Fishery Management Report No. 08-17

Effectiveness of a Finfish-Excluder Device in a Shrimp Fishing Trawl in Shelikof Strait, 2007

by
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and

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April 2008

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) tested the effectiveness of a several finfish-excluder devices at reducing fish catch in a shrimp trawl net. The 27.4 m ADF&G research vessel *Resolution* fished 24 trawl hauls in Shelikof Strait near Kodiak Island October 8-11, 2007. One control and three finfish-excluder devices were placed into a standard three-bridle shrimp trawl net. Testing 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 averaged less fish catch than the next larger configuration. The average catch of northern pink shrimp *Pandalus borealis* from the three net configurations with an excluder device was higher than the average catch from hauls without a finfish-excluder device. The average catch of sidestriped shrimp *Pandalopsis dispar* was lowest in the two most restrictive excluder configurations. Hauls with the 2.5 inch grate averaged the greatest number of large (≥ 28 mm CL) sidestriped shrimp followed by hauls without an excluder device.

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

INTRODUCTION

Beginning in 2006, a finfish-excluder device (FED) consisting of a rigid grate with maximum 2.0 inch bar spacing was required by regulation in Westward Region (shrimp Registration Area J) commercial shrimp trawls. Commonly known as a "Nordmore grate", a rigid grid flushes larger fish out of an opening in the top of the net, while shrimp and smaller fish pass through to the cod end (Figure 1). 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). 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, however recent interest has been expressed in shrimp trawling for sidestriped shrimp *Pandalopsis dispar*.

In 2006, the Alaska Department of Fish and Game (ADF&G) tested the effectiveness of finfish-excluder devices in a shrimp trawl net (Jackson and Vining 2007). Of particular interest was the effect of the FED on the catch of large sidestriped shrimp greater than 28 mm in carapace length (CL). The 27.4 m ADF&G research vessel *Resolution* fished 24 hauls in Marmot Bay near Kodiak Island. Four configurations of a standard three-bridle shrimp trawl net were tested with 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 reduced the bycatch of fish, with each size reduction in bar spacing significantly reducing fish bycatch. Catch in kg of northern pink shrimp *Pandalus borealis* from the four net configurations were significantly different from one another. 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 difference between the number of large (≥ 28 mm CL) sidestriped shrimp caught without an excluder and three different sized finfish excluders.

The 2006 ADF&G study confirmed the fish reduction capabilities of the FED while demonstrating the retention of large (≥ 28 mm CL) sidestriped shrimp. One surprising result of the study was the significant increase in overall shrimp catch for trawl hauls with a FED

deployed. The experiment was repeated in 2007 in a different location. Reasons for repeating the study were to see if the results were repeatable, and to eliminate possible confounding results from the sequential order of experimental tows conducted in 2006. The 2007 study compares the effects of various bar spacing in the FED on catch proportions of fish and shrimp in Shelikof Strait.

OBJECTIVES

The primary objective of the study is to quantify the retention of fish, 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 how the catch of large ($\geq$ 28 mm CL) shrimp was impacted by the recently enacted FED requirement.

A secondary objective was to compare the 2007 result with the 2006 results.

METHODS

TRAWL DESCRIPTION

Two shrimp research trawls identically built by a single manufacturer for (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 *unpublished* 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 dandy lines (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. 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, an aluminum grate was attached with cable ties. Grates with 2.5 inch, 2.0 inch, and 1.5 inch bar spacing were used. 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. There were two floats installed on the top of the grate to neutralize the weight of the grate.

SAMPLING PROCEDURES

The research vessel *Resolution* was used October 8-11, 2007 to trawl 24 hauls in Shelikof Strait near Kodiak Island (Figure 3). Net treatment type for each haul was randomly selected. Sample hauls 1, 4, 7, 10, 15 and 20 were control hauls that used a standard shrimp survey net without a FED installed. Hauls 6, 12, 16, 18, 23 and 24 were conducted utilizing a 2.5 inch grate in a FED. Hauls 2, 3, 5, 11, 13 and 19 had the 2.0 inch grate, while hauls 8, 9, 14, 17 and 21 had a 1.5 inch grate installed in the net. One haul (number 22) had a large mud clump stop passage through the FED and was not utilized in the analysis.

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. Average depth fished ranged from 195 to 201 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.

RESULTS

The catch of fish, shrimp, and other invertebrates from each haul was determined and standardized to kg/km towed(Appendix A).

The total catch weight from all hauls was 1,390 kg and was composed of 56 species of fish, shrimp, and other invertebrates (Table 1). The largest specie catch by weight was northern pink shrimp, followed by flathead sole, arrowtooth flounder and walleye pollock. Total catch per haul ranged from 22 kg/km towed to 259 kg/km towed with the shrimp catch ranging from 7 to 38 kg/km towed. Fish and invertebrates other than shrimp totaled 11 to 253 kg/km towed for each haul (Figure 4). Invertebrates other than shrimp were largely squid *Berryteuthis magister* and jellyfish (Class Scyphozoa). Overall, the invertebrates other than shrimp comprised 11% of the total catch from all hauls.

The largest catch of fish occurred in haul 10 which did not have a finfish-excluder device in the net (Figure 5). This haul also had the smallest catch of shrimp. The largest catch of shrimp occurred in haul 20, which also did not have a FED installed in the net.

The average catch of shrimp from each treatment type ranged from 14.2 kg/km towed to 19.2 kg/km towed, while the average catch per treatment type of fish and invertebrates other than shrimp ranged from 17 to 104 kg/km towed (Figure 6). Hauls with the untreated control survey gear (no excluder) had the largest average catch of fish and other invertebrates, while hauls with a FED and 1.5 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 2.7 kg/km towed to 33.3 kg/km towed (Figure 7). The largest catch of northern pink shrimp appeared in haul 17 with a 1.5 inch grate and the smallest catch of northern pink shrimp was in haul 10, a control haul. The largest average northern pink shrimp catch came from hauls with a 1.5 inch grate, while the smallest average catch came from hauls without a FED in the net. The catch of sidestriped shrimp ranged from 1.5 to 14.7 kg/km towed (Figure 8). Both the smallest and largest catch of sidestriped shrimp came from hauls configured without a finfish excluder device. Haul 4 had the smallest catch and haul 20 had the largest. Unlike northern pink shrimp, hauls with a 1.5 inch grate in the net averaged less sidestriped shrimp catch than any other gear configuration. Hauls with a 2.5 inch grate had the largest sidestriped shrimp average catch.

