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Calibration of Juvenile Salmon Catches using Paired Comparisons between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeast Alaska, July 2009

by

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Calibration of Juvenile Salmon Catches using Paired Comparisons between Two Research Vessels Fishing Nordic 264 Surface Trawls in Southeast Alaska, July 2009

Abstract

Juvenile salmon (*Oncorhynchus* spp.) catches were compared from 28 pairs of surface trawl hauls fished by two vessels in marine waters of the northern region of Southeast Alaska in July 2009. Calibration studies have been conducted for three years 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 obtained using different vessels. In 2009, the chartered commercial fishing vessel *Chellissa* fished concurrently with the Alaska Department of Fish and Game research vessel *Medeia* in Icy and Chatham Straits. Both vessels fished Nordic 264 rope trawls synoptically for 20 minutes at the surface along adjacent, staggered trawl paths. Trawl speed, distance trawled, catch rates, species compositions, and sizes of juvenile salmon were compared between vessels. In paired-difference tests, trawl paths were not significantly different ($P = 0.175$) for the two vessels; the *Chellissa* averaged 1.76 km, and the *Medeia* averaged 1.74 km per trawl. The total number of juvenile salmon caught was, however, greater for the *Chellissa* than the *Medeia* (5,638 versus 3,303). For the catch comparisons between vessels, the numbers of juvenile salmon caught per trawl were first ln-transformed (ln[catch] +1), then paired comparisons were made of the aggregate catch, species-specific catch, and overall species composition. The *Chellissa* caught significantly ($P < 0.05$) more total juvenile salmon, juvenile pink (*O. gorbuscha)* salmon, and juvenile chum (*O. keta)* salmon. Catches of juvenile sockeye salmon (*O. nerka*) and coho salmon (*O. kisutch*) did not differ significantly ($P > 0.4$) between vessels. Numbers of Chinook salmon (*O. tshawytscha*) caught were too low for statistical comparisons to be made. Overall species composition differed significantly (Chi-square, $P < 0.001$) between the two vessels. Sizes of juvenile pink, chum, and sockeye salmon were similar ($P > 0.20$) between the vessels, while size of juvenile coho salmon captured by the *Chellissa* was significantly larger ($P < 0.05$) than for the *Medeia.* The ratios of average ln-transformed catches between the *Chellissa* and the *Medeia* for each species of juvenile salmon were used to develop calibration factors to adjust the *Chellissa* catches relative to the 2007 comparisons between the *Medeia* and the NOAA ship *John N. Cobb*. Thus, this study maintains the consistency of juvenile salmon abundance data with the long-term time series of SECM. However, in contrast to the 2007 and 2008 calibration studies, differences in catches between the two vessels were not explained by differences in vessel speed and trawl distances. Instead, the differences appeared to be a function of the net deployment (warp distance and width between trawl blocks) by the chartered commercial trawler compared to the research vessel. These findings suggest that when different vessels are used for juvenile salmon surveys, calibration of fishing power is important to maintain interannual consistency in catch per unit effort data series.

Introduction

The Southeast Coastal Monitoring Project (SECM) is a coastal monitoring study of the National Oceanic and Atmospheric Administration (NOAA) Auke Bay Laboratories (ABL) in the northern region of Southeast Alaska. The SECM 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 in marine waters in 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; 2009a; 2010). 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*, 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 2008, the *Medeia* fished synoptically with the chartered research vessel *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* (Wertheimer et al. 2009b). In 2009, the commercial trawler *Chellissa* was chartered to fish the SECM transects in the northern and southern regions of Southeast Alaska. The *Medeia* was again fished synoptically in the northern region transects to determine relative fishing efficiency. The objectives of the paired-vessel study were to: (1) compare catch rates, species compositions, and sizes of juvenile salmon caught by the two vessels in 2009 and determine if significant differences in these parameters existed between the vessels; (2) develop appropriate calibration factors between the *Chellissa* and the *Medeia*; and (3) use the relative fishing efficiency of the *Medeia* to the *John N. Cobb* and to the *Chellissa* to "back" calibrate the *Chellissa* catches to those of the *John N. Cobb*.

