normalize the variance of the catches and to be consistent with data used in pink salmon forecasting models (Heinl 2008; Wertheimer et al. 2008a). The species composition in the catches was compared in two ways: (1) Chi-square test of the 2 x 5 contingency table with 2 rows (vessels) and 5 columns (number of juveniles caught per species); and (2) paired-difference t-test of the proportion of coho salmon (the largest species of juvenile salmon on average) in each haul. The proportion data were transformed by the arcsine of the square root of the proportion (Sokal and Rohlf 1995) prior to testing. Mean lengths of each species of juvenile salmon were compared using a two-way analysis of variance (ANOVA), with vessel and species as fixed factors; two-sample t-tests were performed if significant differences were indicated.

Results

A total of 26 matched pairs of trawl hauls were completed (Table 2). The *Medeia* trawl track averaged a distance of 1.74 km during the 20-min fishing period, 17% further than the *Steller,* which averaged 1.50 km. The paired-difference test indicated that the distance traveled while fishing was significantly ($P < 0.001$) greater for the *Medeia*.

The SCANMAR acoustic system was used to define the average width and depth of the net opening while fishing during 7 hauls on the *Steller*, and 14 hauls on the *Medeia*. The average widths and heights were 20.7 m and 30.7 m for the *Steller*, and 21.2 m and 29.6 m for the *Medeia*, and they were not significantly ($P > 0.4$) different between vessels. The coefficient of variation (CV) in the average depth of the net was also similar between vessels: 10.4 % for the *Medeia*, and 10.5% for the *Steller*. However, the average width of the net was more variable for the *Medeia* (CV of 27.3 %) than for the *Steller* (CV of 4.5 %).

The total number of juvenile salmon caught during the paired sampling was greater for the *Medeia* (n = 3,486) than for the *Steller* (n = 3,184) (Tables 3 and 4). The average log-transformed catches were larger for the *Medeia* for all species of juvenile salmon. The average paired difference was also greater for the *Medeia* for all species of juvenile salmon tested (Table 5). The paired-difference analyses of the catches indicated that the total number of juvenile salmon caught and the number of coho salmon caught were significantly ($P < 0.05$) greater for the *Medeia* than for the *Steller* (Table 5), but catches of the other species did not differ significantly ($P > 0.1$) between the vessels.

Relative catch efficiency of the *Medeia* to the *Steller* was calculated by dividing the average Ln(catch +1) catch of the *Medeia* by the average Ln(catch +1) catch of the *Steller* for total juvenile salmon and for juvenile pink, chum, sockeye, and coho salmon (Table 6). The ratio of the averages between the two vessels for all juvenile salmon was 1.13. For the individual species, the ratios ranged from 1.04 for chum salmon to 1.48 for coho salmon (Table 6).

Catch patterns for each species were similar for the two vessels, with juvenile pink salmon the most abundant, followed by chum, coho, sockeye, and Chinook salmon (Tables 3 and 4). However, the species composition was significantly different between the two vessels (Chi-square, $P < 0.01$). No significant difference was indicated for the proportion of juvenile coho salmon in each haul between the two vessels (paired difference test, $P = 0.47$) (Table 5).

The ANOVA of size of juvenile salmon indicated significant ($P < 0.01$) differences for both species and vessel (Table 7), and significant ($P = 0.016$) interaction between vessel and fish size. Average fish size was larger for all species in the *Medeia* catches (Table 8). Species-specific t-tests between vessels, corrected for multiple comparisons, showed that juvenile pink, chum, and sockeye salmon were significantly ($P < 0.05$) larger on average for the *Medeia* catches (Table 8). In contrast, coho salmon sizes were not significantly different between vessels, which caused the significant interaction term in the ANOVA.

