Fishery Management Report No. 07-41

Effectiveness of a Finfish-Excluder Device in a Shrimp Fishing Trawl

by

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and

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July 2007

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

The Alaska Department of Fish and Game (ADF&G) conducted a study to determine the effectiveness of a finfish-excluder device in a shrimp trawl net. The 27.4 m ADF&G research vessel *Resolution* was used October 26-28, 2006 to trawl 24 hauls in Marmot Bay near Kodiak Island. Four configurations of a standard three-bridle shrimp trawl net were tested. Configurations included: no excluder and excluders with bar spacing in a rigid grate of 2.5 inch, 2.0 inch, and 1.5 inch. All three net configurations with an excluder device were successful at reducing the bycatch of fish. Each size reduction in bar spacing was significantly ($p < 0.0001$) more efficient. Catch of northern pink shrimp *Pandalus borealis* from the four net configurations were significantly ($p = 0.0072$) different from one another. The multiple comparison showed that the catch of northern pink shrimp was least with no excluder but not significantly different than the catch with the 2.0 inch and 1.5 inch grate excluders. However, the northern pink shrimp catch was significantly smaller in hauls without an excluder than in hauls with the 2.5 inch grate excluder. The total catch of sidestriped shrimp *Pandalopsis dispar* did not vary significantly among all net configurations. In addition, there was no significant ($p = 0.5960$) difference between the number of large (≥ 28 mm CL) sidestriped shrimp caught without an excluder and three different sized finfish excluders.

Key words: ADF&G, shrimp, finfish excluder, northern pink shrimp, *Pandalus borealis*, sidestriped shrimp, *Pandalopsis dispar*

INTRODUCTION

A finfish-excluder device (FED) with a rigid grate with a maximum 2.0 inch bar spacing is required in Westward Region commercial shrimp trawls beginning in 2006. Commonly known as a "Nordmore grate", a rigid grid flushes fish out of an opening in the top of the net, while shrimp pass through to the cod end (Figure 1). Northern pink shrimp *Pandalus borealis* compose about 85% of Alaska's Westward Region shrimp populations. Historically, trawl fisheries profitably targeted these smaller, relatively low-valued shrimp by harvesting large catches. Recently interest in shrimp trawling for sidestriped shrimp *Pandalopsis dispar* has occurred.

A rigid FED, properly rigged and monitored, significantly reduces the quantity of incidental fish captured while shrimp fishing. Canadian researchers found 60-99% of the fish were removed from the catch, while minimally affecting the size of northern pink shrimp caught (Hickey et al. 1993). What was not known was the effectiveness of the FED in retaining shrimp as large as sidestriped shrimp. This study compares the effects various bar spacing in the FED will have on catch proportions of fish and shrimp.

OBJECTIVES

The primary objective of the study was to determine the retention of sidestriped shrimp and northern pink shrimp with various bar spacing in the FED. Data collected included the quantity of catch and size of captured individuals. We were especially interested in learning if the larger shrimp were retained with the recently enacted 2.0 inch grate size.

A secondary objective was to determine the retention of fish in a shrimp trawl equipped with various bar spacing in the FED.

METHODS

TRAWL DESCRIPTION

Two shrimp research trawls identically built by a single manufacturer for Alaska Department of Fish and Game (ADF&G) were used. The small-mesh high opening trawl with three bridles was initially developed by National Marine Fisheries Service (NMFS) and adopted as the standard for shrimp trawl research by NMFS, ADF&G, and Canadian researchers in British Columbia.

(Watson 1987). This net had a 61 ft footrope with a 3/8 inch height regulating chain suspended by six 12 inch dropper chains. The net also had a 56 ft tickler chain. Astoria semi-vee trawl doors weighing 750 lb each and measuring 5.5 ft x 9 ft were attached with three 60 ft dandylines (3/8 inch diameter) to hold the net open. Flotation was achieved by using twenty-nine 8 inch floats. The net was constructed with 1.25 inch stretch mesh through the mouth, body, and cod end.

One net was not modified with a finfish-excluder device and was fished as a control treatment. The other net had a 3 ft diameter aluminum ring installed at an approximately 48° angle in the intermediate section prior to the cod end. To that ring, aluminum grates with various bar spacing were attached with cable ties. Grates were used with 2.5 inch, 2.0 inch, and 1.5 inch bar spacing. An opening for fish escape was cut out of the net immediately anterior to the grate. The opening was as wide as the grate and extended forward 2.5 feet (Figure 2). The sorting system also included a mesh funnel that was installed in the intermediate of the net, which forced the catch to the bottom of the net in front of the grate (Figure 1). There were two floats installed on the top of the grate to neutralize the weight.

SAMPLING PROCEDURES

The 27.4 m ADF&G research vessel *Resolution* was used October 26-28, 2006 to trawl 24 hauls in Marmot Bay near Kodiak Island (Figure 3). The trawl net was towed for a distance of 0.9 km at a speed of 3.7 km/h. Distance towed was recorded by Differential Global Position System (DGPS) readings. Depths fished ranged from 180 to 205 m for each haul.

The catch from each haul was sampled according to standard ADF&G Westward Region small-mesh trawl survey procedures (Jackson 2003). Species composition by weight and size was determined for fish, shrimp, and other invertebrates. Fish species were measured from snout tip to fork or mid-point of the caudal fin. From each haul, 200 northern pink shrimp and 200 sidestriped shrimp were selected at random and measured from the right eye socket to the midpoint on the posterior margin of the carapace to the nearest 0.5-mm.

ANALYSIS SELECTION

There were four analyses performed on the data collected during the project. The first analysis was to determine whether adding excluders to the shrimp trawl net significantly lowered the amount of fish caught. The second set of tests were to determine whether adding excluders to the shrimp trawl net significantly lowered the amount of shrimp caught, with northern pink shrimp and sidestriped shrimp tested separately. For the third analysis, there was concern that fish-excluders would also exclude the larger shrimp, so shrimp-size was tested for the different net configurations (no excluder, 2.5 inch, 2.0 inch, and 1.5 inch bar spacing). As with the amount of shrimp caught, pink and sidestriped shrimp were tested separately. The fourth analysis was done to further analyze whether the excluder was excluding large sidestriped shrimp (≥ 28 mm-CL), the number of large sidestriped shrimp caught by the different net configurations was tested for differences.

An ANOVA was used to test whether the amount of fish or shrimp caught among the different net configurations (no excluder, 2.5 inch, 2.0 inch, and 1.5 inch bar spacing) was significantly ($\alpha = 0.05$) different. If there was a significant difference, a modified Tukey multiple comparison (Devore 1995) was used to determine which configurations were significantly ($\alpha = 0.05$) different from one another. If the net configuration with no excluder was an important

component in determining a significant difference among the net configurations, another ANOVA was run just between the different net configurations with excluders (2.5 inch, 2.0 inch, and 1.5 inch bar spacing). This ANOVA was done to determine if there was significant variation in fish and shrimp catch between the different bar spacing.

A nested-ANOVA (Hickey et al. 1993, Neter et al. 1985) was used to test whether the size of shrimp was significantly ($\alpha = 0.05$) different among net configurations (no excluder, 2.5 inch, 2.0 inch, and 1.5 inch bar spacing). A second nested-ANOVA was performed on size of shrimp among the different net configurations but without the data when no excluder was used.

A Kruskal-Wallis nonparametric ANOVA (Conover 1980) was used to test whether the number of large shrimp caught was significantly ($\alpha = 0.05$) different between net configurations. A nonparametric analysis was necessary due to a strong indication that the number of larger shrimp caught was not normally distributed.

RESULTS

CATCH

The catch of fish, shrimp, and other invertebrates from each haul was ascertained (Appendix A). Sample hauls 1-6 were control hauls that used a standard shrimp survey net without a FED installed. Hauls 7-12 were conducted utilizing a 2.5 inch grate in a FED. Hauls 13-18 had the 2.0 inch grate, while hauls 19-24 had a 1.5 inch grate installed in the net. One haul (number 12) had an equipment malfunction and was not utilized in the analysis.

The total catch weight was 4,300.7 kg from all hauls with 40 species of fish, shrimp, and other invertebrates identified (Table 1). Northern pink shrimp were caught in greatest weight followed by walleye pollock, flathead sole and arrowtooth flounder. Total catch per haul ranged from 75 kg/km towed to 440 kg/km towed with the shrimp catch ranging from 35 to 137 kg/km towed. Fish and invertebrates other than shrimp totaled 22 to 405 kg/km towed for each haul (Figure 4). Invertebrates other than shrimp were largely octopus *Octopus dofleini*, squid *Berryteuthis magister* and jellyfish (Class Scyphozoa). Overall, the invertebrates other than shrimp comprised less than 1% of the total catch from all hauls. The largest catch of fish occurred in the first haul which had a control configuration to the gear (no excluder). This haul also had the smallest catch of shrimp. The largest catch of shrimp occurred in haul 10, which had a 2.5 inch grate installed in the finfish-excluder device.

The average catch of shrimp from each treatment type ranged from 67 kg/km towed to 113 kg/km towed, while the average catch per treatment type of fish and invertebrates other than shrimp ranged from 28 to 300 kg/km towed (Figure 5). Hauls with the control survey gear (no excluder) had the largest average catch of fish and other invertebrates, while hauls with a FED and 2.5 inch grate had the largest average catch of shrimp. On average, all three treatment types caught more shrimp and less fish than the control survey gear. Northern pink shrimp catches ranged from 30 kg/km towed to 122 kg/km towed (Figure 6). Similar to total shrimp catch, the largest catch of northern pink shrimp appeared in haul 10 with a 2.5 inch grate and the smallest catch of northern pink shrimp was in haul 1, an untreated haul. The catch of sidestriped shrimp ranged from 4 to 17 kg/km towed (Figure 7). Unlike northern pink shrimp, the largest catch of sidestriped shrimp occurred in haul 19, which was configured with the tightest bar spacing, 1.5 inch spacing.

Pacific cod *Gadus macrocephalus*, spiny dogfish *Squalus acanthias* and Pacific halibut *Hippoglossus stenolepis* were captured in the control trawl net (no excluder), but were nearly absent in all of the hauls with a finfish-excluder device in the trawl (Figure 8). Arrowtooth flounder *Atheresthes stomias* were caught in similar amounts between the control hauls and the hauls with a 2.5 inch grate. Less arrowtooth flounder were caught in the hauls with the two smallest-sized grates. Flathead sole *Hippoglossoides elassodon* appeared to be effectively released through the finfish excluder. Less flathead sole were caught with each reduction in bar spacing. Walleye pollock *Theragra chalcogramma* in the age 1+ size class at around 20 cm in length were similarly caught by all of the study treatments (Figure 9). Larger pollock in the 2+ age class at around 38 cm were effectively released by the smallest sized excluder, but some went through the two larger-sized grates. Young of the year walleye pollock were less than 14 cm in length and readily went through even the smallest grate (Figure 10).

ANALYSIS

All three finfish-excluder configurations were successful at excluding fish from the catch. The ANOVA analysis determined fish catches among the four net configurations (no excluder, 2.5 inch, 2.0 inch, and 1.5 inch bar spacing) were significantly ($p < 0.0001$) different from one another. The multiple comparisons showed that the catches of fish when there was no excluder were significantly larger than catches from all three excluder configurations. From a separate ANOVA, the catches of fish among the three excluder configurations (2.5 inch, 2.0 inch, and 1.5 inch bar spacing) were also significantly ($p < 0.0001$) different from one another. The multiple comparisons indicated that the catches of fish from each excluder configuration were different than the others ($p < 0.05$), with the 2.5 inch grate catching the most fish and the 1.5 inch grate catching the least fish.