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 9). Walleye pollock *Theregra chalcogramma* were most prevalent in the hauls without the excluder installed. Less

pollock were caught in hauls with a 2.5 inch grate in the FED and fewer still with more restrictive grates. 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 smaller-sized grates. Flathead sole *Hippoglossoides elassodon* also were caught in similar amounts between the control hauls and the hauls with a 2.5 inch grate. Less flathead sole were caught with each reduction in bar spacing. The longsnout prickleback *Lumpenella longirostris* catch seemed to increase in the hauls with a finfish-excluder device installed, while eulachon *Thaleichthys pacificus* appeared unaffected.

Northern pink shrimp size distribution showed some similarity between hauls, having a bi-modal distribution with modes at about 13.0 to 15.0 mm-CL and 17.0 to 19.0 mm-CL (Figures 10-13). Signs of older age classes of shrimp were occasionally present. Relative frequency of smaller (< 16.0 mm-CL) northern pink shrimp was greater in hauls with the two most restrictive grates in the FED (Figure 14).

The sidestriped shrimp size distribution tended to have three prominent modes at about 18.0 to 20.0 mm-CL, 24.0 to 26.0 mm-CL and 29.0 to 31.0 mm-CL (Figures 15-18). As with the northern pink shrimp, signs of older age classes were occasionally present. The relative frequency of sidestriped shrimp appeared greater for small shrimp less than 20 mm-CL in hauls with a FED, but a trend was not discernable at the larger sizes (Figure 19).

The number of large (≥ 28 mm-CL) sidestriped shrimp caught in each haul ranged from 45 per km towed to 215 per km towed (Figure 20). The largest average catch came from hauls with a 2.5 inch grate in the FED. Catch from hauls with a 1.5 inch grate had the lowest number of large sidestriped shrimp on average.

DISCUSSION

Results from the 2007 FED trials were similar to those obtained in 2006 (Jackson and Vining 2007) with one notable exception. As in 2006, this study 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. In both years there appeared to be an overall increase in shrimp catch when utilizing the FED.

The major contrast between 2006 and 2007 results was the retention of large sidestriped shrimp in 2006. Analysis of 2006 data indicated there was no significant difference between the numbers of large sidestriped shrimp caught by the four different net configurations. Catches from 2007 had considerably fewer large sidestriped shrimp in the most restrictive gear. The average number of large sidestriped shrimp was highest in hauls with a 2.5 inch grate installed in the FED. This observation may have been influenced by apparently better fishing toward the end of the experiment when, due to the random numbers drawn for each treatment, more hauls were conducted with a 2.5 inch grate.

A surprising result of the 2006 and 2007 FED trials was the increased shrimp catch when utilizing the excluder. The analyses of total shrimp catch indicated that overall more shrimp were caught when there was an excluder than when there wasn't. 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. It appears the increased catch is mostly smaller shrimp. 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. Although hauls with

a 2.5 inch grate did catch on average a greater number of large sidestriped shrimp, they also caught a large proportion of small shrimp. These shrimp might need to be filtered out of the catch if the target is large sidestriped shrimp during a commercial fishery. Both of these results contrast to previous studies done by Canadian researchers (Hickey et al. 1993). They did not see a significant reduction in mean shrimp size, but did find decreased shrimp catch in hauls with an excluder.

One factor that needs to be considered when interpreting this data is the use of different net configurations between the control net and the net installed with the FED. All three grate sizes were installed on the same net, modified for use with an excluder. The control net was not modified in any way. To eliminate any differences due to net configuration a treatment net should be fished that is configured as the current treatment net, but not installed with a grate. This could help to show if there are any differences in fishing capability between the two net configurations, and possibly explain the increased shrimp catch in hauls with an excluder.

A rigorous statistical analysis of the data collected in 2007 has been delayed because staff was unavailable. Future plans include a formal review with a comparison to 2006 results.

ACKNOWLEDGEMENTS

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Watson, L. *Unpublished*. ADF&G shrimp research shrimp trawl survey manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Research Operational Plan, Revised January 1987.

TABLE AND FIGURES

Table 1.–Catch of fish, shrimp and other invertebrates from the 2007 finfish-excluder device study.

Common name	Scientific name	Catch (kg)
northern pink shrimp	*Pandalus borealis*	239.1
flathead sole	*Hippoglossoides elassodon*	181.9
arrowtooth flounder	*Atheresthes stomias*	175.4
walleye pollock (age 1+ and up)	*Theragra chalcogramma*	135.2
light dusky rockfish	*Sebastes variabilis*	102.1
eulachon	*Thaleichthys pacificus*	95.6
sidestriped shrimp	*Pandalopsis dispar*	94.1
magistrate armhook squid	*Berryteuthis magister*	80.6
spiny dogfish	*Squalus acanthias*	64.9
Pacific halibut	*Hippoglossus stenolepis*	52.3
Cyanea sp.	*Cyanea* sp.	43.8
rex sole	*Glyptocephalus zachirus*	17.7
walleye pollock (age 0+)	*Theragra chalcogramma*	16.7
Aleutian skate	*Bathyraja aleutica*	14.9
jellyfish unident.	Class: Scyphozoa	11.7
twospine crangon	*Crangon communis*	9.9
Pacific cod	*Gadus macrocephalus*	8.2
rougheye rockfish	*Sebastes aleutianus*	7.2
Pacific glass shrimp	*Pasiphaea pacifica*	6.1
longsnout prickleback	*Lumpenella longirostris*	5.1
common mud star	*Ctenodiscus crispatus*	5.0
Bering skate	*Bathyraja interrupta*	3.2
Aequorea sp.	*Aequorea* sp.	3.0
ocean pink shrimp	*Pandalus jordani*	2.4
Pacific ocean perch	*Sebastes alutus*	1.9
smooth lumpsucker	*Aptocyclus ventricosus*	1.7
spinyhead sculpin	*Dasycottus setiger*	1.4
Dover sole	*Microstomus pacificus*	1.2
sablefish	*Anoplopoma fimbria*	0.9
northern rockfish	*Sebastes polyspinis*	0.9
yellow Irish lord	*Hemilepidotus jordani*	0.7
worm unident.	Phylum: Annelida	0.6
Oregon triton	*Fusitriton oregonensis*	0.6
snail unident.	Class: Gastropoda	0.5
Molpadia sp.	*Molpadia* sp.	0.4
sea anemone unident.	Order: Actiniaria	0.3
Beroe sp.	*Beroe* sp.	0.3
snailfish unident.	Family: Liparidinae	0.3
bigmouth sculpin	*Hemitripterus bolini*	0.3
Tanner crab	*Chionoecetes bairdi*	0.2
hermit crab unident.	Family: Paguridae	0.2
snail eggs	gastropod eggs	0.2
Eualus sp.	*Eualus* sp.	0.1
bivalve unident.	Class: Bivalvia	0.1
deepsea smelt unident.	Family: Bathylagidae	0.1
roughspine sculpin	*Triglops macellus*	0.1
shortscale eualid	*Eualus suckleyi*	0.1
juvenile Pacific cod	*Gadus macrocephalus*	0.1
isopod unident.	Order: Isopoda	0.1
gray starsnout	*Bathyagonus alascanus*	0.1
Solaster sp.	*Solaster* sp.	0.1
Aurelia sp.	*Aurelia* sp.	0.1
great sculpin	*Myoxocephalus polyacanthocep*	<0.1
comb jelly unident.	Phylum: Ctenophora	<0.1
cockle unident.	Family: Cardiidae	<0.1
spinycheek starsnout	*Bathyagonus infraspinatus*	<0.1
Hyas sp.	*Hyas* sp.	<0.1
capelin	*Mallotus villosus*	<0.1
grenadier unident.	Family: Macrouridae	<0.1