Discussion

The higher towing speed of the *Medeia* relative to the *Steller* and commensurately longer distance trawled for a standard haul resulted in higher average catches of juvenile salmon. The

Medeia trawl tracks were 15% longer on average, and its mean log-transformed catches of juvenile salmon were 13% larger. Similar results were observed in 2007 between the *Medeia* and the *John N. Cobb*: the *Medeia* trawl tracks were 11% longer on average, and its mean log-transformed catches of juvenile salmon were 19% greater (Wertheimer et al. 2008b). The mean trawl distance of the *Medeia* was remarkably similar between years, averaging 1.73 km in 2008 and 1.74 km in 2007.

Based on the sonar data, the average widths and depths the trawls fished were similar between the *Medeia* and *Steller*, but the trawl opening was more variable for the *Medeia*. We attribute this higher variability to lower stability in the net opening due to the shorter length of trawl warp to the doors, 75 m for the *Medeia* versus 150 m for the *Steller*. The shorter trawl warp distance for the *Medeia* has been standard operating procedure on the vessel since 2005, when day/night fishing in the Gulf of Alaska required a shorter warp out to maintain visual contact with the gear at night, to ensure the doors were not broaching in the ocean swell conditions encountered. The shorter warp distances have been used since then to maintain consistency in the *Medeia* sampling. The variation in trawl spread on the *Medeia* did not appear to directly affect catch; the log-transformed catch was not significantly correlated ($r = -0.11$, $P > 0.5$) with the spread of the net.

The average sizes of all species of juvenile salmon were larger on the *Medeia* than on the *Steller* in 2008. This finding contrasts with comparisons in 2007 between the *Medeia* and the *John N. Cobb*, for which we did not observe consistent size differences in juvenile salmon species between the two vessels (Wertheimer et al. 2008b). The fact that the trawling speed of the *John N. Cobb* was faster and more similar to the *Medeia* than was the trawling speed of the *Steller* may account for these differences.

Conversely, the catch of juvenile salmon on the *Steller* in 2008 was proportionately closer to that of the *Medeia* than was the catch of the *John N. Cobb* in 2007, in spite of the larger difference in trawl speed. The reasons for this result are not obvious, but lower abundance in 2007 may have contributed to the differences. Catches were substantially smaller in 2007 than in 2008: the *Medeia* averaged 38 juveniles per tow in 2007, and 132 juveniles per tow in 2008. The correlation of catches between paired sets in 2008, at higher abundance, was 0.7, but was only 0.4 in 2007 at lower abundance. The lower correlation in 2007 suggests that the lower abundance in 2007 may have resulted in higher variability between vessels.

A major objective of the paired comparisons was to develop appropriate fishing efficiency factors between the vessels so that the catches could be calibrated for consistency with the long term data set collected by the *John N. Cobb.* Because both abundance and size were consistently lower for pink, chum, sockeye, and coho salmon juveniles for the *Steller* relative to the *Medeia* (Table 5, Table 8), we used the fishing efficiency factors in Table 6 for each individual species to calibrate the *Steller* catches. In comparisons between the *Medeia* and the *John N. Cobb* in 2007, the fishing efficiency factor for total juvenile salmon was used for these four species (Wertheimer et al. 2008b). However, because the fishing efficiencies for the *Steller* were calculated at the species level, we used the species-specific ratios for the 2007 comparisons between the *Medeia* and the *John N. Cobb* to determine the calibration factor for converting the *Steller* catches to "Cobb equivalents" shown in Table 9. Chinook salmon were excluded from this analysis due to the low numbers captured.

The differences in the calibration factor based on total juveniles or individual species was small relative to the variability in catches between sets within a sampling period, and the large variability between sampling periods and years (e.g., Orsi et al. 2000, Wertheimer et al. 2008a).

However, the average trawl distance between years for the *Medeia* was remarkably consistent, and in good correspondence of the ratio of average catches to the ratio of the relative trawl distances of the paired vessels in both 2007 and 2008. These observations suggest that trawl distance may be a reasonable proxy for calibrating the catches of other vessels that may be contracted for SECM sampling in future years. In 2009, a third series of paired comparisons between the *Medeia* and another chartered vessel will be initiated to provide more insight into relative fishing efficiencies of vessels fishing the same gear for the SECM project.