The catches of northern pink shrimp varied between configurations. The ANOVA analysis determined northern pink shrimp catches among the four net configurations were significantly ($p = 0.0072$) different from one another. The multiple comparison showed that the catch of northern pink shrimp was least with no excluder but not significantly different from the 2.0 inch and 1.5 inch grate excluders. However, the standard net configuration catch was significantly smaller than the catch from the 2.5 inch grate excluder. From a separate ANOVA, the catches of northern pink shrimp between the three excluder configurations were also significantly ($p = 0.0285$) different from one another. The multiple comparison indicated that the catch of northern pink shrimp was significantly ($p < 0.05$) greater in the 2.5 inch grate excluder than the 1.5 inch grate excluder. However, northern pink shrimp catches from neither the 1.5 inch nor 2.5 inch grate excluders were significantly ($p > 0.05$) different from the 2.0 inch grate excluder catches.

The catches of sidestriped shrimp varied little between net configurations. The ANOVA analysis determined sidestriped shrimp catches for the four net configurations were not significantly ($p = 0.1155$) different from one another. Since there was not a significant difference in the catch of sidestriped shrimp between net configurations, no further ANOVA or multiple comparison was performed.

The sizes of northern pink shrimp caught had a similar trend between hauls, having a bi-modal distribution with modes at about 14.0 to 16.0 mm-CL and 19.0 to 21.0 mm-CL (Figures 11-14). For the hauls where excluders were used (Figures 12–14), there seemed to be more, smaller (< 18.0 mm-CL) northern pink shrimp caught, than the hauls with no excluder (Figure 11). The nested-ANOVA analysis showed a significant ($p = 0.0054$) difference between the average sizes of the northern pink shrimp caught with the different net configurations. However, when the

nested-ANOVA analysis was run on the size of northern pink shrimp caught with the three different excluders, there was no significant ($p = 0.4782$) difference indicated.

The sidestriped shrimp size distribution tended to have a single prominent mode at about 19.0 to 21.0 mm-CL (Figures 15-18). As with the northern pink shrimp, there seemed to be more, smaller sidestriped shrimp caught with excluders than without an excluder. The nested-ANOVA showed a significant ($p = 0.0012$) difference between the four net configurations for the sidestriped shrimp average size. However, when the nested-ANOVA analysis was run on the size of sidestriped shrimp caught with the three different excluders, there was no significant ($p = 0.2954$) difference indicated.

The comparison of size distributions of shrimp caught with and without excluders indicated that hauls with excluders tended to catch a higher proportion of smaller shrimp, however the analyses of shrimp catch indicated that overall more shrimp were caught when there was an excluder than when there wasn't. So, an analysis was performed on the number of large (≥ 28 mm-CL) sidestriped shrimp caught between the four different net configurations (no excluder, 2.5 inch, 2.0 inch, and 1.5 inch bar spacing). The number of large sidestriped shrimp varied extensively between hauls (Figure 19), so a nonparametric Kruskal-Wallis ANOVA was used. The ANOVA indicated that there was no significant ($p = 0.5960$) difference between the number of large sidestriped shrimp caught by the four different net configurations.

DISCUSSION

This experiment successfully answered the question of whether or not large sidestriped shrimp evaded capture with the finfish-excluder device. The large shrimp were caught in similar numbers in all hauls with the two highest catches in the most restrictive device. This study also demonstrated the effectiveness of a finfish-excluder device in removing large fish from the shrimp catch. Smaller bar spacing in the finfish excluder allowed more fish to escape.

A surprising result of the study was the increased shrimp catch when utilizing the excluder. This might be good news to commercial fishermen; however, it appears the increased catch is mostly smaller shrimp. These shrimp might also need to be filtered out of the catch if the target is large sidestriped shrimp. Although 2.0 inch bar spacing is the regulatory maximum, commercial fishermen may want to use a closer bar spacing to reduce the catch of small shrimp and further reduce the catch of fish. Increased water flow at the mouth of the net and through the cod end is one possible explanation for the increased shrimp catch with the fish excluder installed in the trawl.

The department intends to further investigate finfish excluders in shrimp trawls during October, 2007. Changes to the study design will include randomizing treatment types and moving to a larger study site, where hauls will not overlap. A different study site may also provide higher densities of sidestriped shrimp so we can further investigate fishing power of the grated shrimp trawls on catching larger shrimp.

ACKNOWLEDGEMENTS

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TABLE AND FIGURES

Table 1.–Catch of fish, shrimp and other invertebrates from the finfish-excluder device study.

Common name	Scientific name	Catch (kg)
northern pink shrimp	*Pandalus borealis*	1,604.2
walleye pollock (age 1+ and up)	*Theragra chalcogramma*	1,087.1
flathead sole	*Hippoglossoides elassodon*	450.1
arrowtooth flounder	*Atheresthes stomias*	350.3
sidestriped shrimp	*Pandalopsis dispar*	236.3
Pacific cod	*Gadus macrocephalus*	135.7
spiny dogfish	*Squalus acanthias*	88.9
eulachon	*Thaleichthys pacificus*	73.3
longsnout prickleback	*Lumpenella longirostris*	58.6
Pacific halibut	*Hippoglossus stenolepis*	55.3
walleye pollock (age 0+)	*Theragra chalcogramma*	35.5
rex sole	*Glyptocephalus zachirus*	24.5
giant octopus	*Octopus dofleini*	24.2
ocean pink shrimp	*Pandalus jordani*	18.8
magistrate armhook squid	*Berryteuthis magister*	10.8
monster snailfish	*Careproctus phasma*	9.3
rougheye rockfish	*Sebastes aleutianus*	8.0
twospine crangon	*Crangon communis*	7.0
spinyhead sculpin	*Dasycottus setiger*	4.8
wattled eelpout	*Lycodes palearis*	2.4
Bering skate	*Bathyraja interrupta*	2.0
Dover sole	*Microstomus pacificus*	1.8
snailfish unident.	Family Liparidinae	1.6
spot shrimp	*Pandalus platyceros*	1.5
eualid shrimp sp.	*Eualus* sp.	1.3
bigmouth sculpin	*Hemitripterus bolini*	1.2
shortfin eelpout	*Lycodes brevipes*	0.9
sablefish	*Anoplopoma fimbria*	0.9
Aurelia sp.	*Aurelia* sp.	0.9
Aequorea sp.	*Aequorea* sp.	0.8
redbanded rockfish	*Sebastes babcocki*	0.7
jellyfish unident.	Class Scyphozoa	0.5
marbled snailfish	*Liparis dennyi*	0.4
grenadier unident.	Family Macrouridae	0.3
beroid jellyfish sp.	*Beroe* sp.	0.3
juvenile Pacific cod	*Gadus macrocephalus*	0.1
blackfin poacher	*Bathyagonus nigripinnis*	0.1
Tanner crab	*Chionoecetes bairdi*	0.1
sea anemone unident.	Order Actiniaria	0.1
comb jelly unident.	Phylum Ctenophora	0.1
gray starsnout	*Bathyagonus alascanus*	< 0.1
isopod unident.	Order Isopoda	< 0.1

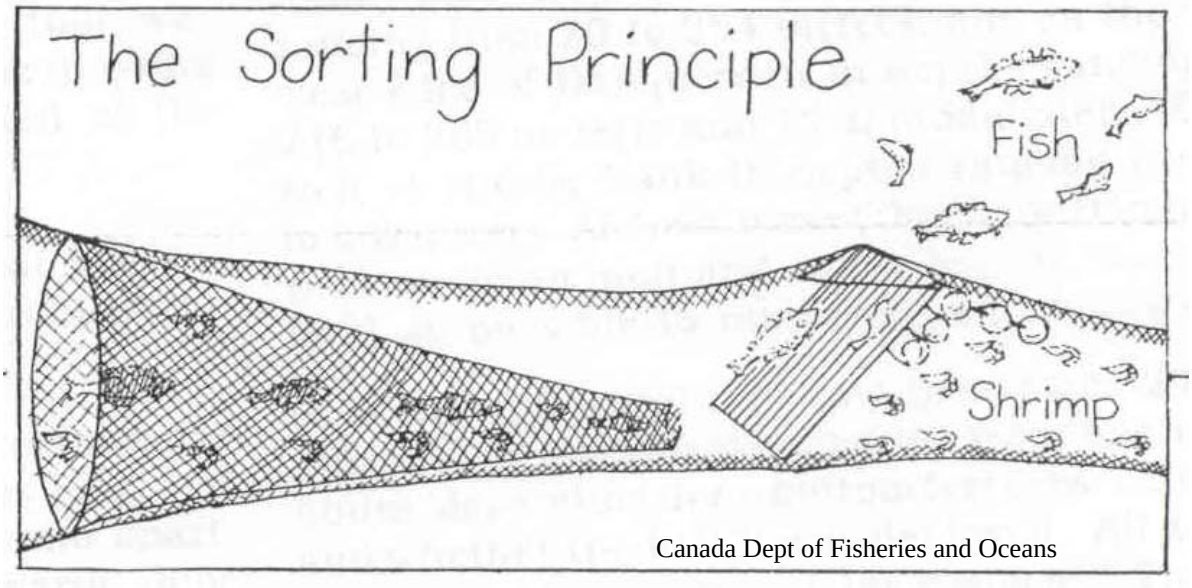

Figure 1.-Shrimp fishing bycatch reduction method known as a “Nordmore grate”.

Figure 2.-Finfish-excluder device installed on the ADF&G shrimp research trawl.