Methods

The *Chellissa* and the *Medeia* are vessels rigged with stern ramps and net reels for trawling. The *Chellissa* is 28 m in length, 10 m in beam, and has a single main engine producing 1,200 hp. The *Medeia* is 33 m in length, 8 m in beam, and has two main engines producing 1,250 hp. Each vessel fished a Nordic 264 rope trawl, modified to fish the surface water directly astern. The trawls were 184 m long and had mouth openings of 24 m by 30 m (depth by width). A pair of 3-m foam-filled Lite trawl doors, each weighing 544 kg (91 kg submerged), was used to spread the trawls 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 ends. The trawls also contained a small mesh panel of 10.2-cm mesh sewn along the jib lines on the 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 0.5 m diameter), was clipped into a mesh kite pocket in the center of the headrope. The trawls were 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 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. 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.

Deployment of the trawls differed between the two vessels. The *Chellissa* deployed its trawl with 150 m of 1.6-cm wire main warp attached to each door, and typically averaged 3.0 kt while fishing. The trawl blocks were 12 m apart when fishing, which was a function of both her 10 m beam and the hydraulic block extensions. The *Medeia* deployed its trawl with 75 m of 1.6-cm wire main warp attached to each door, and typically averaged 3.0 kt while fishing. The trawl blocks were 8 m apart when fishing.

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

After each trawl haul, the fish were anaesthetized with tricaine methanesulfonate (MS-222), and sorted, identified, enumerated, measured, labeled, bagged, and frozen. 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 (overall and per species) 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, 2009a). The species composition in the catches was compared with a Chi-square test of the 2 x 5 contingency table with 2 rows (vessels) and 5 columns (number of juveniles caught per species). Mean lengths of each species of juvenile salmon were compared using a two-way analysis of variance (ANOVA; Sokal and Rohlf 1995), with vessel and species as fixed factors and with a length x species interaction term. Two-sample t-tests were performed by species, with significance level controlled for multiple comparisons, if significant differences were indicated in the interaction term.

Results

A total of 28 matched pairs of trawl hauls were completed (Table 2). The *Chellissa* trawl track averaged a distance of 1.76 km and the *Medeia* averaged 1.74 km, during the 20-min fishing periods. The average distance trawled per haul did not differ significantly ($P > 0.17$) between vessels.

The *Chellissa* caught more juvenile salmon ($n = 5,638$) than the *Medeia* ($n = 3,303$) during the paired sampling (Tables 3 and 4). The average catches were larger for the *Chellissa* for all species of juvenile salmon except Chinook. The paired-difference analysis indicated that the catch per haul was significantly greater ($P < 0.02$) for the *Chellissa* for total juvenile salmon, pink salmon, and chum salmon, but that there was no significant difference ($P > 0.4$) for juvenile sockeye salmon and coho salmon (Table 5).

Relative catch efficiency of the *Chellissa* versus the *Medeia* was calculated by dividing the average ln(catch +1) catch of the *Chellissa* by the average ln(catch +1) catch of the *Medeia* 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 1.14. For the individual species, the ratios ranged from 0.99 for sockeye salmon to 1.27 for pink salmon. The inverse ratio, *Medeia : Chellissa* (Table 6), therefore represents the scalar for adjusting ln-transformed *Chellissa* catches to *Medeia* "units".

Catch patterns for each species were similar for the two vessels, with juvenile chum salmon the most abundant species, followed by pink, coho, sockeye, and Chinook salmon (Tables 3 and 4). However, the species composition differed significantly between the two vessels (Chi-square, $P < 0.01$). While numbers of juvenile sockeye and coho salmon captured were similar between the two vessels, the *Chellissa* caught substantially more juvenile chum and pink salmon; these species made up 88% of the total catch for the *Chellissa* versus 80% for the *Medeia.*

The ANOVA of size of juvenile salmon indicated no significant difference ($P > 0.2$) in lengths of juvenile salmon sampled between the two vessels (Table 7). However, the interaction between length and species was significant ($P < 0.01$), so species-specific t-tests between vessels, corrected for multiple comparisons, were used to compare sizes (Table 8). Juvenile pink, chum, and sockeye salmon were not significantly larger ($P > 0.2$) between vessels, but juvenile coho salmon captured by the *Chellissa* were significantly larger ($P < 0.05$), which caused the significant interaction term in the ANOVA analysis.