Acknowledgments

We thank the crew of the ADF&G research vessel *Medeia*: Russell Sandstrom; Bob Frampton, Jim DeLabruere, and Rix Gottwald, for making this study possible through their collaboration, hard work, and skilled operation of vessels and gear. We also thank Dan Foley and the crew of the *Steller* for their contribution and help on this project. We are grateful to Sarah Ballard, LaCroix, Sara Miller, and Ki Baik Seong for their assistance on the surveys. We also thank Bill Flerx for providing and operating the SCANMAR gear so that we have a better understanding of how the nets were actually configured when fishing.

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Table 1.—Stations sampled during trawl calibrations between the ADF&G research vessel *Medeia* and the research vessel *Steller*, with location coordinates, distances offshore (km), and bottom depths (m), in marine waters of the northern region of southeastern Alaska, July 2008.

Station	**Latitude**	**Longitude**	**Offshore distance (km)**	**Bottom depth (m)**
		Upper Chatham Strait		
UCA	58°04.57’N	135°00.08’W	3.2	400
UCB	58°06.22’N	135°00.91’W	6.4	100
UCC	58°07.95’N	135°04.00’W	6.4	100
UCD	58°09.64’N	135°02.52’W	3.2	200
		Icy Strait		
ISA	58°13.25’N	135°31.76’W	3.2	128
ISB	58°14.22’N	135°29.26’W	6.4	200
ISC	58°15.28’N	135°26.65’W	6.4	200
ISD	58°16.38’N	135°23.98’W	3.2	234

Table 2.—Number of trawl hauls, average and standard error (SE) of distance traveled (km), and average paired difference traveled for paired 20-min trawl hauls conducted by the ADF&G research vessel *Medeia* and the research vessel *Steller* in marine waters of the northern region of southeastern Alaska, July 2008. Distances traveled by the *Medeia* were significantly greater than those for the *Steller* (paired t-test, $P < 0.001$).

		Distance traveled per trawl (km)	
Vessel	**Number of trawls**	**Average**	**SE**
Medeia	26	1.74	0.03
Steller	26	1.50	0.05
Paired differences (*Medeia* – *Steller*)	26	0.25	0.04

Table 3.—Juvenile salmon catches, transformed catches (Ln[catch+1], in parentheses), and proportion of juvenile coho salmon in total catch from trawl samples using the ADF&G research vessel *Medeia* during paired comparisons with the research vessel *Steller*, in marine waters of the northern region of southeastern Alaska, July 2008.