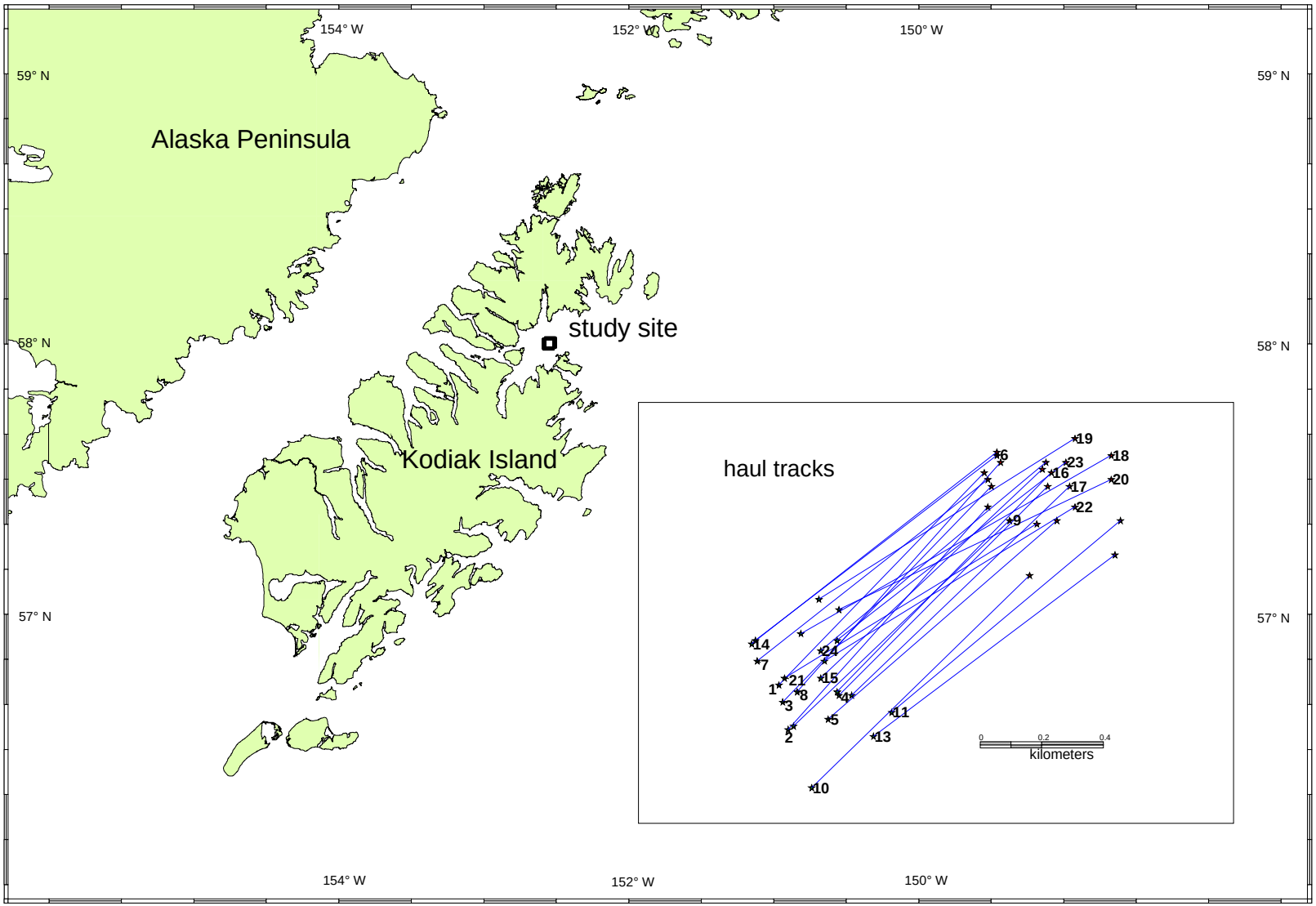

Figure 3.-Fishing site with trawl tracks and haul numbers for finfish-excluder device study.

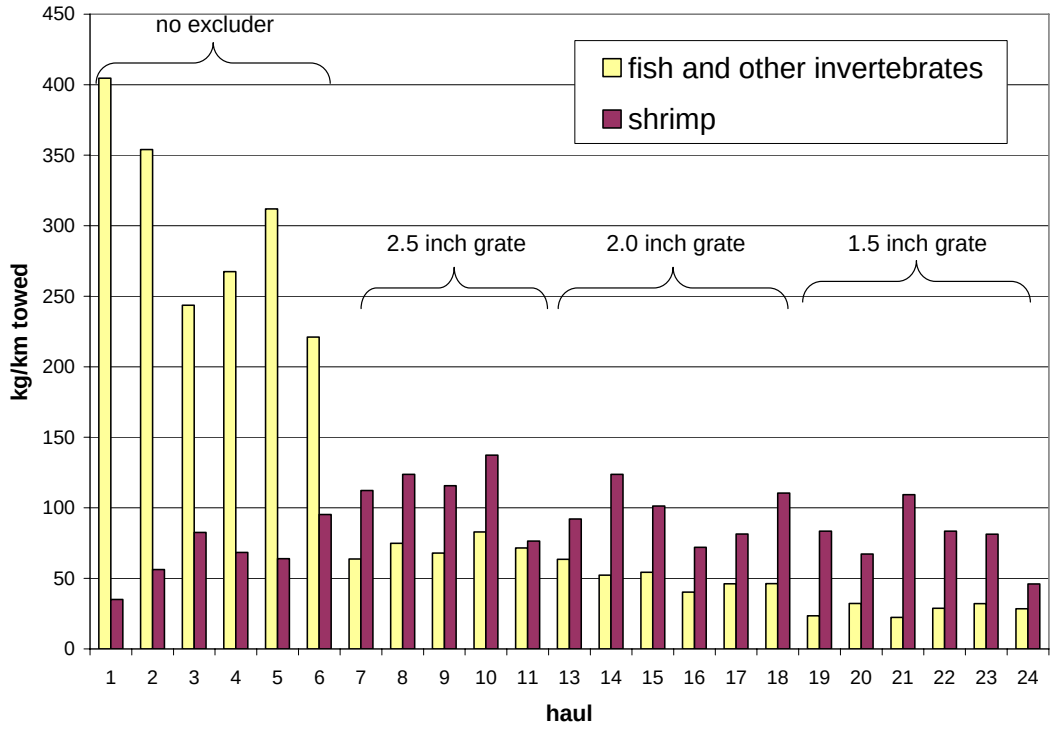

Figure 4.-Catch per haul in kg/km towed from the finfish-excluder device study.

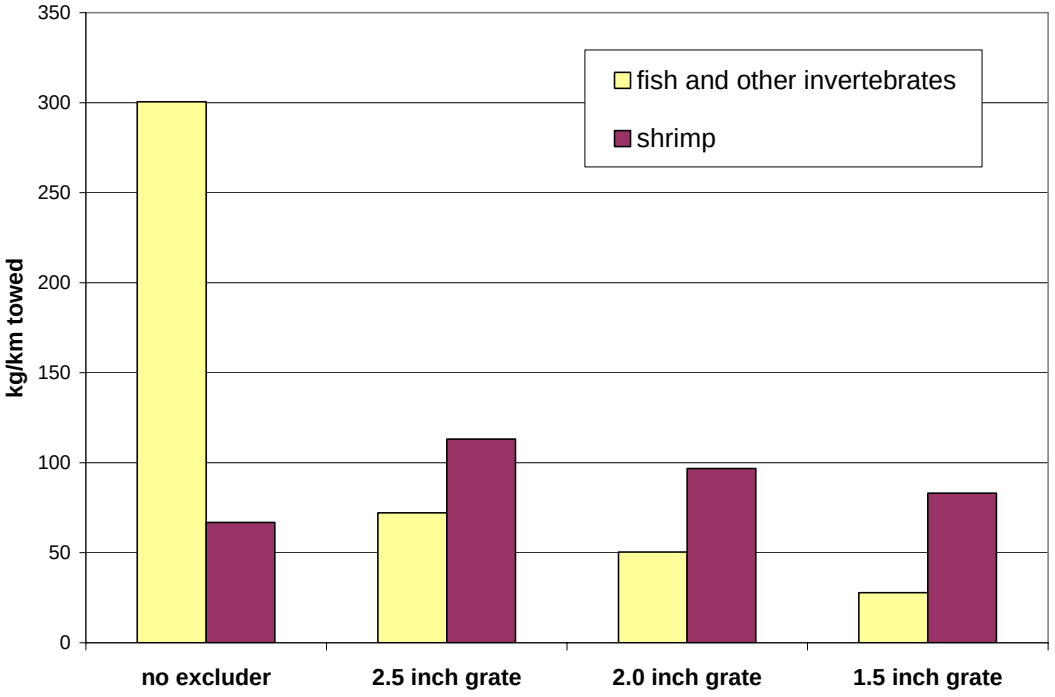

Figure 5.-Average catch per treatment type in kg/km towed from the finfish-excluder device study.

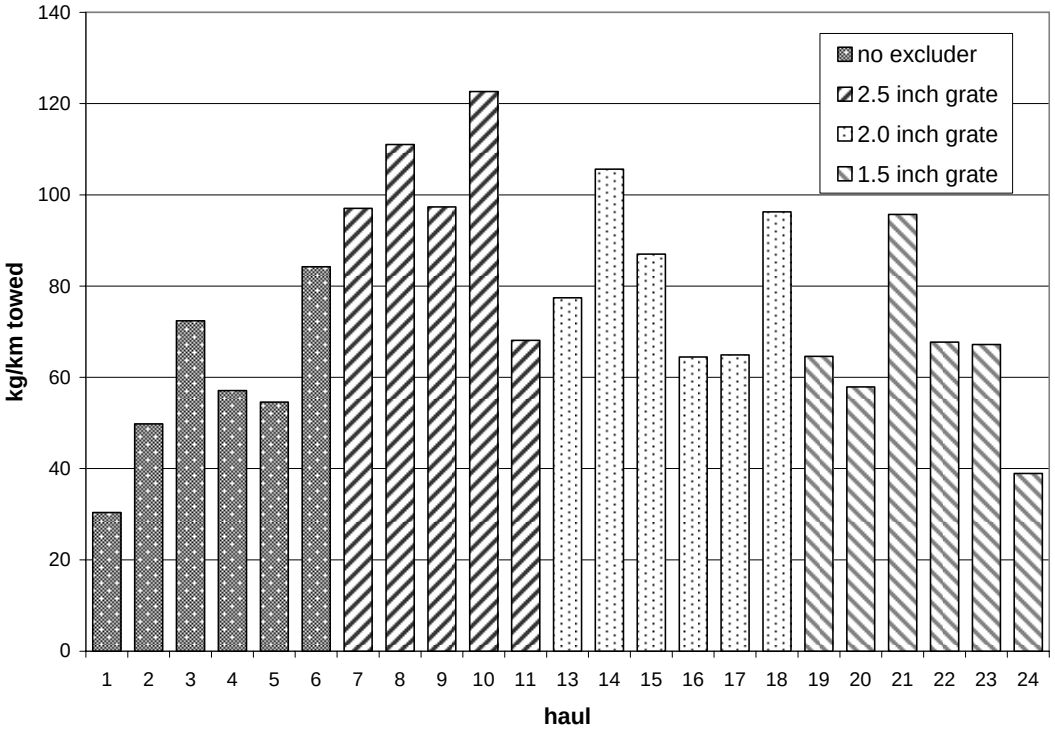

Figure 6.-Catch per haul in kg/km towed of northern pink shrimp towed from the finfish-excluder device study.

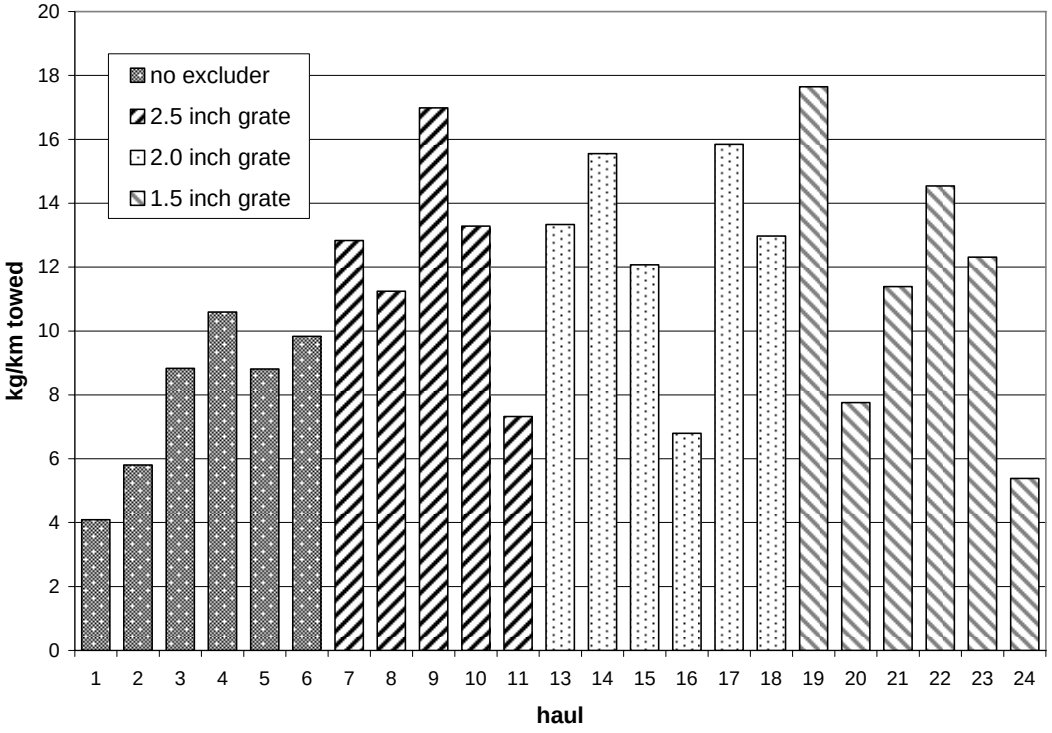

Figure 7.-Catch per haul in kg/km towed of sidestriped shrimp from the finfish-excluder device study.