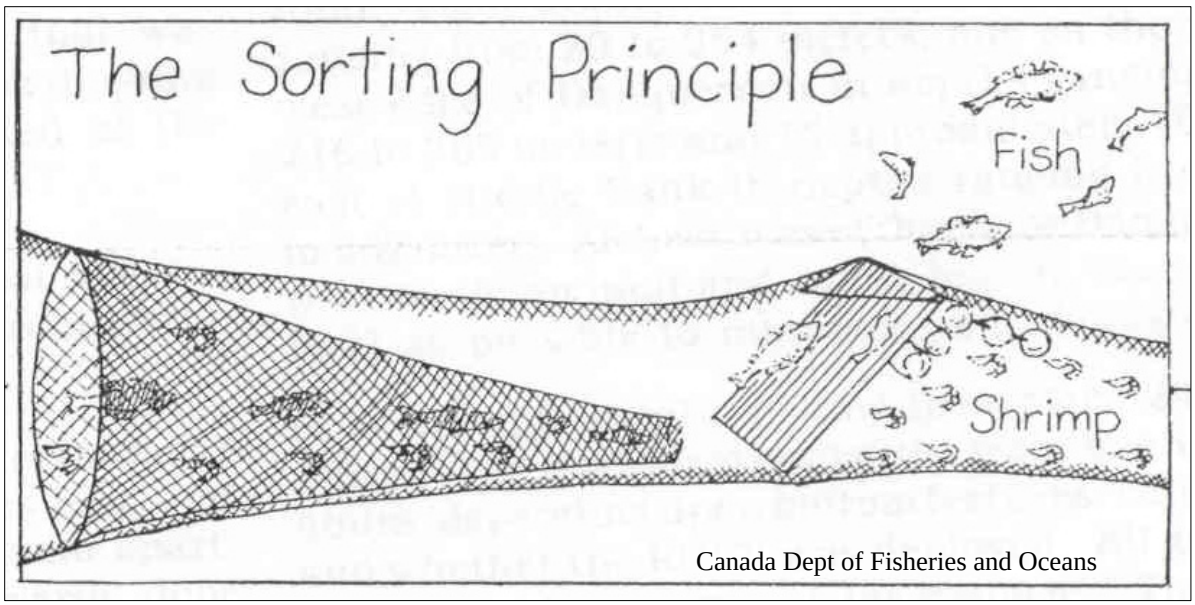

Figure 1.–Shrimp fishing bycatch reduction method known as a “Nordmore grate”.

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

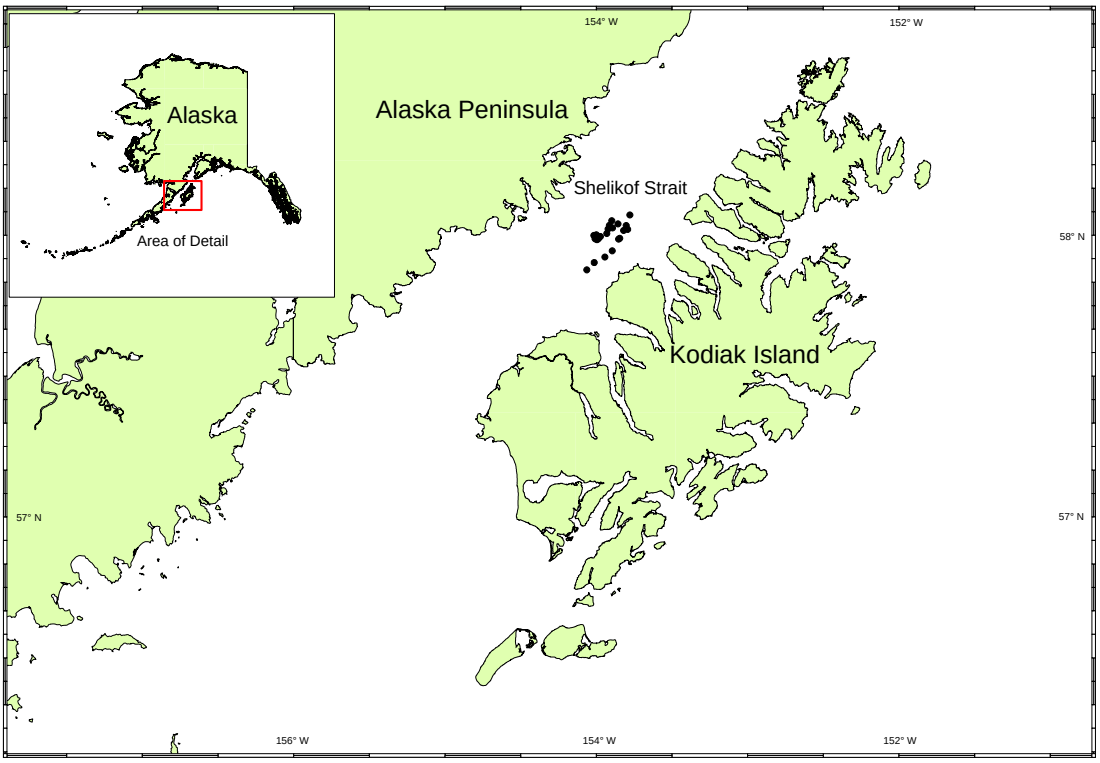

Figure 3.–Fishing sites for the 2007 ADF&G finfish-excluder device study.