		Number caught and (Ln[catch+1])						Proportion
Date	**Station**	**Pink**	**Chum**	**Sockeye**	**Coho**	**Chinook**	**Total**	**coho**
26 July	ISC	42 (3.76)	42 (3.76)	10 (2.40)	20 (3.04)	0 (0.00)	114 (4.74)	0.18
27 July	ISD	73 (4.30)	40 (3.71)	8 (2.20)	14 (2.71)	0 (0.00)	135 (4.91)	0.10
27 July	ISD	271 (5.61)	110 (4.71)	19 (3.00)	28 (3.37)	1 (0.69)	429 (6.06)	0.07
27 July	ISC	111 (4.72)	52 (3.97)	8 (2.20)	47 (3.87)	1 (0.69)	219 (5.39)	0.21
27 July	ISB	8 (2.20)	2 (1.10)	7 (2.08)	52 (3.97)	1 (0.69)	70 (4.26)	0.74
27 July	ISA	0 (0.00)	0 (0.00)	1 (0.69)	29 (3.40)	0 (0.00)	30 (3.43)	0.97
28 July	ISA	0 (0.00)	0 (0.00)	0 (0.00)	5 (1.79)	1 (0.69)	6 (1.95)	0.83
28 July	ISA	3 (1.39)	5 (1.79)	0 (0.00)	5 (1.79)	0 (0.00)	13 (2.64)	0.38
28 July	ISB	119 (4.79)	50 (3.93)	1 (0.69)	22 (3.14)	0 (0.00)	192 (5.26)	0.11
28 July	ISB	253 (5.54)	91 (4.52)	4 (1.61)	33 (3.53)	0 (0.00)	381 (5.95)	0.09
28 July	ISC	241 (5.49)	131 (4.88)	17 (2.89)	31 (3.47)	0 (0.00)	420 (6.04)	0.07
28 July	ISD	160 (5.08)	97 (4.58)	15 (2.77)	24 (3.22)	0 (0.00)	296 (5.69)	0.08
29 July	UCA	98 (4.60)	38 (3.66)	1 (0.69)	22 (3.14)	7 (2.08)	166 (5.12)	0.13
29 July	UCB	84 (4.44)	41 (3.74)	5 (1.79)	14 (2.71)	2 (1.10)	146 (4.99)	0.10
29 July	UCC	20 (3.04)	20 (3.04)	5 (1.79)	21 (3.09)	0 (0.00)	66 (4.20)	0.32
29 July	UCD	1 (0.69)	7 (2.08)	5 (1.79)	8 (2.20)	2 (1.10)	23 (3.18)	0.35
29 July	UCD	1 (0.69)	4 (1.61)	1 (0.69)	12 (2.56)	2 (1.10)	20 (3.04)	0.60
29 July	UCC	12 (2.56)	5 (1.79)	5 (1.79)	18 (2.94)	7 (2.08)	47 (3.87)	0.38
30 July	UCA	28 (3.37)	49 (3.91)	8 (2.20)	25 (3.26)	2 (1.10)	112 (4.73)	0.22
30 July	UCA	6 (1.95)	10 (2.40)	2 (1.10)	6 (1.95)	1 (0.69)	25 (3.26)	0.24
30 July	UCB	98 (4.60)	50 (3.93)	7 (2.08)	14 (2.71)	4 (1.61)	173 (5.16)	0.08
30 July	UCB	0 (0.00)	0 (0.00)	0 (0.00)	25 (3.26)	1 (0.69)	26 (3.30)	0.96
30 July	UCC	2 (1.10)	5 (1.79)	3 (1.39)	14 (2.71)	1 (0.69)	25 (3.26)	0.56
30 July	UCD	4 (1.61)	1 (0.69)	4 (1.61)	20 (3.04)	2 (1.10)	31 (3.47)	0.65
31 July	ISD	140 (4.95)	36 (3.61)	6 (1.95)	13 (2.64)	0 (0.00)	195 (5.28)	0.07
31 July	ISC	35 (3.58)	27 (3.33)	7 (2.08)	6 (1.95)	1 (0.69)	76 (4.34)	0.08
TOTAL		1810	913	149	528	36	3436	
AVG		69.6 (3.08)	35.1 (2.79)	5.7 (1.60)	20.3 (2.90)	1.38 (0.65)	132.1 (4.37)	0.33

Table 4.—Juvenile salmon catches, transformed catches (Ln[catch+1], in parentheses), and proportion of juvenile coho salmon in total catch from trawl samples using the research vessel *Steller* during paired comparisons with the ADF&G research vessel *Medeia*, in marine waters of the northern region of southeastern Alaska, July 2008.