Discussion

The *Chellissa* caught significantly more total juvenile salmon than the *Medeia* because of its higher catches of juvenile pink and chum salmon. In earlier calibration studies, the *Medeia* had higher fishing power than either the *John N. Cobb* in 2007 or the *Steller* in 2008 (Wertheimer et al. 2008b, 2009b). The higher fishing power of the *Medeia* in those years was attributed to its faster trawling speed and commensurately longer distance trawled for a standard haul. In 2009, however, the *Chellissa* and *Medeia* had nearly identical trawling speeds and distance trawled per haul. Therefore, the differential catches must have been due to differences in deployment of the trawls between the two vessels. The *Chellissa* set the trawl with a longer warp distance (150 m versus 75 m) and had a wider distance between the trawl blocks (12 m versus 8 m) than the *Medeia*. This configuration may have spread the net wider, resulting in greater

fishing efficacy near the water surface where the smaller pink and chum salmon are more concentrated compared to the larger sockeye and coho salmon. However, the potentially wider distance was not verified because mensuration gear was unavailable to determine actual net dimensions when fishing. An alternate explanation is that the wider blocks and resultant wider placement of the trawl doors caused more herding of surface-oriented juvenile salmon into the path of the *Chellissa's* trawl.

The higher fishing power of the *Chellissa* did not substantially affect average sizes of juvenile salmon sampled by the two vessels. The average sizes of pink and chum salmon (the species of juvenile salmon caught at a significantly higher rate by the *Chellissa*; Table 5), were almost identical (Table 8). Sockeye salmon average lengths were slightly (but not significantly) larger on the *Medeia,* and coho salmon lengths were significantly larger on the *Chellissa*.

A major objective of the paired comparison study 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 of the significant species differences in the fishing effectiveness for the *Chellissa* relative to the *Medeia* (Table 5), we used the fishing efficiency factors for individual species (Table 6) to calibrate the *Chellissa* catches. In comparisons between the *Medeia* and the *John N. Cobb* in 2007, the fishing efficiency factor for total juvenile salmon was used for all four species (Wertheimer et al. 2008b). However, because the fishing efficiencies for the *Chellissa* were calculated at the species level, we compared both the species-specific scalars and the total juvenile salmon scalar for the 2007 comparisons between the *Medeia* and the *John N. Cobb* to determine the calibration factor for converting the *Chellissa* catches to "Cobb equivalents" shown in Table 9. Chinook salmon were excluded from this analysis due to the low numbers captured.

The difference 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). The average trawl distance for the *Medeia* was remarkably consistent between years, averaging 1.74 km in 2009, 1.73 km in 2008 and 1.74 km in 2007. However, unlike in 2007 and 2008, trawl distance did not explain differences in fishing efficiencies between vessels. These observations suggest that consistency in interannual comparisons using the same vessel and gear can be reliably assumed, but that some means of calibration is needed to ensure the consistency of long-term data series consistency vessel type changes substantially between years.

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Table 1.—Stations sampled during trawl calibrations between the chartered fishing vessel *Chellissa* and the ADF&G research vessel *Medeia* , with location coordinates, distances offshore (km), and bottom depths (m), in marine waters of the northern region of Southeast Alaska, July 2009.

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 distance traveled (km), standard error (SE) , and average paired difference traveled for paired 20-min trawl hauls conducted by the chartered fishing vessel *Chellissa* and the ADF&G research vessel *Medeia* in marine waters of the northern region of Southeast Alaska, July 2009. Distance traveled did not differ significantly (paired t-test, $P > 0.17$).

Vessel	Number of trawls	Distance traveled per trawl (km)	
		Average	SE
Medeia	28	1.74	0.03
Chellissa	28	1.76	0.02
Paired differences (*Chellissa-Medeia*)	28	0.03	0.02

Table 3.—Juvenile salmon catches and transformed catches (ln[catch+1]), in parentheses from trawl samples using the chartered fishing vessel *Chellissa* during paired comparisons with the ADF&G research vessel *Medeia*, in marine waters of the northern region of Southeast Alaska, July 2009.