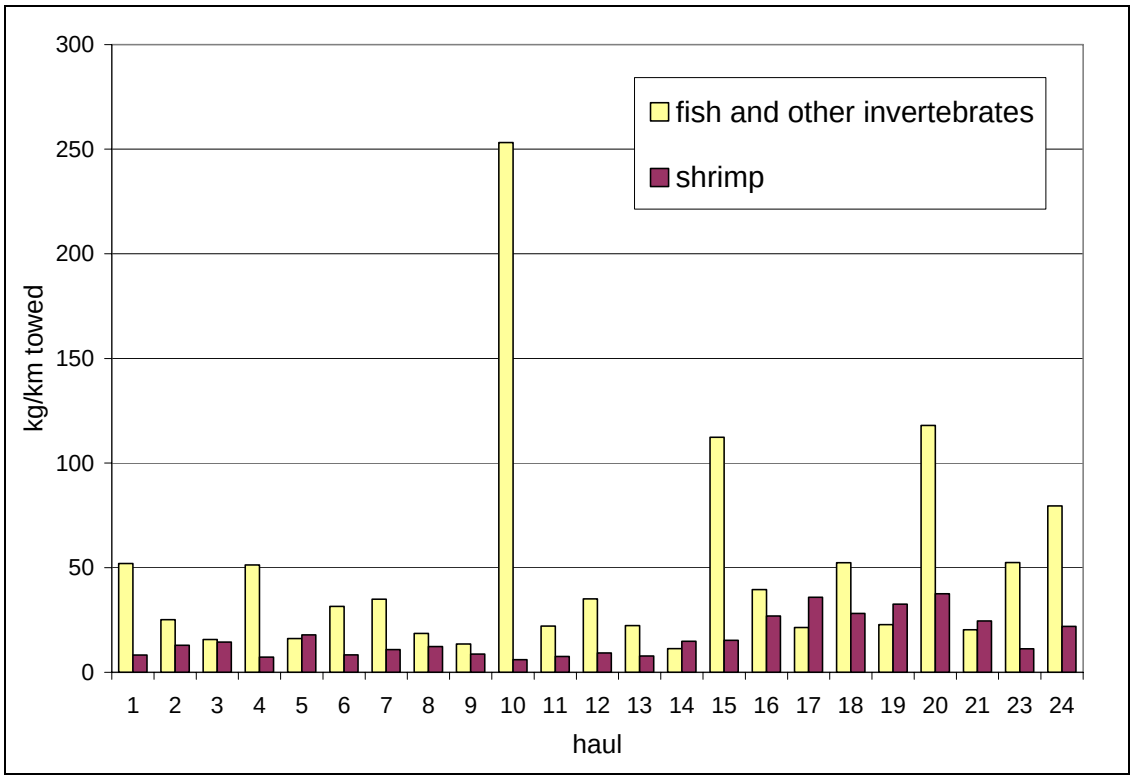

Figure 4.–Catch per haul in kg/km towed from the 2007 finfish-excluder device study.

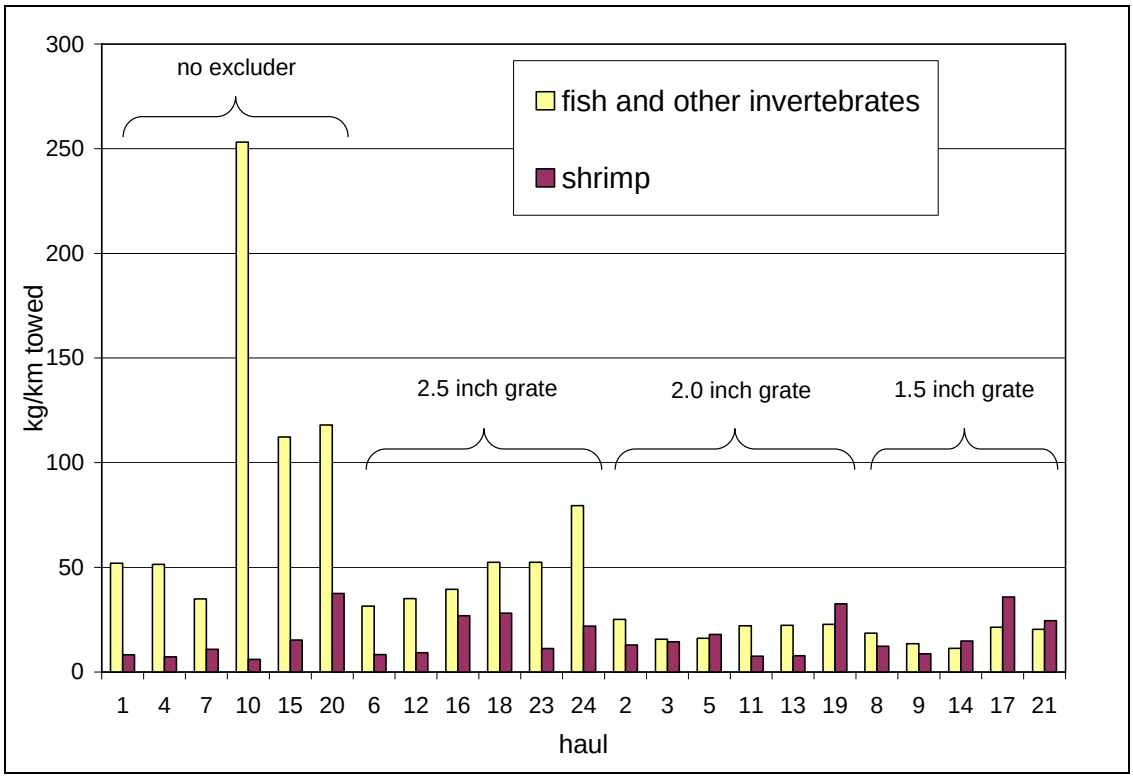

Figure 5.–Catch per haul in kg/km towed by treatment type from the 2007 finfish-excluder device study.