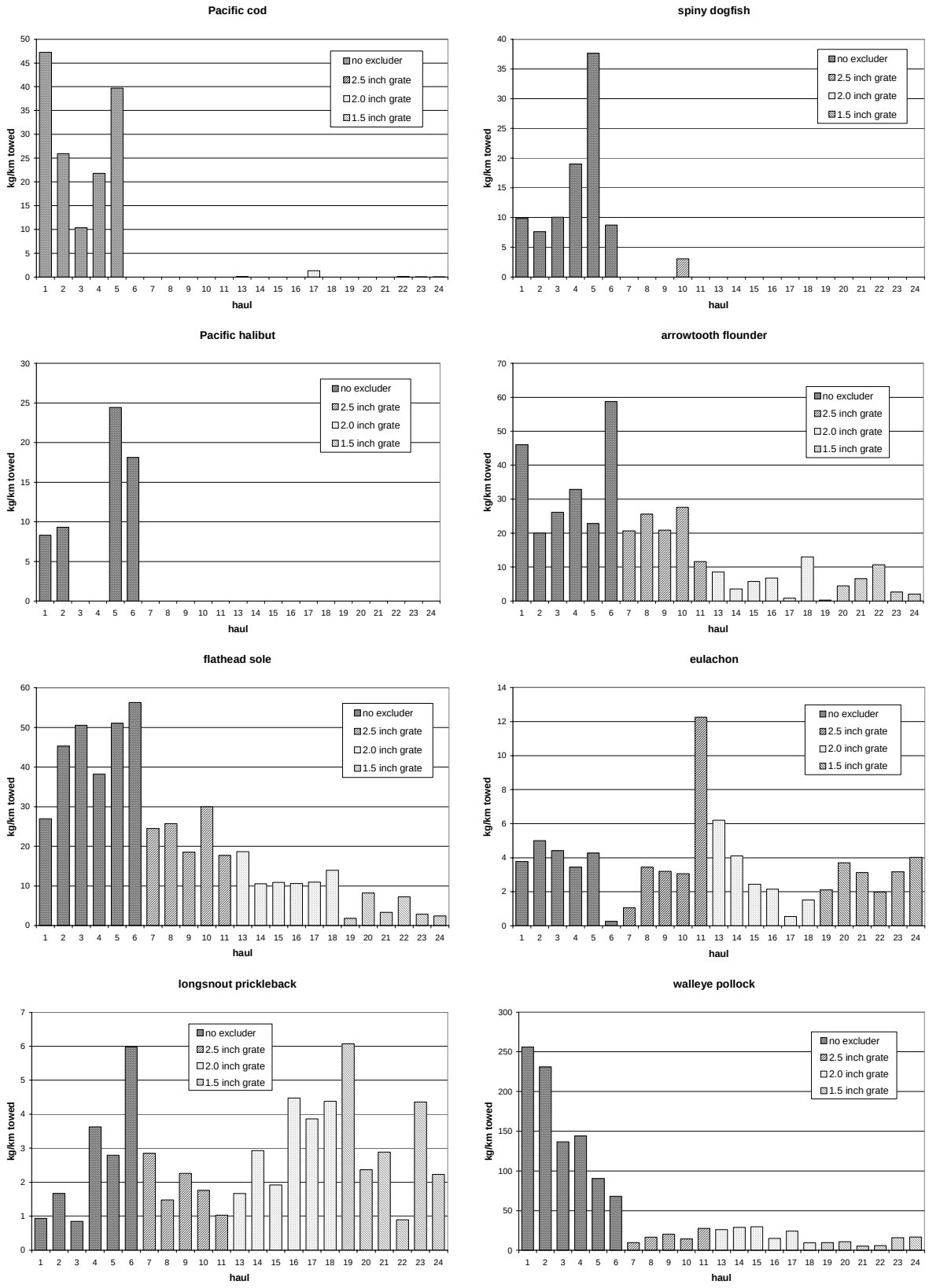

Figure 8.-Catch per haul in kg/km towed of 8 fish species from the finfish-excluder device study.

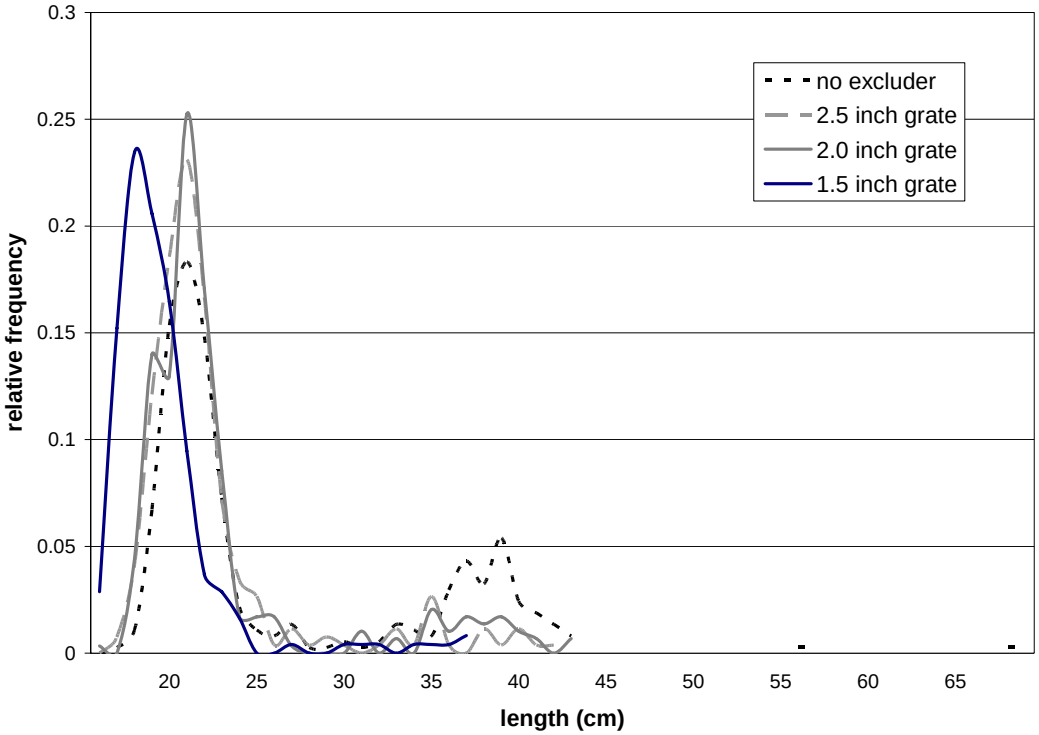

Figure 9.-Length of age 1+ and larger walleye pollock from the finfish-excluder device study.

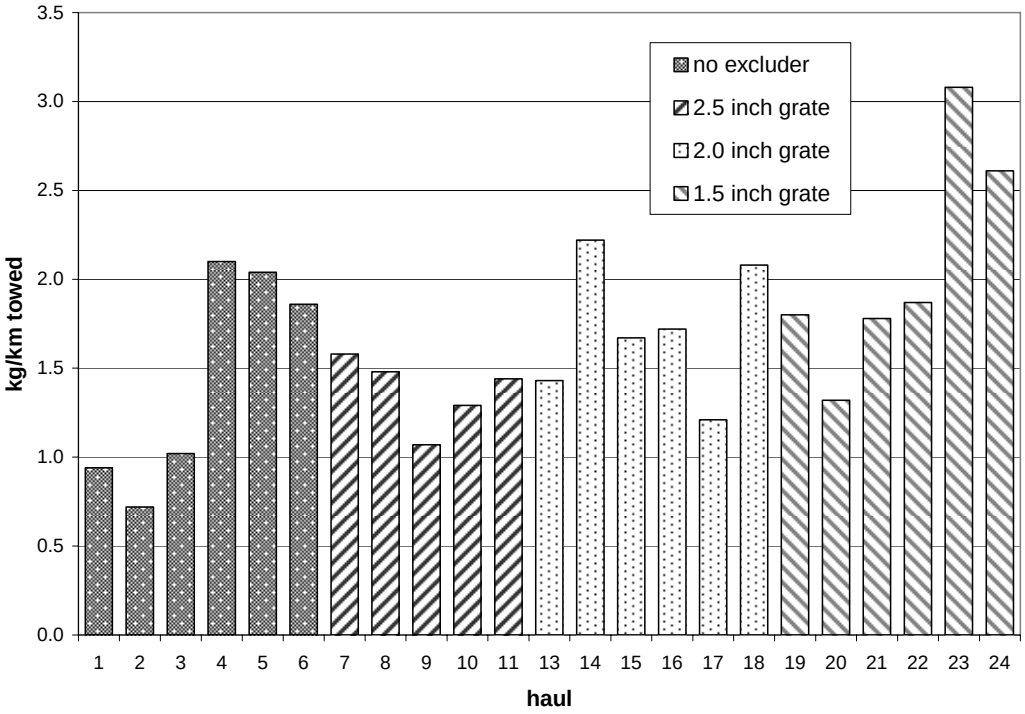

Figure 10.-Catch per haul in kg/km towed of young of the year walleye pollock from the finfish-excluder device study.