		Number of salmon caught and (ln[catch+1])					
Date	**Station**	**Pink**	**Chum**	**Sockeye**	**Coho**	**Chinook**	**Total**
26 July	ISA	0 (0.00)	0 (0.00)	1 (0.69)	3 (1.39)	0 (0.00)	4 (1.61)
26 July	ISB	8 (2.20)	12 (2.56)	1 (0.69)	5 (1.79)	0 (0.00)	26 (3.30)
26 July	ISC	172 (5.15)	118 (4.78)	14 (2.71)	19 (3.00)	0 (0.00)	323 (5.78)
26 July	ISD	28 (3.37)	32 (3.50)	1 (0.69)	12 (2.56)	0 (0.00)	73 (4.30)
27 July	ISD	488 (6.19)	478 (6.17)	35 (3.58)	32 (3.50)	0 (0.00)	1,033 (6.94)
27 July	ISC	48 (3.89)	97 (4.58)	5 (1.79)	6 (1.95)	0 (0.00)	156 (5.06)
27 July	ISB	13 (2.64)	31 (3.47)	3 (1.39)	29 (3.40)	0 (0.00)	76 (4.34)
27 July	ISA	1 (0.69)	19 (3.00)	1 (0.69)	12 (2.56)	0 (0.00)	33 (3.53)
27 July	ISC	27 (3.33)	30 (3.43)	1 (0.69)	4 (1.61)	0 (0.00)	62 (4.14)
27 July	ISD	152 (5.03)	186 (5.23)	16 (2.83)	23 (3.18)	0 (0.00)	377 (5.93)
28 July	ISA	26 (3.30)	86 (4.47)	3 (1.39)	14 (2.71)	0 (0.00)	129 (4.87)
28 July	ISB	65 (4.19)	116 (4.76)	5 (1.79)	43 (3.78)	0 (0.00)	229 (5.44)
28 July	ISC	64 (4.17)	134 (4.91)	1 (0.69)	56 (4.04)	0 (0.00)	255 (5.55)
28 July	ISD	127 (4.85)	252 (5.53)	4 (1.61)	13 (2.64)	1 (0.69)	397 (5.99)
28 July	ISB	22 (3.14)	101 (4.62)	2 (1.10)	20 (3.04)	0 (0.00)	145 (4.98)
28 July	ISA	121 (4.80)	515 (6.25)	9 (2.30)	27 (3.33)	0 (0.00)	672 (6.51)
29 July	UCD	18 (2.94)	71 (4.28)	2 (1.10)	5 (1.79)	0 (0.00)	96 (4.57)
29 July	UCC	9 (2.30)	21 (3.09)	6 (1.95)	13 (2.64)	0 (0.00)	49 (3.91)
29 July	UCB	53 (3.99)	82 (4.42)	9 (2.30)	11 (2.48)	0 (0.00)	155 (5.05)
29 July	UCA	181 (5.20)	462 (6.14)	23 (3.18)	5 (1.79)	0 (0.00)	671 (6.51)
29 July	UCA	1 (0.69)	4 (1.61)	0 (0.00)	33 (3.53)	0 (0.00)	38 (3.66)
29 July	UCD	15 (2.77)	24 (3.22)	0 (0.00)	17 (2.89)	0 (0.00)	56 (4.04)
30 July	UCA	17 (2.89)	62 (4.14)	5 (1.79)	36 (3.61)	0 (0.00)	120 (4.80)
30 July	UCB	9 (2.30)	72 (4.29)	4 (1.61)	18 (2.94)	0 (0.00)	103 (4.64)

Table 3.—cont.

Date	Station	Number of salmon caught and (ln[catch+1]) Pink	Chum	Sockeye	Coho	Chinook	Total
30 July	UCC	7 (2.08)	109 (4.70)	0 (0.00)	17 (2.89)	0 (0.00)	133 (4.90)
30 July	UCD	2 (1.10)	3 (1.39)	0 (0.00)	18 (2.94)	1 (0.69)	24 (3.22)
30 July	UCD	3 (1.39)	45 (3.83)	0 (0.00)	17 (2.89)	0 (0.00)	65 (4.19)
30 July	UCC	54 (4.01)	54 (4.01)	6 (1.95)	24 (3.22)	0 (0.00)	138 (4.93)
TOTAL		1,731	3,216	157	532	2	5,638
Average		61.8 (3.16)	114.9 (4.01)	5.6 (1.38)	19.0 (2.79)	0.1 (0.05)	201.4 (4.74)

Table 4.—Juvenile salmon catches and transformed catches (ln[catch+1]), in parentheses, from trawl samples using the ADF&G research vessel *Medeia* during paired comparisons with the chartered fishing vessel *Chellissa*, in marine waters of the northern region of Southeast Alaska, July 2009.