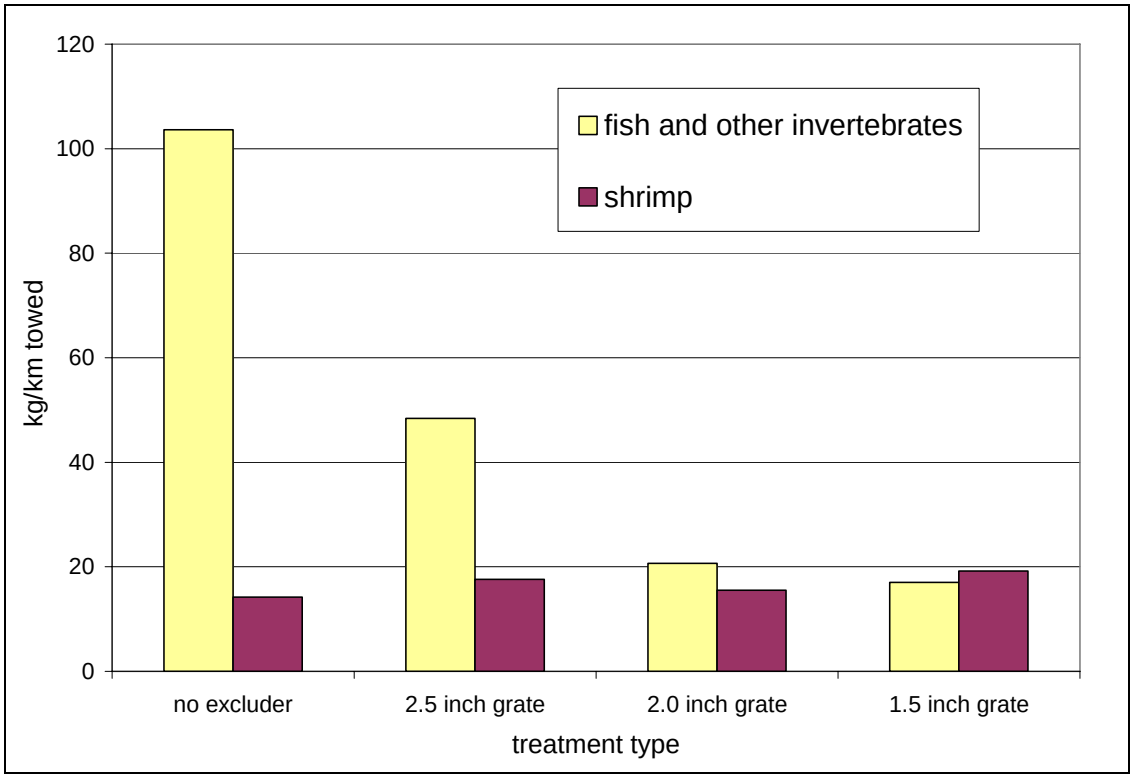

Figure 6.–Average catch per treatment type in kg/km towed from the 2007 finfish-excluder device study.

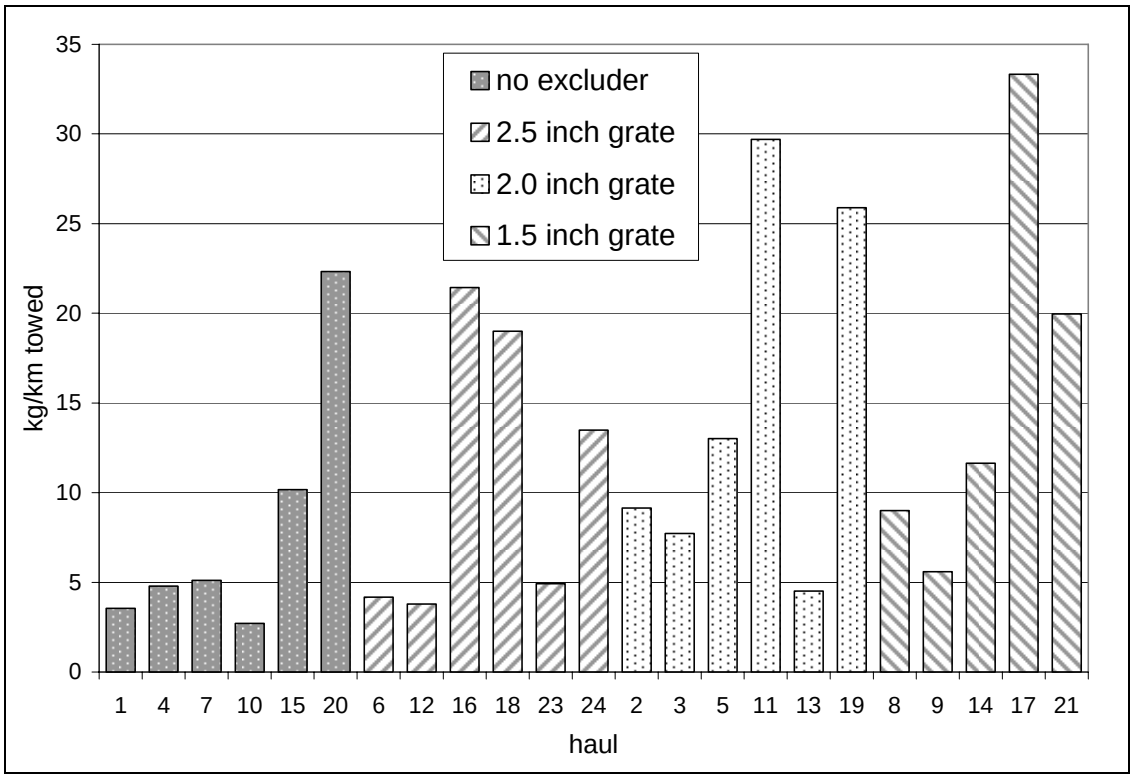

Figure 7.–Catch per haul in kg/km towed of northern pink shrimp from the 2007 finfish-excluder device study.