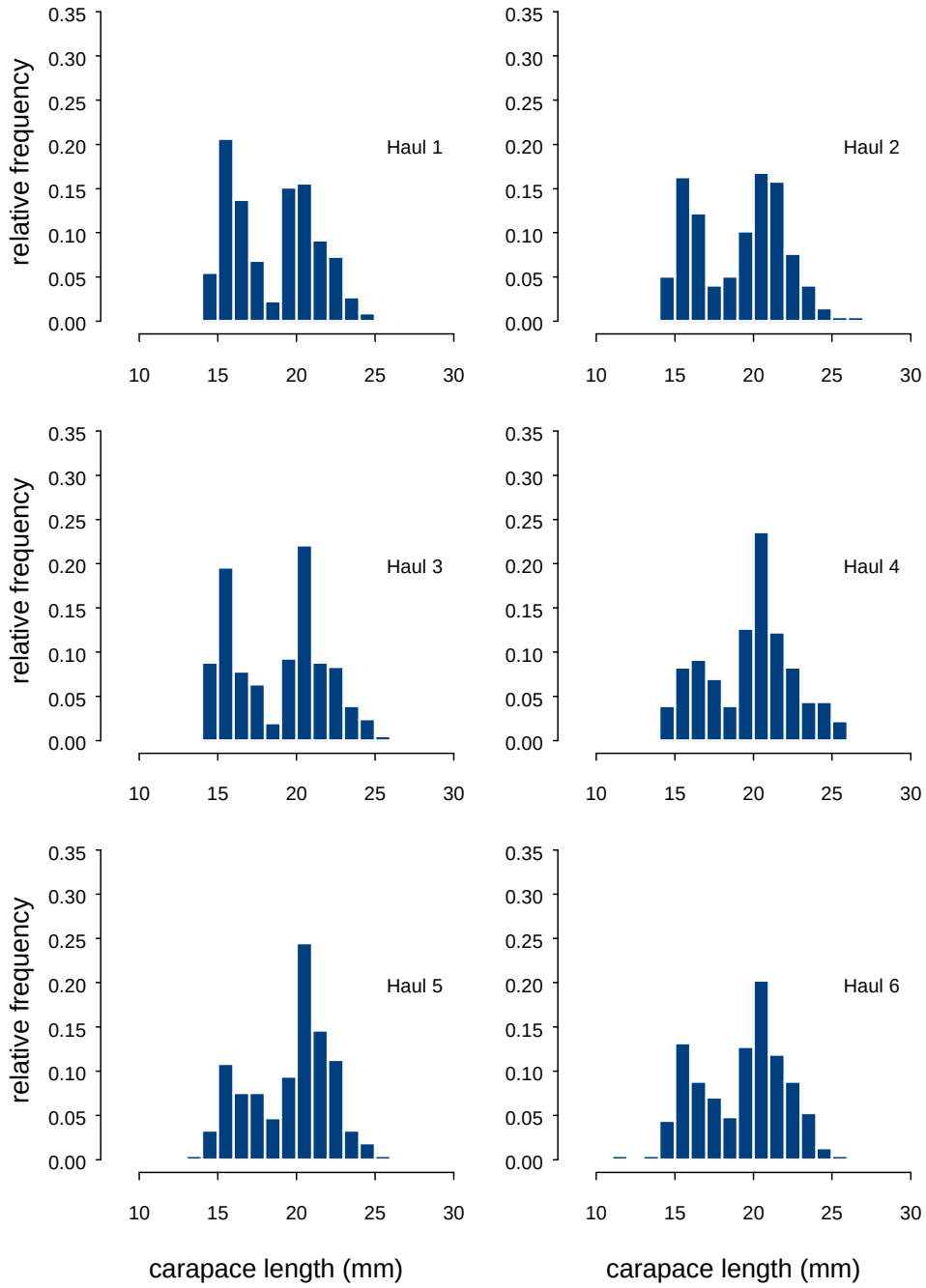

Figure 11.-Size distribution of northern pink shrimp caught from the hauls with no excluder device.

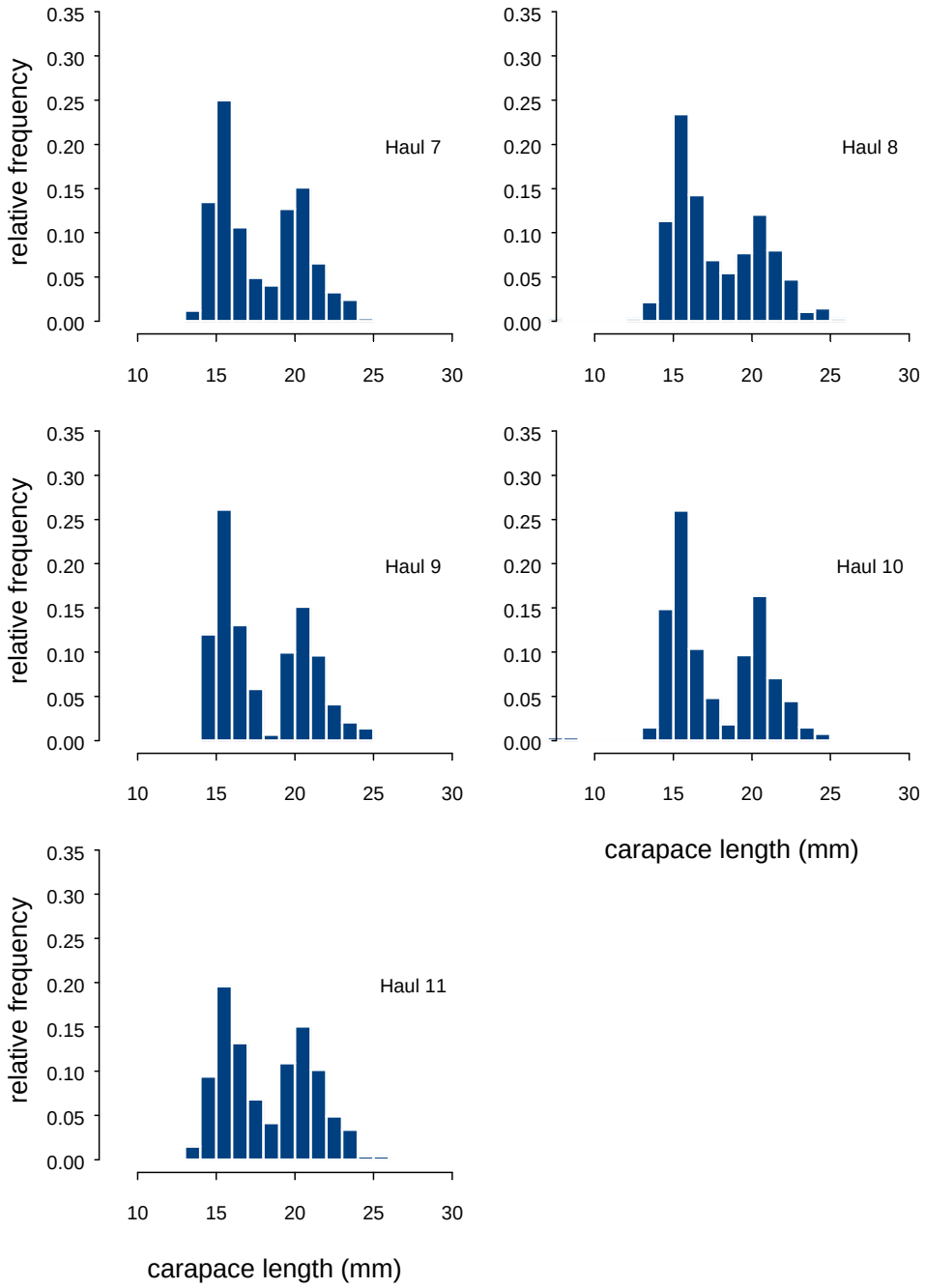

Figure 12.-Size distribution of northern pink shrimp caught from the hauls with 2.5 inch bar spacing in the excluder.

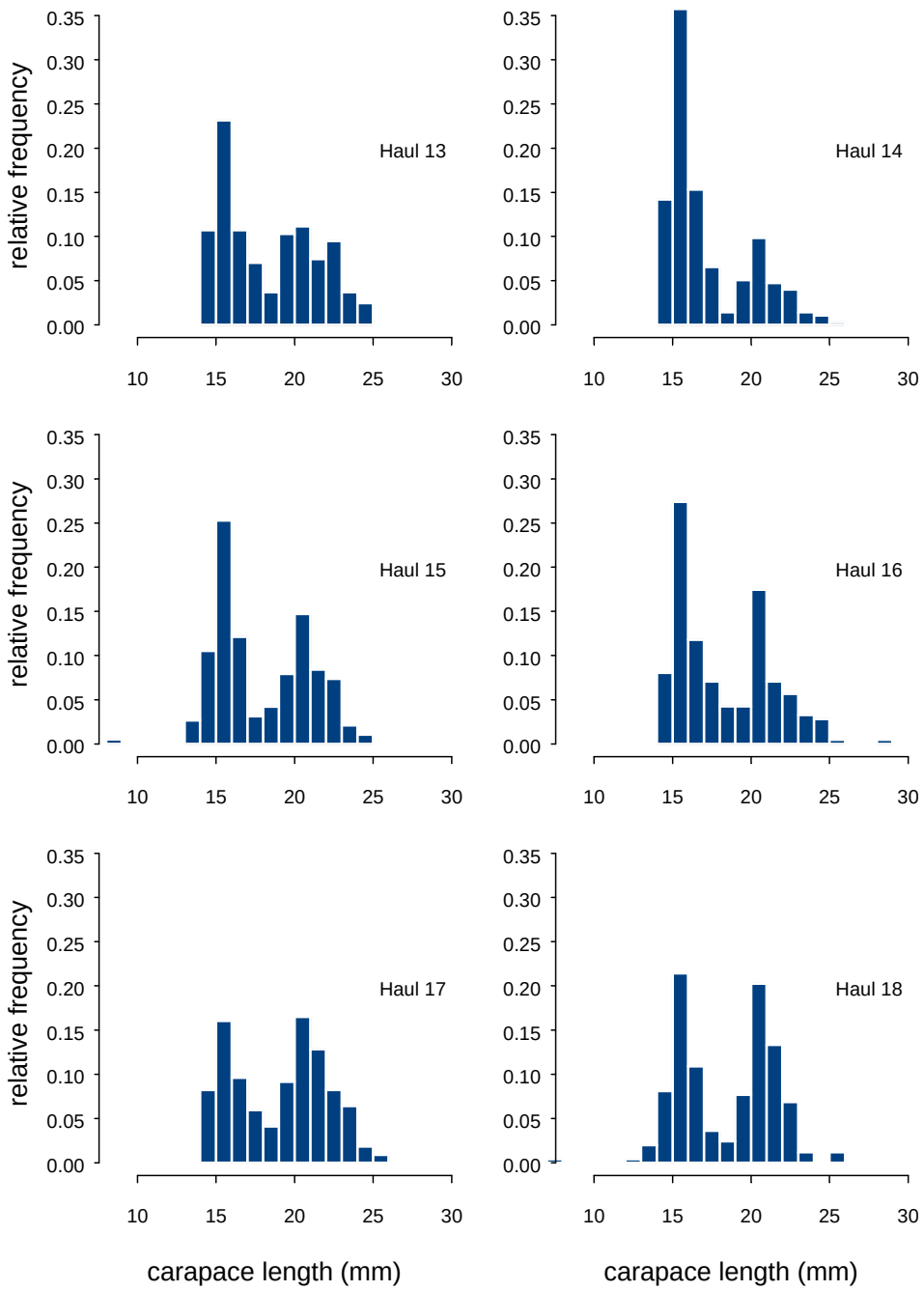

Figure 13.-Size distribution of northern pink shrimp caught from the hauls with 2.0 inch bar spacing in the excluder.