		Number of salmon caught and (Ln[catch+1])						Proportion
Date	**Station**	**Pink**	**Chum**	**Sockeye**	**Coho**	**Chinook**	**Total**	**coho**
26 July	ISC	286 (5.66)	138 (4.93)	30 (3.43)	9 2.30	1 (0.69)	464 (6.14)	0.00
27 July	ISD	52 (3.97)	46 (3.85)	9 (2.30)	4 1.61	1 (0.69)	112 (4.73)	0.04
27 July	ISD	765 (6.64)	103 (4.64)	25 (3.26)	7 2.08	0 (0.00)	900 (6.80)	0.01
27 July	ISC	32 (3.50)	24 (3.22)	1 (0.69)	24 3.22	0 (0.00)	81 (4.41)	0.30
27 July	ISB	4 (1.61)	5 (1.79)	1 (0.69)	30 3.43	0 (0.00)	40 (3.71)	0.75
27 July	ISA	0 (0.00)	1 (0.69)	0 (0.00)	4 1.61	0 (0.00)	5 (1.79)	0.80
28 July	ISA	1 (0.69)	4 (1.61)	0 (0.00)	1 0.69	0 (0.00)	6 (1.95)	0.17
28 July	ISA	0 (0.00)	0 (0.00)	0 (0.00)	2 1.10	0 (0.00)	2 (1.10)	1.00
28 July	ISB	58 (4.08)	65 (4.19)	6 (1.95)	14 2.71	0 (0.00)	143 (4.97)	0.10
28 July	ISB	154 (5.04)	44 (3.81)	4 (1.61)	9 2.30	0 (0.00)	211 (5.36)	0.04
28 July	ISC	67 (4.22)	47 (3.87)	8 (2.20)	5 1.79	0 (0.00)	127 (4.85)	0.04
28 July	ISD	179 (5.19)	103 (4.64)	33 (3.53)	10 2.40	1 (0.69)	326 (5.79)	0.03
29 July	UCA	75 (4.33)	55 (4.03)	12 (2.56)	10 2.40	4 (1.61)	156 (5.06)	0.06
29 July	UCB	4 (1.61)	4 (1.61)	3 (1.39)	9 2.30	0 (0.00)	20 (3.04)	0.45
29 July	UCC	23 (3.18)	30 (3.43)	8 (2.20)	8 2.20	5 (1.79)	74 (4.32)	0.11
29 July	UCD	8 (2.20)	32 (3.50)	3 (1.39)	6 1.95	1 (0.69)	50 (3.93)	0.12
29 July	UCD	13 (2.64)	9 (2.30)	5 (1.79)	14 2.71	4 (1.61)	45 (3.83)	0.31
29 July	UCC	0 (0.00)	2 (1.10)	0 (0.00)	2 1.10	0 (0.00)	4 (1.61)	0.67
30 July	UCA	3 (1.39)	12 (2.56)	1 (0.69)	7 2.08	2 (1.10)	25 (3.26)	0.28
30 July	UCA	20 (3.04)	9 (2.30)	0 (0.00)	3 1.39	0 (0.00)	32 (3.50)	0.09
30 July	UCB	0 (0.00)	1 (0.69)	5 (1.79)	8 2.20	3 (1.39)	17 (2.89)	0.47
30 July	UCB	2 (1.10)	15 (2.77)	0 (0.00)	3 1.39	0 (0.00)	20 (3.04)	0.15
30 July	UCC	0 (0.00)	2 (1.10)	0 (0.00)	19 3.00	1 (0.69)	22 (3.14)	0.86
30 July	UCD	0 (0.00)	0 (0.00)	0 (0.00)	9 2.30	0 (0.00)	9 (2.30)	1.00
31 July	ISD	16 (2.83)	13 (2.64)	8 (2.20)	0 0.00	0 (0.00)	37 (3.64)	0.00
31 July	ISC	133 (4.90)	105 (4.66)	17 (2.89)	1 0.69	0 (0.00)	256 (5.55)	0.00
TOTAL		1895	869	179	218	23	3184	
AVG		72.9 (2.61)	31.0 (2.69)	6.9 (1.41)	8.4 (1.96)	0.8 (0.42)	220.7 (3.87)	0.35

Table 5.—Paired-difference t-tests of juvenile salmon catches in paired trawl hauls by the ADF&G research vessel *Medeia* and the research vessel *Steller* in marine waters of the northern region of southeastern Alaska, July 2008. Prior to testing, the numbers of fish caught in each haul were transformed by Ln(catch+1) and the proportion of coho salmon caught in each haul was transformed by the arcsine of the square root. The averages shown are the *Medeia* values minus the *Steller* values (see Tables 3 and 4); t-statistic and *P*-values are for the test of the average not equal to zero.