		Number caught and (ln[catch+1])					
Date	**Station**	**Pink**	**Chum**	**Sockeye**	**Coho**	**Chinook**	**Total**
26 July	ISA	0 (0.00)	0 (0.00)	0 (0.00)	9 (2.30)	0 (0.00)	9 (2.30)
26 July	ISB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
26 July	ISC	171 (5.15)	269 (5.60)	11 (2.48)	14 (2.71)	0 (0.00)	465 (6.14)
26 July	ISD	122 (4.81)	98 (4.60)	12 (2.56)	9 (2.30)	1 (0.69)	242 (5.49)
27 July	ISD	52 (3.97)	123 (4.82)	8 (2.20)	34 (3.56)	1 (0.69)	218 (5.39)
27 July	ISC	6 (1.95)	31 (3.47)	0 (0.00)	11 (2.48)	0 (0.00)	48 (3.89)
27 July	ISB	11 (2.48)	9 (2.30)	0 (0.00)	7 (2.08)	0 (0.00)	27 (3.33)
27 July	ISA	20 (3.04)	47 (3.87)	2 (1.10)	1 (0.69)	0 (0.00)	70 (4.26)
27 July	ISC	2 (1.10)	12 (2.56)	0 (0.00)	4 (1.61)	0 (0.00)	18 (2.94)
27 July	ISD	30 (3.43)	40 (3.71)	6 (1.95)	24 (3.22)	1 (0.69)	101 (4.62)
28 July	ISA	16 (2.83)	71 (4.28)	6 (1.95)	44 (3.81)	1 (0.69)	138 (4.93)
28 July	ISB	72 (4.29)	102 (4.63)	7 (2.08)	27 (3.33)	0 (0.00)	208 (5.34)
28 July	ISC	15 (2.77)	19 (3.00)	4 (1.61)	19 (3.00)	1 (0.69)	58 (4.08)
28 July	ISD	30 (3.43)	44 (3.81)	5 (1.79)	33 (3.53)	1 (0.69)	113 (4.74)
28 July	ISB	20 (3.04)	68 (4.23)	8 (2.20)	36 (3.61)	0 (0.00)	132 (4.89)
28 July	ISA	143 (4.97)	513 (6.24)	14 (2.71)	27 (3.33)	0 (0.00)	697 (6.55)
29 July	UCD	4 (1.61)	14 (2.71)	3 (1.39)	11 (2.48)	1 (0.69)	33 (3.53)
29 July	UCC	33 (3.53)	76 (4.34)	12 (2.56)	1 (0.69)	0 (0.00)	122 (4.81)
29 July	UCB	1 (0.69)	15 (2.77)	5 (1.79)	15 (2.77)	2 (1.10)	38 (3.66)
29 July	UCA	8 (2.20)	53 (3.99)	1 (0.69)	11 (2.48)	0 (0.00)	73 (4.30)
29 July	UCA	18 (2.94)	26 (3.30)	2 (1.10)	21 (3.09)	0 (0.00)	67 (4.22)
29 July	UCD	10 (2.40)	45 (3.83)	7 (2.08)	35 (3.58)	1 (0.69)	98 (4.60)
30 July	UCA	2 (1.10)	6 (1.95)	1 (0.69)	35 (3.58)	1 (0.69)	45 (3.83)
30 July	UCB	0 (0.00)	10 (2.40)	0 (0.00)	31 (3.47)	0 (0.00)	41 (3.74)

Table 4.—cont.