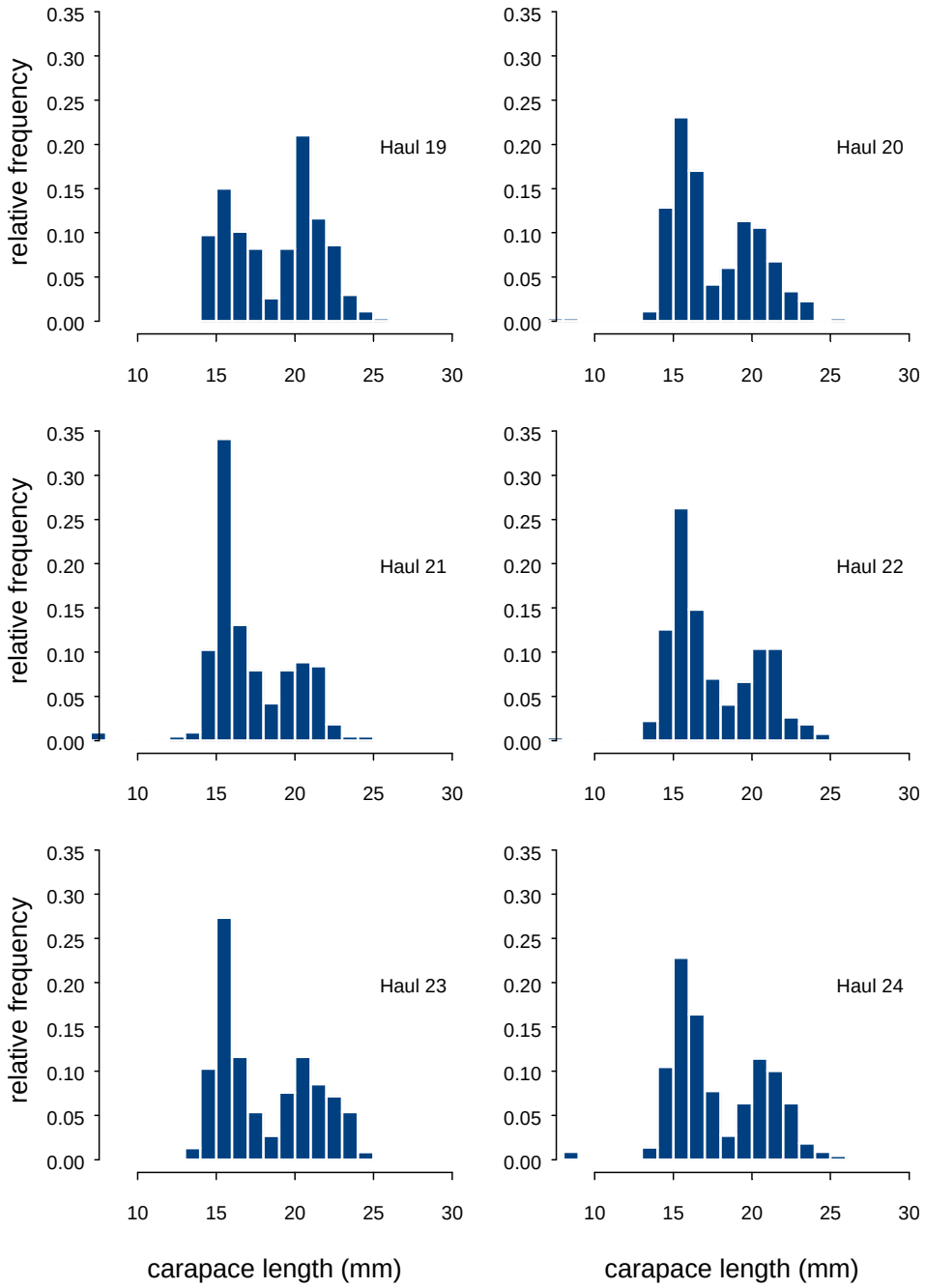

Figure 14.--Size distribution of northern pink shrimp caught from the hauls with 1.5 inch bar spacing in the excluder.

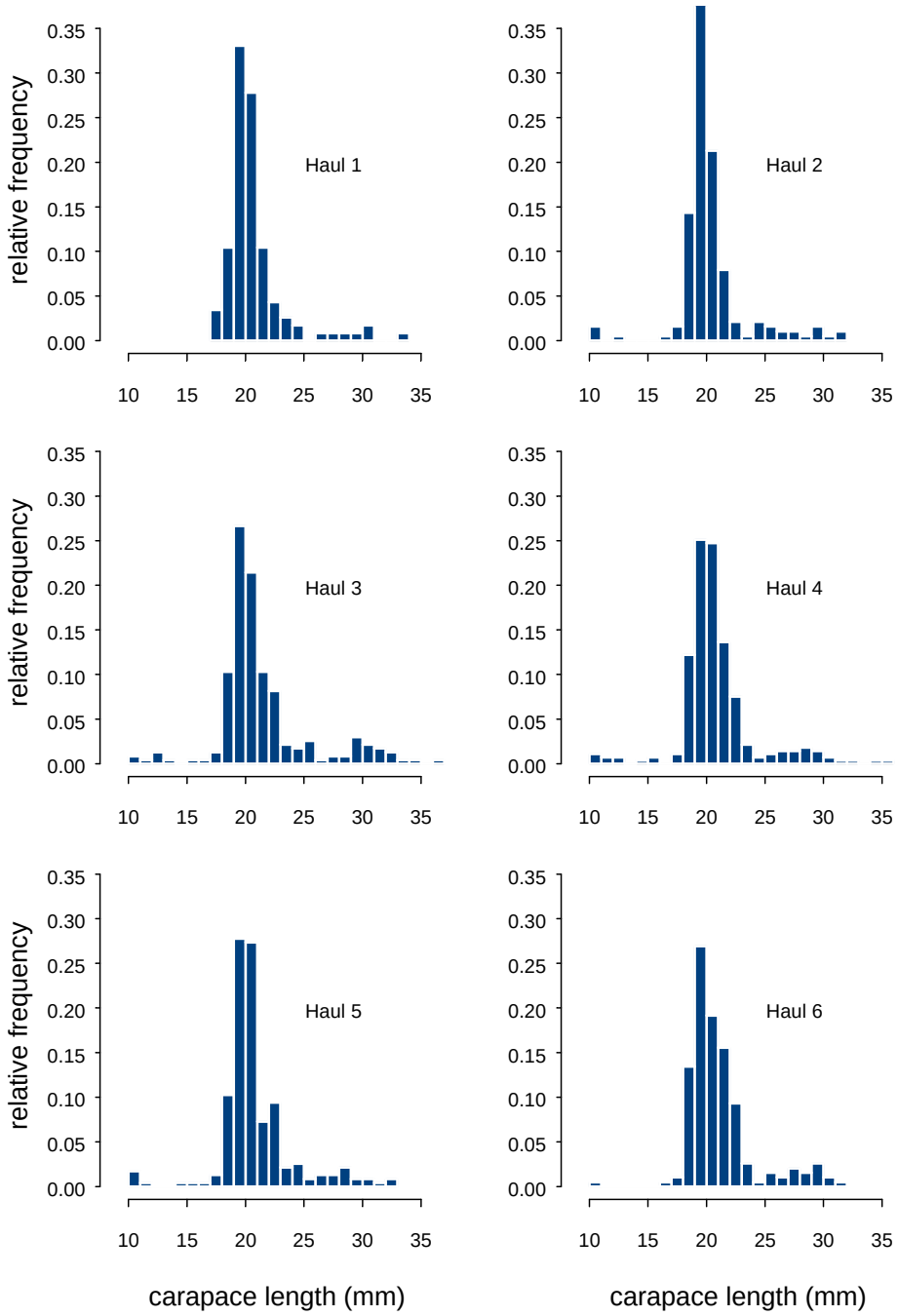

Figure 15.-Size distribution of sidestriped shrimp caught from the hauls with no excluder device.

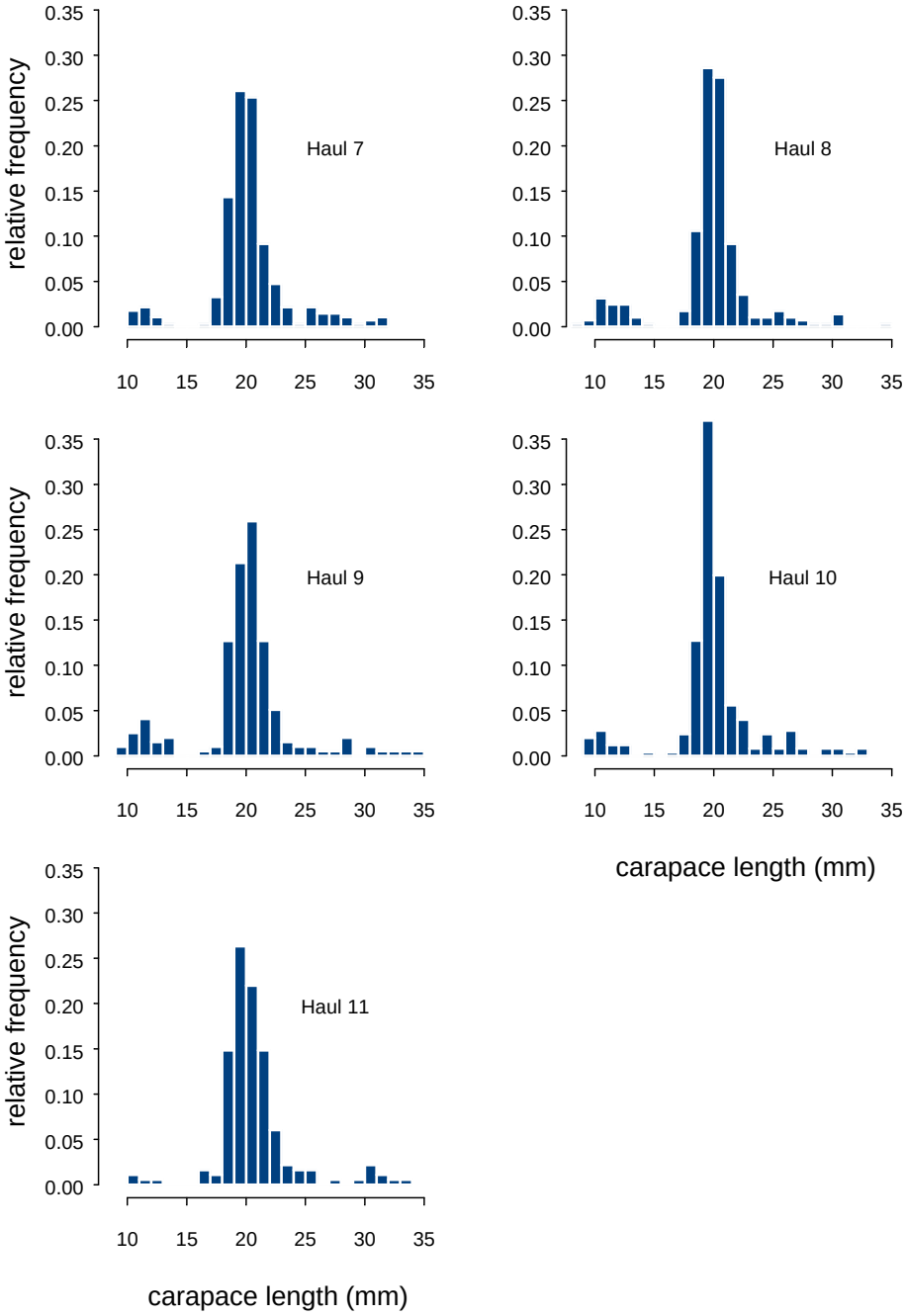

Figure 16.-Size distribution of sidestriped shrimp caught from the hauls with 2.5 inch bar spacing in the excluder.