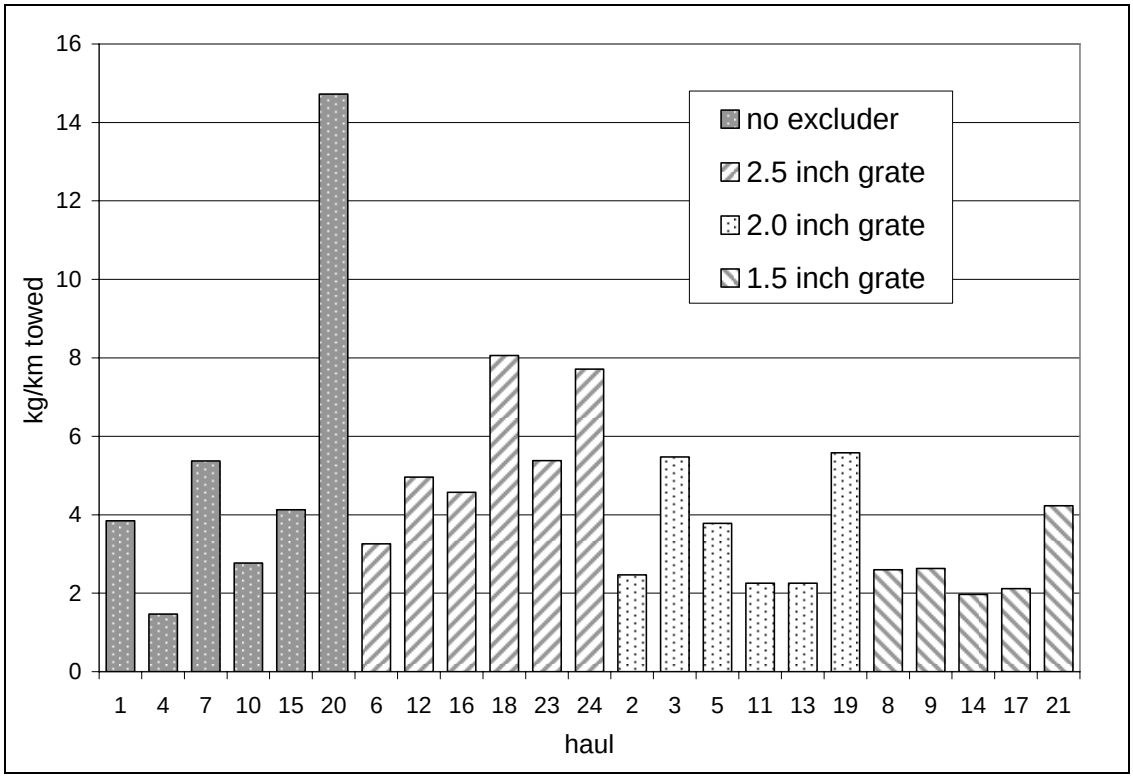

Figure 8.–Catch per haul in kg/km towed of sidestriped shrimp from the 2007 finfish-excluder device study.

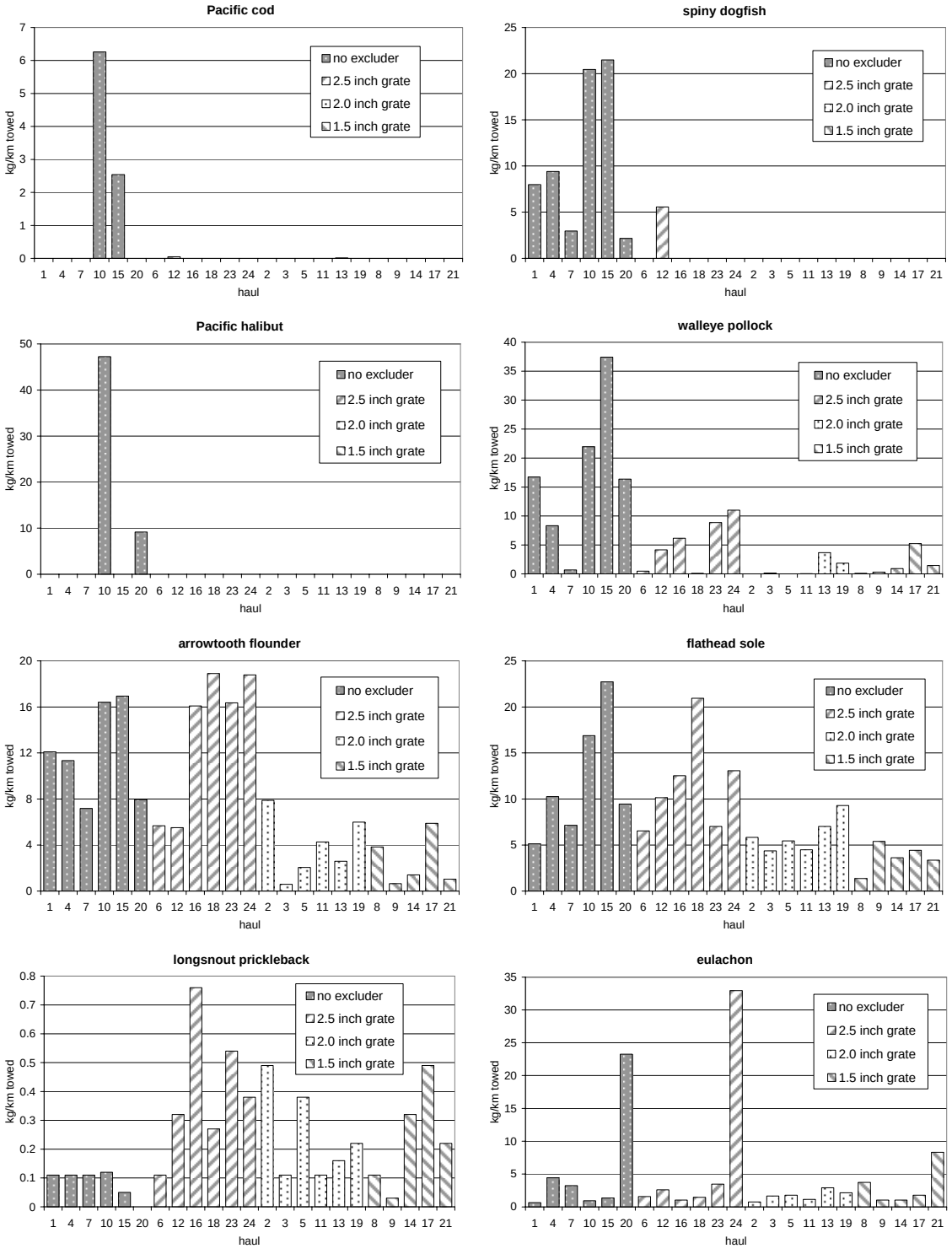

Figure 9.–Catch per haul in kg/km towed of 8 fish species from the 2007 finfish-excluder device study.