Date	Station	Number caught and (ln[catch+1]) Pink	Chum	Sockeye	Coho	Chinook	Total
30 July	UCC	13 (2.64)	42 (3.76)	10 (2.40)	17 (2.89)	0 (0.00)	82 (4.42)
30 July	UCD	1 (0.69)	12 (2.56)	4 (1.61)	9 (2.30)	0 (0.00)	26 (3.30)
30 July	UCD	1 (0.69)	5 (1.79)	0 (0.00)	12 (2.56)	0 (0.00)	18 (2.94)
30 July	UCC	42 (3.76)	45 (3.83)	6 (1.95)	23 (3.18)	0 (0.00)	116 (4.76)
TOTAL		843	1,795	134	520	11	3,303
AVG		30.1 (2.48)	64.1 (3.37)	4.8 (1.39)	18.6 (2.67)	0.4 (0.26)	118.0 (4.18)

Table 5.—Paired-difference t-tests of juvenile salmon catches in paired trawl hauls by the chartered fishing vessel *Chellissa* and the ADF&G research vessel *Medeia* in marine waters of the northern region of Southeast Alaska, July 2009. Prior to testing, the numbers of fish caught in each haul were transformed by ln(catch+1). The averages shown are the *Chellissa* values minus the *Medeia* 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	28	0.57	0.20	2.86	0.008
Juvenile pink salmon	28	0.68	0.28	2.47	0.020
Juvenile chum salmon	28	0.64	0.23	2.75	0.011
Juvenile sockeye salmon	28	-0.01	0.23	-0.06	0.952
Juvenile coho salmon	28	0.12	0.16	0.77	0.445

Table 6.—Between-vessel ratios of average ln(catch+1) per haul for juvenile salmon species captured in 28 paired trawl hauls by the chartered fishing vessel *Chellissa* and the ADF&G research vessel *Medeia* in marine waters of the northern region of Southeast Alaska, July 2009.

	Ratio of average ln (catch+1) per haul	
Salmon species	*Chellissa* : *Medeia*	*Medeia* : *Chellissa*
Pink	1.27	0.78
Chum	1.19	0.84
Sockeye	0.99	1.01
Coho	1.05	0.96
Total juvenile salmon	1.14	0.88

Table 7.—Analysis of variance of size of juvenile salmon sampled by the chartered fishing vessel *Chellissa* and the ADF&G research vessel *Medeia* in marine waters of the northern region of Southeast Alaska, July 2009.

Factor	Degrees of freedom	Sequential sum of squares	Adjusted sum of squares	Adjusted mean square error	F-Test	*P*-value
Vessel	1	25,349	265	265	1.4	0.232
Species	3	4,032,038	4,005,096	1,335,032	7,181.3	<0.01
Interaction	3	3,654	3,654	1,218	6.55	<0.01
Error	6,937	1,289,618	1,289,618	186		
Total	6,944	5,350,658				

Table 8.—Two-sample t-tests of size of juvenile salmon by species between vessels for fish sampled by the chartered fishing vessel *Chellissa* and the ADF&G research vessel *Medeia* in marine waters of the northern region of Southeast Alaska, July 2009. 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*	784	127.3	0.45	0.39
	Chellissa	1,523	127.5	0.29	
Chum	*Medeia*	1,427	134.8	0.36	-1.19
	Chellissa	2,162	134.2	0.27	
Sockeye	*Medeia*	113	138.2	1.72	-0.57
	Chellissa	142	136.9	1.44	
Coho	*Medeia*	393	205.1	0.99	3.07*
	Chellissa	401	209.2	0.91	

Table 9.—Calibration factors for adjusting the juvenile salmon catch of the chartered fishing vessel *Chellissa* for consistency with the long-term SECM data series collected by the NOAA research vessel *John N. Cobb*. Fishing efficiencies are from species-specific paired comparisons between the *Chellissa* and the ADF&G research vessel *Medeia* in 2009 (Table 6) and the *John N. Cobb* in 2007 (Wertheimer et al. 2008b). The numbers in parentheses are based on the fishing efficiency for total juvenile salmon from the 2007 comparison of the *Medeia* and the *John N. Cobb.*

	Fishing efficiency		**Calibration factor**
Salmon Species	***Chellissa : Medeia***	***Medeia : John N. Cobb***	***Chellissa* : *John N. Cobb***
Pink	1.27	1.13 (1.19)	0.694 (0.659)
Chum	1.19	1.21 (1.19)	0.694 (0.705)
Sockeye	0.99	1.19 (1.19)	0.848 (0.848)
Coho	1.05	1.26 (1.19)	0.759 (0.803)