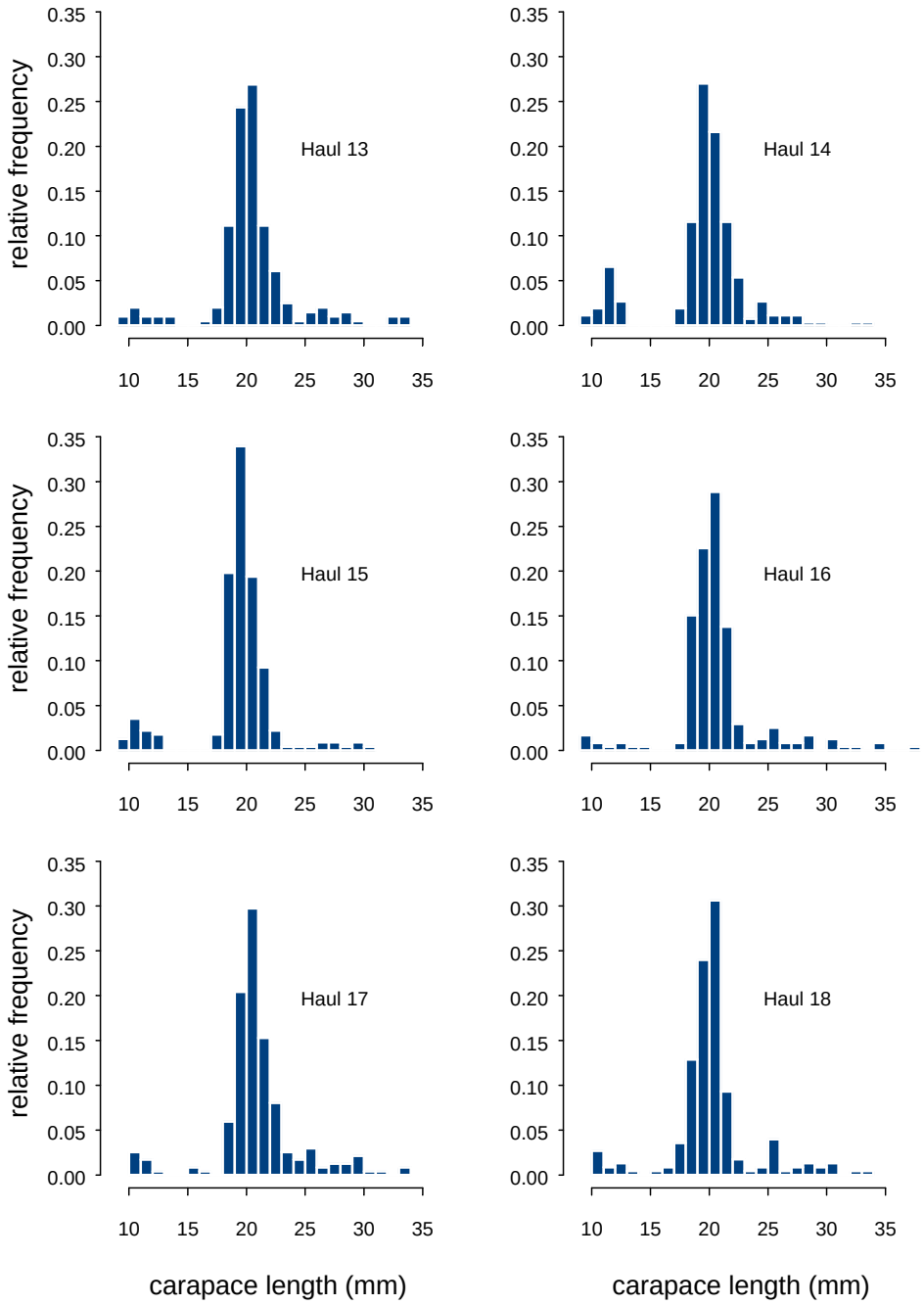

Figure 17.-Size distribution of sidestriped shrimp caught from the hauls with 2.0 inch bar spacing in the excluder.

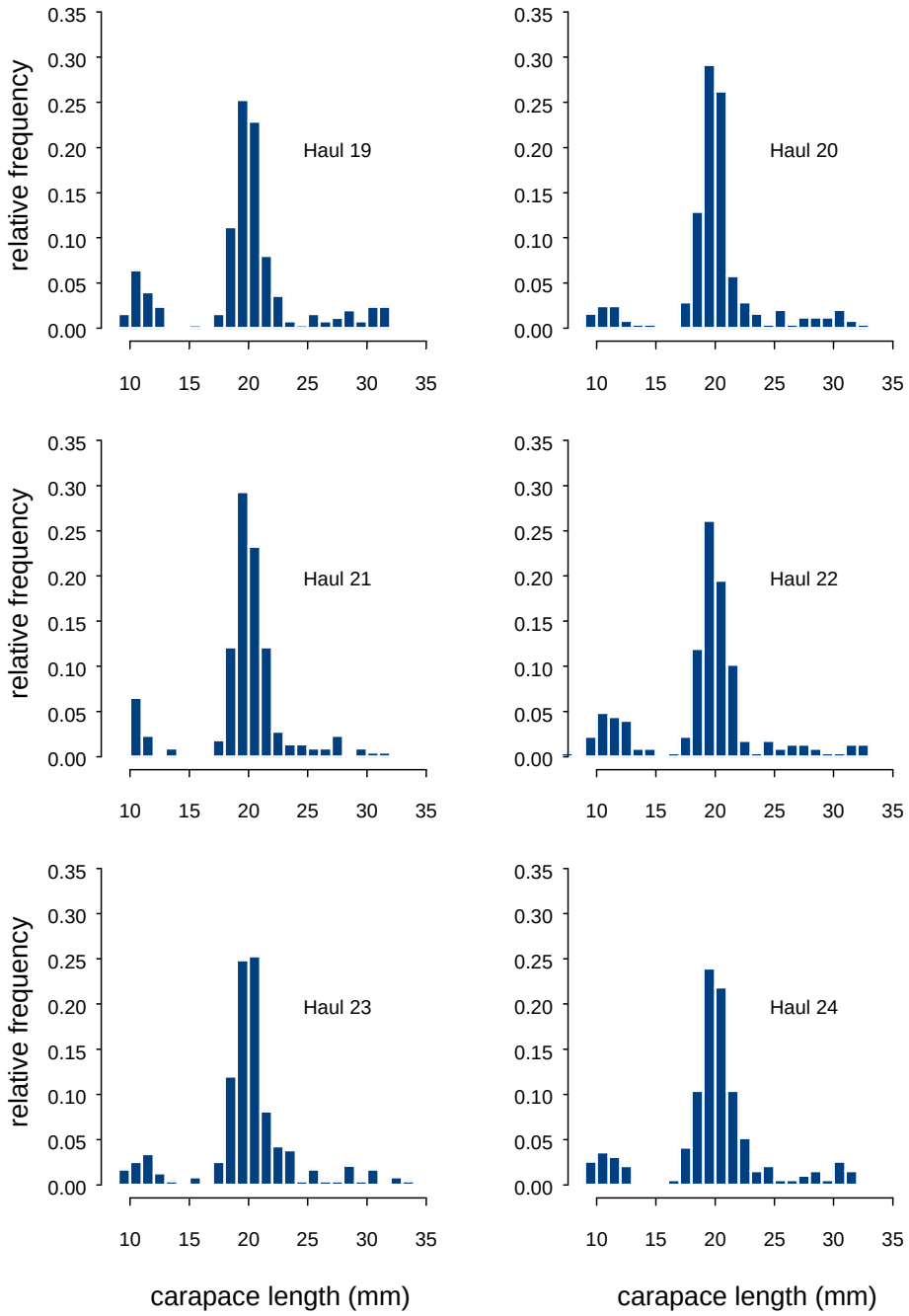

Figure 18.-Size distribution of sidestriped shrimp caught from the hauls with 1.5 inch bar spacing in the excluder.

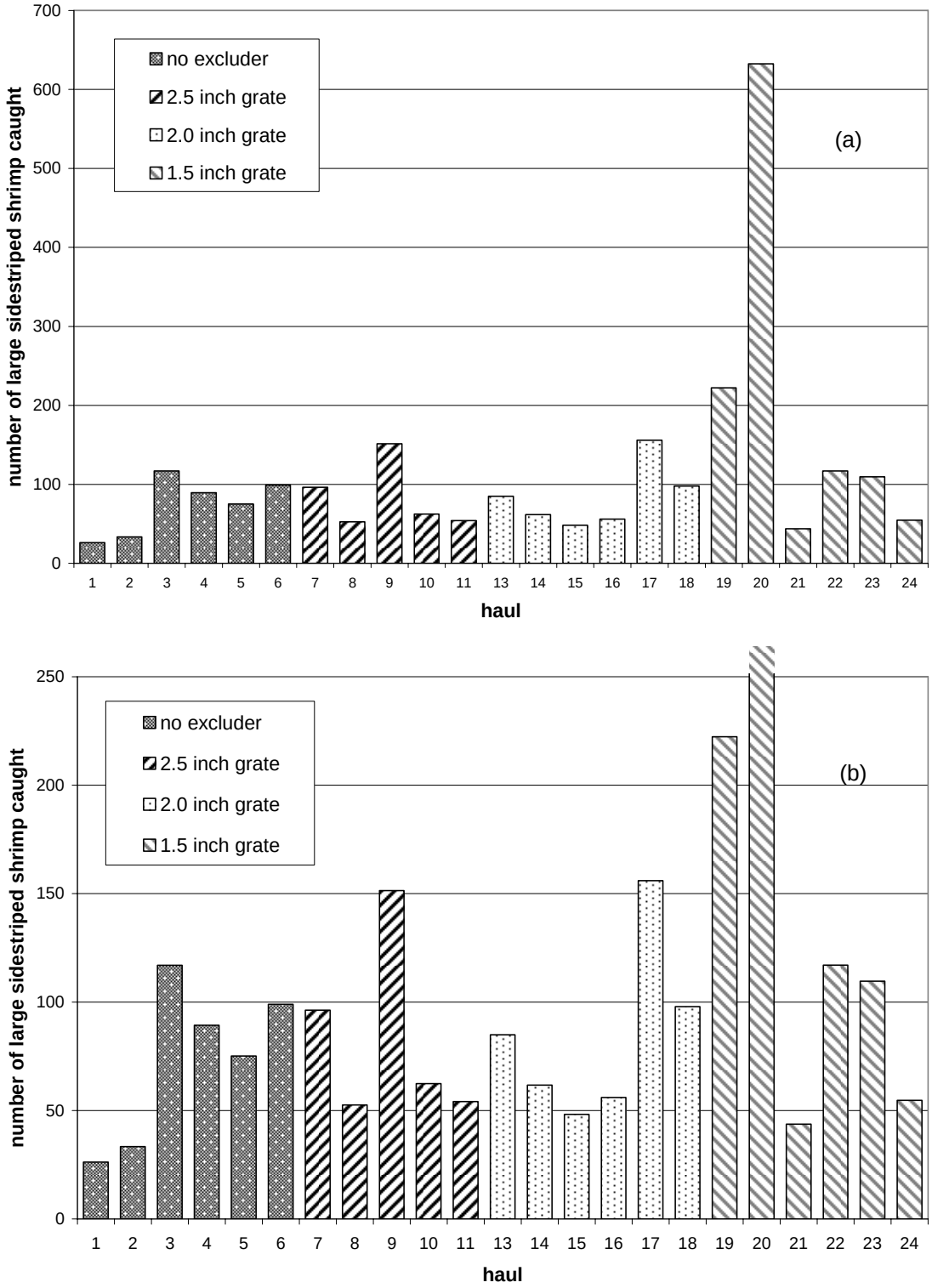

Figure 19.-Number of large (≥ 28 mm-CL) sidestriped shrimp caught by haul, with (a) showing all catches and (b) scaled down to better show smaller catches and exclude part of large catch at haul 20.