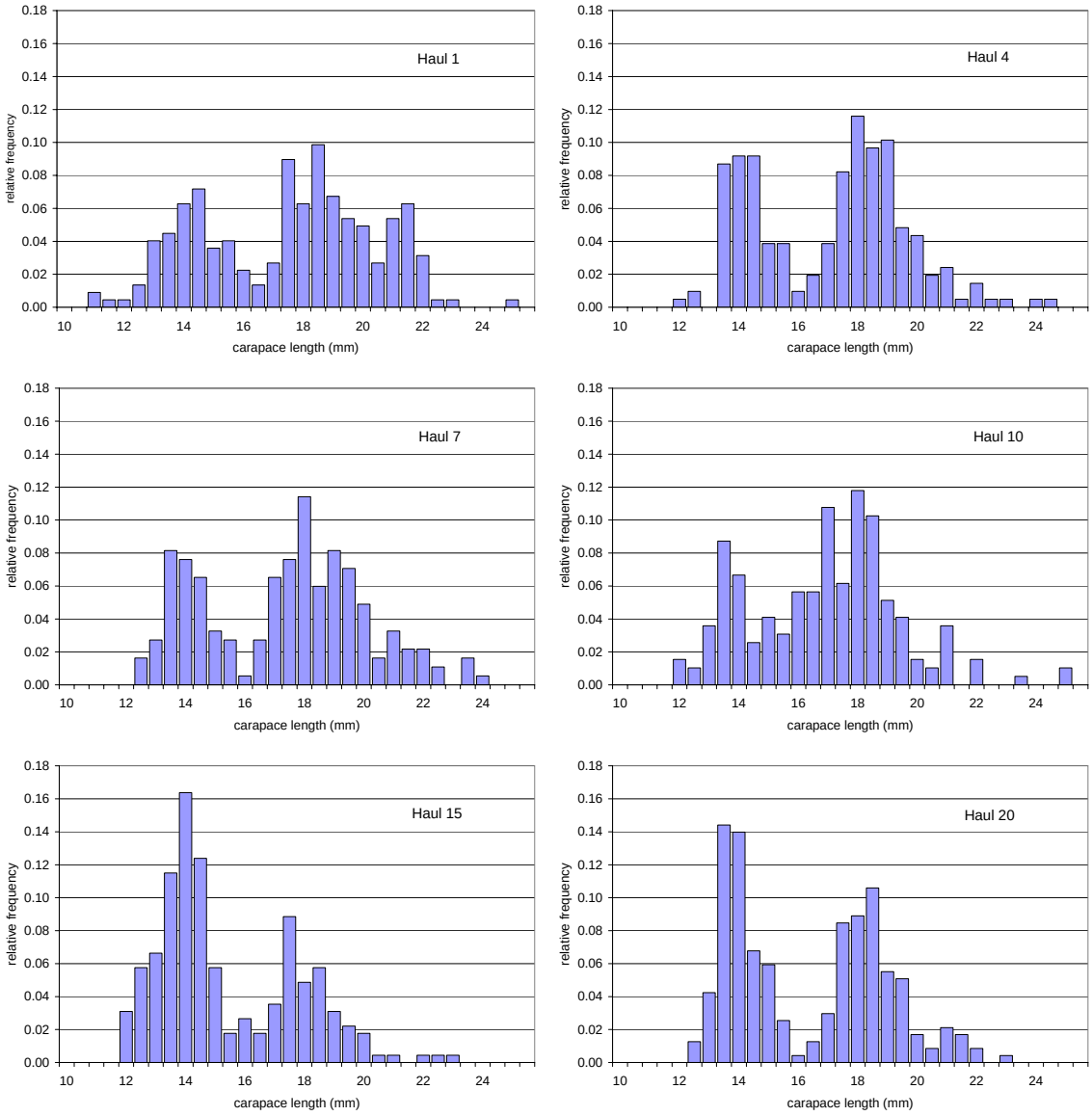

Figure 10.–Size distribution of northern pink shrimp caught in the hauls with no excluder device.