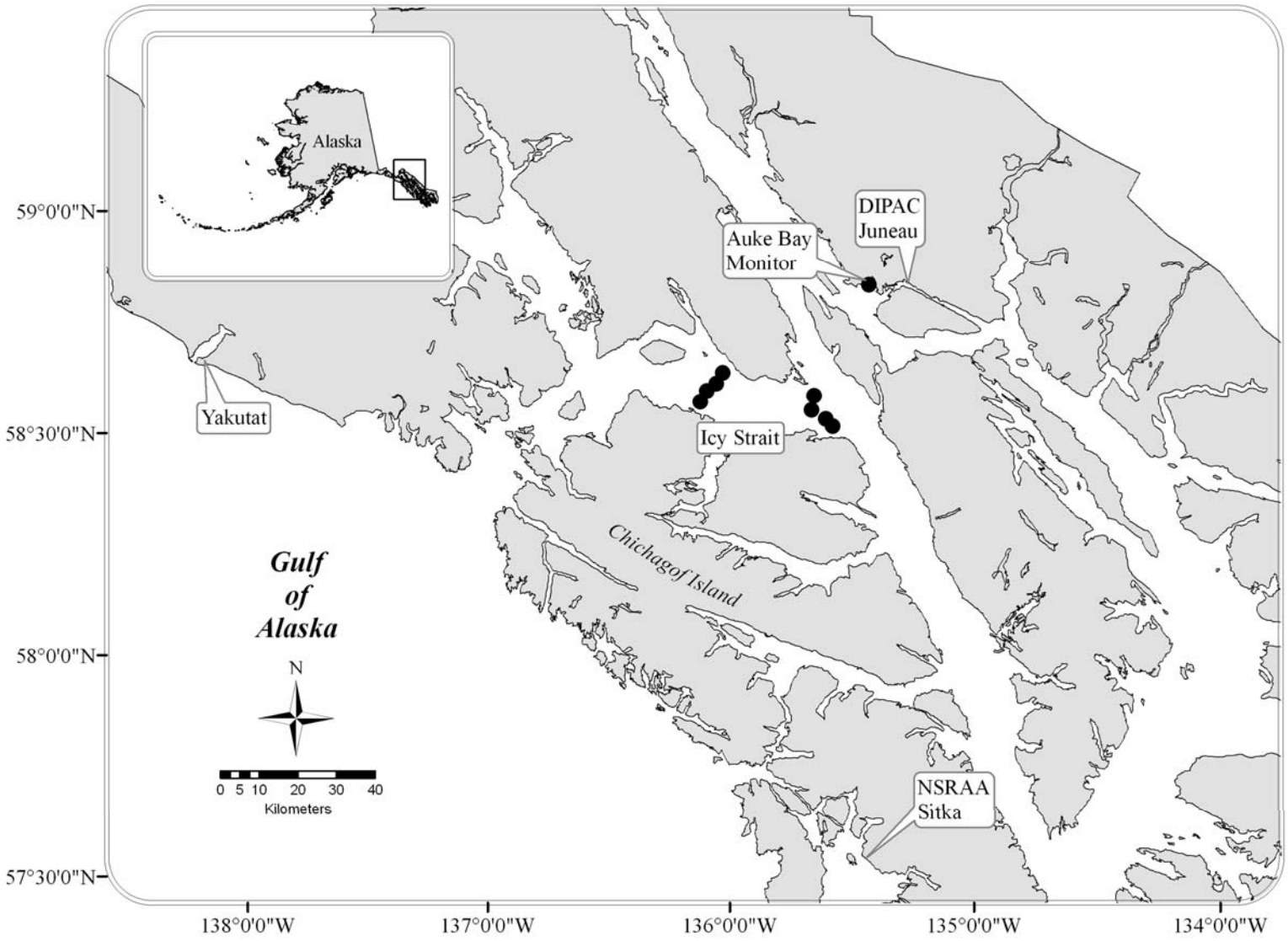

Figure 1.—Stations sampled in marine waters of the northern region of Southeast Alaska, July 2009. Transect and station coordinates are shown in Table 1.