Comparison	**n**	**Average**	**SE**	**t-statistic**	***P*-value**
Total juvenile salmon	26	0.49	0.21	2.40	0.024
Juvenile pink salmon	26	0.47	0.31	1.50	0.146
Juvenile chum salmon	26	0.10	0.25	0.40	0.696
Juvenile sockeye salmon	26	0.19	0.20	0.97	0.341
Juvenile coho salmon	26	0.94	0.13	7.33	<0.001
Proportion of coho salmon	26	0.06	0.08	0.74	0.468

Table 6.—Between-vessel ratios of average Ln(catch+1) per haul for juvenile salmon species captured in 26 paired trawl hauls by the ADF&G research vessel *Medeia* and the research vessel *Steller* in marine waters of the northern region of southeastern Alaska, July 2008.

Salmon species	***Medeia* : *Steller* ratio of average Ln (catch+1) per haul**
Pink	1.18
Chum	1.04
Sockeye	1.13
Coho	1.48
Total juvenile salmon	1.13

Table 7.—Analysis of variance of size of juvenile salmon sampled by the ADF&G research vessel *Medeia* and the research vessel *Steller* in marine waters of the northern region of southeastern Alaska, July 2008.

Factor	Degrees of freedom	Sequential sum of squares	Adjusted sum of squares	Adjusted mean square error	F-Test	*P*-value
Vessel	1	183,482	28,980	28,980	149.8	<0.01
Species	3	3,167,093	2,892,135	964,045	4983.7	<0.01
Interaction	3	2,004	2,004	668	3.45	0.016
Error	5518	1,067,406	1,067,406	193		
Total	5525	4,419,985				

Table 8.—Two-sample t-tests of size of juvenile salmon by species between vessels for fish sampled by the ADF&G research vessel *Medeia* and the research vessel *Steller* in marine waters of the northern region of southeastern Alaska, July 2008. Significance level was adjusted by the Bonferroni method to control experiment-wise error for multiple comparisons. T-values with asterisks were significant at $P < 0.05$.

Salmon species	**Vessel**	**Sample size**	**Mean fork length (mm)**	**Standard error**	**T-value between vessels by Species**
Pink	*Medeia*	1,395	115.6	0.31	14.60*
	Steller	1,282	109.5	0.29	
Chum	*Medeia*	883	112.5	0.40	10.04*
	Steller	859	106.8	0.39	
Sockeye	*Medeia*	149	112.5	1.85	4.39*
	Steller	189	102.9	1.16	
Coho	*Medeia*	520	182.9	0.98	2.15
	Steller	249	179.2	1.42	

Table 9.—Calibration factors for adjusting the juvenile salmon catch of the research vessel *Steller* for consistency with the long-term SECM data series collected by the NOAA ship *John N. Cobb*. Fishing efficiencies are from paired comparisons between the ADF&G research vessel *Medeia* and the *Steller* in 2008 (Table 6) and the *John N. Cobb* in 2007 (Wertheimer et al. 2008b).