APPENDIX A. FISHING LOG AND CATCH DATA

Appendix A1.–Fishing log and catch data from the 2006 finfish-excluder device study.

Haul	1	2	3	4	5	6	7	8	9	10
Date	10/26/06	10/26/06	10/26/06	10/26/06	10/26/06	10/26/06	10/27/06	10/27/06	10/27/06	10/27/06
Longitude Start	152°33.4'	152°33.4'	152°33.4'	152°33.2'	152°33.3'	152°33.5'	152°33.5'	152°33.4'	152°33.4'	152°33.3'
Latitude Start	57°60.0'	57°59.9'	57°59.9'	57°59.9'	57°59.9'	58°0.1'	58°0.0'	57°60.0'	57°59.9'	57°59.8'
Heading, Degrees	48	48	45	52	49	53	51	39	42	35
Average Depth (m)	192	195	195	195	195	195	195	195	195	195
Distance Fished (km)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Bottom Temperature (°C)	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Treatment	no grate	no grate	no grate	no grate	no grate	no grate	2.5" grate	2.5" grate	2.5" grate	2.5" grate
					kg/km towed					
Pollock	256.06	230.84	136.8	144.04	90.44	68.06	9.61	16.37	20.1	14.44
Pacific Cod	47.24	25.96	10.37	21.81	39.69	0	0	0	0	0
Pacific Sandfish	0	0	0	0	0	0	0	0	0	0
Eulachon	3.78	5.01	4.41	3.44	4.27	0.25	1.06	3.45	3.2	3.05
Capelin	0	0	0	0	0	0	0	0	0	0
Rockfish	4.49	0.7	0	0	0	2.16	0	0.76	0	0
Herring	0	0	0	0	0	0	0	0	0	0
Sculpins	0	0	0.01	0.43	1.14	0.02	0.02	0.1	0.27	1.06
Other Forage Fish	0.94	1.67	0.85	3.63	2.79	5.98	2.85	1.48	2.26	1.76
Other Roundfish	0.05	0.31	0.85	0.61	0.19	2.27	0.76	0.74	1.51	0.36
TOTAL ROUNDFISH	312.57	264.49	153.29	173.96	138.51	78.73	14.29	22.89	27.34	20.67
Arrowtooth Flounder	46.06	20.03	26.14	32.86	22.84	58.78	20.69	25.6	20.9	27.59
Flathead Sole	26.93	45.31	50.58	38.21	51.07	56.3	24.49	25.72	18.51	29.94
Rock Sole	0	0	0	0	0	0	0	0	0	0
Rex Sole	0	2.86	2.55	3.06	1.86	0.21	2.64	0.06	0.53	1.29
Dover Sole	0	0	0	0	0	0	0	0	0	0
Pacific Halibut	8.24	9.21	0	0	24.28	18.01	0	0	0	0
Starry Flounder	0	0	0	0	0	0	0	0	0	0
Yellowfin Sole	0	0	0	0	0	0	0	0	0	0
Other Flatfish	0	0	0	0	0	0	0	0	0	0
TOTAL FLATFISH	81.23	77.41	79.26	74.12	100.05	133.29	47.82	51.38	39.94	58.82
Northern Pink Shrimp	30.38	49.78	72.39	57.11	54.55	84.22	97.03	111.05	97.34	122.63
Humpy Shrimp	0	0	0	0	0	0	0	0	0	0
Coonstripe Shrimp	0	0	0	0	0	0	0	0	0	0
Sidestriped Shrimp	4.09	5.8	8.83	10.59	8.81	9.83	12.83	11.24	16.98	13.28
Other Shrimp	0.48	0.7	1.27	0.69	0.52	1.22	2.36	1.52	1.37	1.46
TOTAL SHRIMP	34.96	56.28	82.49	68.39	63.88	95.28	112.22	123.81	115.69	137.37
Squid	0	1.91	0.85	0	8.73	0	0	0	0.22	0
Jellyfish	0	0.24	0.03	0.38	0.93	0.16	0	0	0	0
Other Inverts	0	0	0	0	26.08	0	0	0	0	0
TOTAL INVERTS	0	2.15	0.88	0.38	35.74	0.16	0	0	0.22	0
Skates	0	2.19	0	0	0	0	0	0	0	0
Spiny Dogfish	9.83	7.61	10.04	19.01	37.63	8.75	0	0	0	3.08
Other	0.94	0.24	0.17	0	0	0.21	1.69	0.62	0.4	0.35
TOTAL CATCH	439.52	410.37	326.13	335.85	375.81	316.41	176.03	198.7	183.59	220.3

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Haul	11	12	13	14	15	16	17	18	19	20
Date	10/27/06	10/27/06	10/27/06	10/27/06	10/27/06	10/27/06	10/27/06	10/28/06	10/28/06	10/28/06
Longitude Start	152°33.1'	152°33.3'	152°33.1'	152°33.5'	152°33.3'	152°33.3'	152°33.2'	152°33.4'	152°33.3'	152°33.2'
Latitude Start	57°59.9'	57°59.9'	57°59.9	58°0.0'	57°60.0'	57°60.0'	57°59.9'	58°0.1'	58°0.1'	58°0.1'
Heading, Degrees	49	53	54	55	54	36	55	54	50	61
Average Depth (m)	195	195	195	195	195	195	195	195	195	195
Distance Fished (km)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Bottom Temperature (°C)	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Treatment	2.5" grate	2.5 " grate	2" grate	2" grate	2" grate	2" grate	2" grate	2" grate	1.5" grate	1.5" grate
					kg/km towed					
Pollock	27.63		26.24	28.9	29.74	14.89	24.18	9.46	9.67	10.88
Pacific Cod	0		0.11	0	0	0	1.33	0	0	0
Pacific Sandfish	0		0	0	0	0	0	0	0	0
Eulachon	12.27		6.2	4.1	2.44	2.15	0.55	1.5	2.08	3.69
Capelin	0		0	0	0	0	0	0	0	0
Rockfish	0.05		0	0.32	0.22	0	0.55	0	0.19	0
Herring	0		0	0	0	0	0	0	0	0
Sculpins	0		0.6	0	0.13	0	0.99	0.12	0.19	0.19
Other Forage Fish	1.03		1.67	2.93	1.92	4.48	3.86	4.38	6.07	2.37
Other Roundfish	0.82		0.75	1.81	1.15	0.61	0.66	0.58	0.77	0.76
TOTAL ROUNDFISH	41.81		35.57	38.05	35.6	22.14	32.13	16.03	18.96	17.88
Arrowtooth Flounder	11.65		8.59	3.51	5.77	6.8	0.88	13.03	0.28	4.45
Flathead Sole	17.73		18.61	10.53	10.9	10.59	10.93	13.95	1.8	8.23
Rock Sole	0		0	0	0	0	0	0	0	0
Rex Sole	0.1		0.05	0	1.54	0.6	1.77	2.88	1.71	1.51
Dover Sole	0		0	0	0	0	0	0	0	0
Pacific Halibut	0		0	0	0	0	0	0	0	0
Starry Flounder	0		0	0	0	0	0	0	0	0
Yellowfin Sole	0		0	0	0	0	0	0	0	0
Other Flatfish	0		0	0	0	0	0	0	0	0
TOTAL FLATFISH	29.49		27.25	14.04	18.2	17.99	13.58	29.87	3.79	14.19
Northern Pink Shrimp	68.13		77.42	105.6	87.01	64.49	64.91	96.28	64.62	57.91
Humpy Shrimp	0		0	0	0	0	0	0	0	0
Coonstripe Shrimp	0		0	0	0	0	0	0	0	0
Sidestriped Shrimp	7.32		13.33	15.55	12.07	6.79	15.84	12.97	17.64	7.76
Other Shrimp	0.96		1.34	2.66	2.19	0.69	0.64	1.11	1.24	1.51
TOTAL SHRIMP	76.41		92.09	123.81	101.27	71.97	81.38	110.36	83.49	67.18
Squid	0		0	0	0	0	0	0	0	0
Jellyfish	0.03		0	0	0.13	0.03	0.11	0	0	0
Other Inverts	0		0	0	0.05	0	0	0.21	0	0.1
TOTAL INVERTS	0.03		0	0	0.18	0.03	0.11	0.21	0	0.1
Skates	0		0	0	0	0	0	0	0	0
Spiny Dogfish	0		0	0	0	0	0	0	0	0
Other	0.21		0.6	0.12	0.26	0.17	0.22	0.12	0.66	0
TOTAL CATCH	147.95		155.51	176.03	155.51	112.31	127.43	156.59	106.91	99.35

unacceptable gear performance

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	kg/km towed			
Haul	21	22	23	24
Date	10/27/06	10/28/06	10/28/06	10/28/06
Longitude Start	152°33.4'	152°33.3'	152°33.3'	152°33.3'
Latitude Start	57°60.0'	58°0.0'	58°0.1'	58°0.0'
Heading, Degrees	57	56	51	54
Average Depth (m)	195	195	195	195
Distance Fished (km)	0.9	0.9	0.9	0.9
Bottom Temperature (°C)	7.2	7.2	7.2	7.2
Treatment	1.5" grate	1.5" grate	1.5" grate	1.5" grate
Pollock	5.44	5.97	15.75	16.75
Pacific Cod	0	0.09	0.02	0.05
Pacific Sandfish	0	0	0	0
Eulachon	3.11	1.96	3.17	4
Capelin	0	0	0	0
Rockfish	0	0	0	0
Herring	0	0	0	0
Sculpins	0.11	0.09	0.43	0.61
Other Forage Fish	2.89	0.89	4.36	2.23
Other Roundfish	0.48	0.45	0.44	0.38
TOTAL ROUNDFISH	12.02	9.45	24.17	24.03
Arrowtooth Flounder	6.55	10.68	2.65	2
Flathead Sole	3.33	7.21	2.82	2.38
Rock Sole	0	0	0	0
Rex Sole	0.04	0.98	0.17	0
Dover Sole	0	0	1.97	0
Pacific Halibut	0	0	0	0
Starry Flounder	0	0	0	0
Yellowfin Sole	0	0	0	0
Other Flatfish	0	0	0	0
TOTAL FLATFISH	9.93	18.88	7.62	4.38
Northern Pink Shrimp	95.69	67.74	67.19	38.95
Humpy Shrimp	0	0	0	0
Coonstripe Shrimp	0	0	0	0
Sidestriped Shrimp	11.39	14.54	12.31	5.38
Other Shrimp	2.28	1.24	1.8	1.69
TOTAL SHRIMP	109.36	83.52	81.3	46.02
Squid	0	0	0	0
Jellyfish	0.22	0.11	0	0
Other Inverts	0.11	0	0.06	0.01
TOTAL INVERTS	0.33	0.12	0.06	0.01
Skates	0	0	0	0
Spiny Dogfish	0	0	0	0
Other	0.11	0.36	0.26	0.08
TOTAL CATCH	131.75	112.31	113.39	74.51