Salmon Species	**Fishing efficiency *Steller***	**Fishing efficiency *John N. Cobb***	**Calibration factor *Steller* to *John N. Cobb***
Pink	1.18	1.13	1.045
Chum	1.04	1.21	0.857
Sockeye	1.13	1.19	0.954
Coho	1.48	1.26	1.179

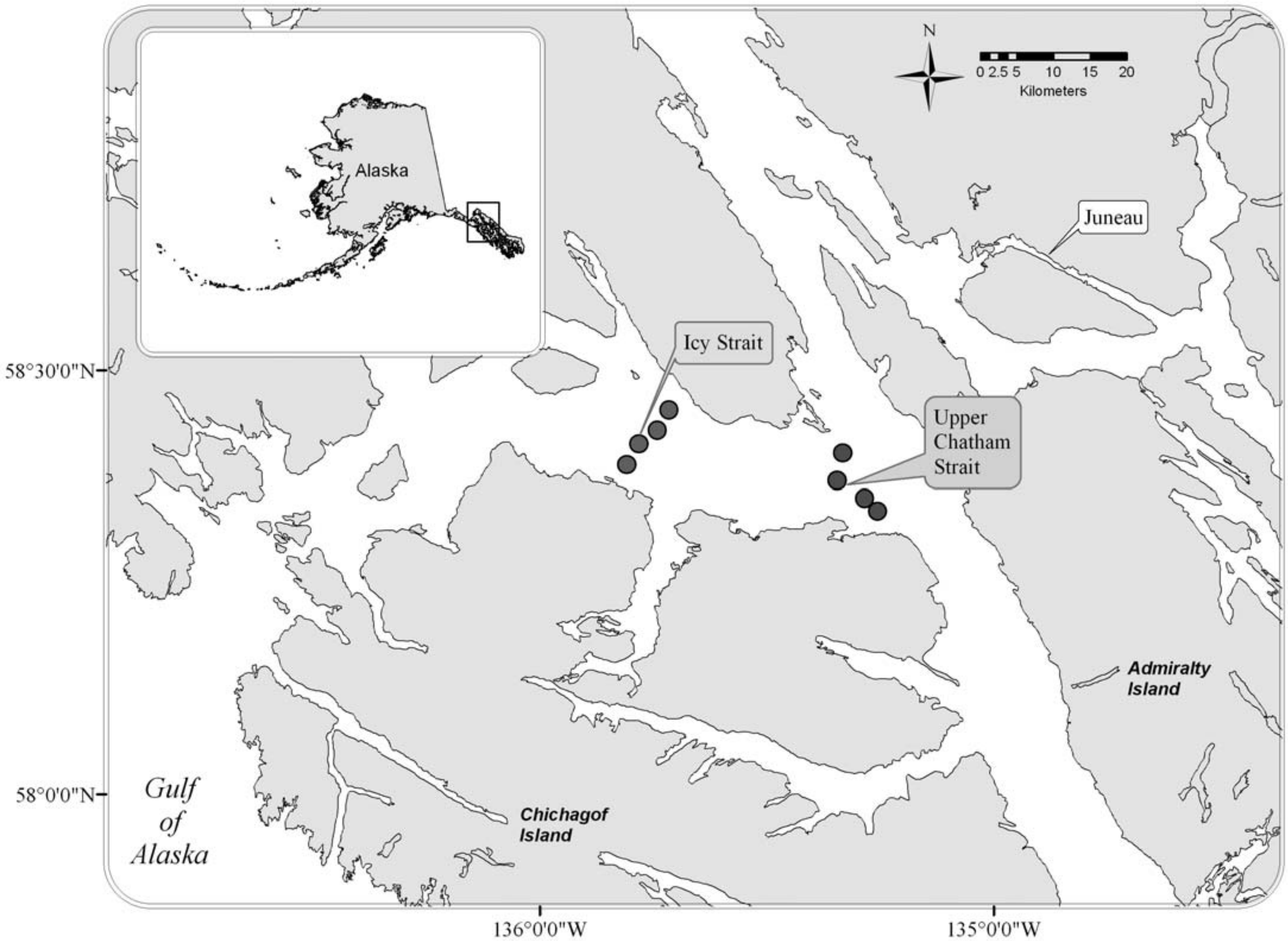

Figure 1.—Stations sampled in marine waters of the northern region of southeastern Alaska, July 2008. Transect and station coordinates are shown in Table 1.