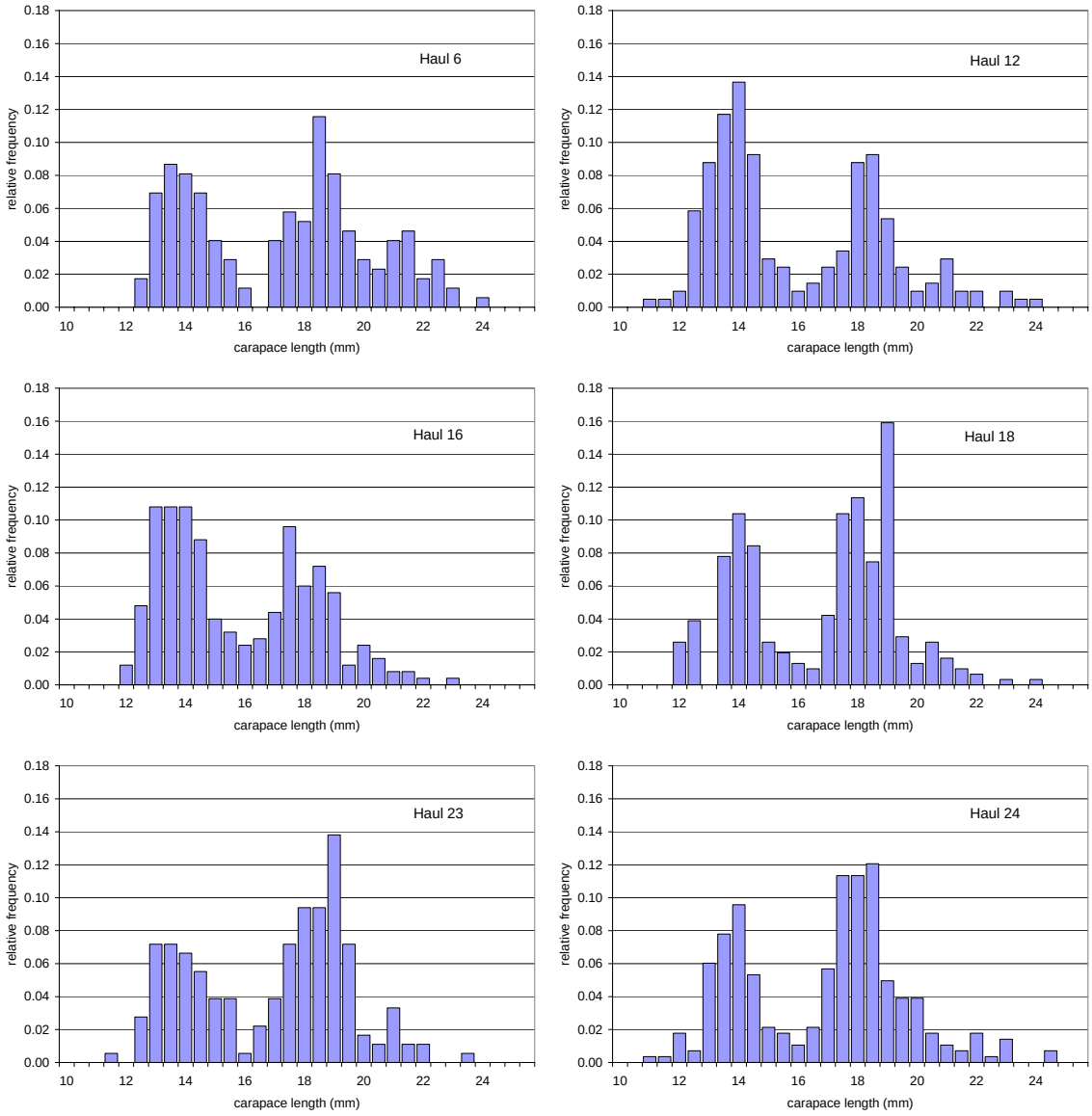

Figure 11.–Size distribution of northern pink shrimp caught in the hauls with 2.5 inch bar spacing in the excluder.

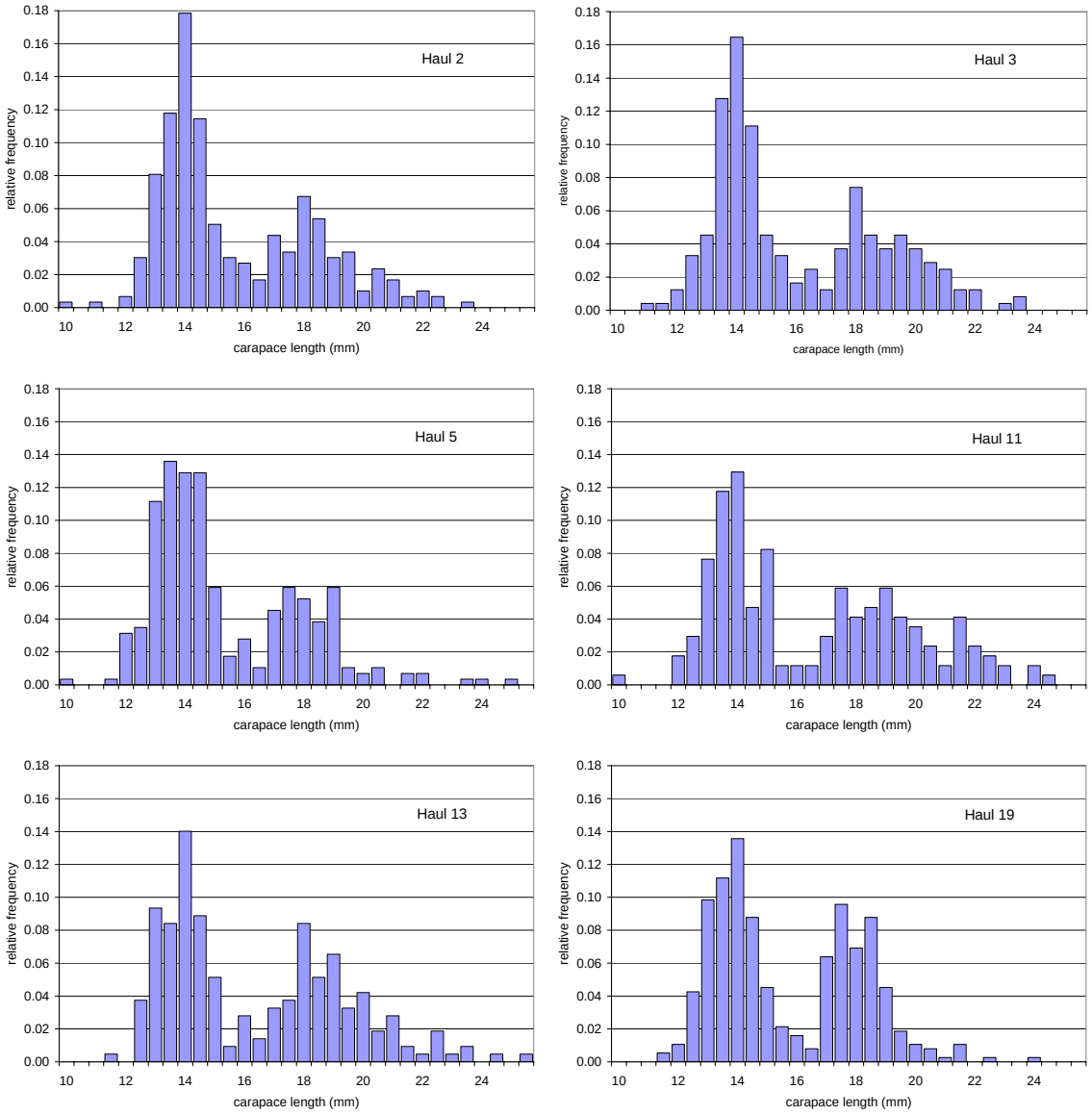

Figure 12.–Size distribution of northern pink shrimp caught in the hauls with 2.0 inch bar spacing in the excluder.

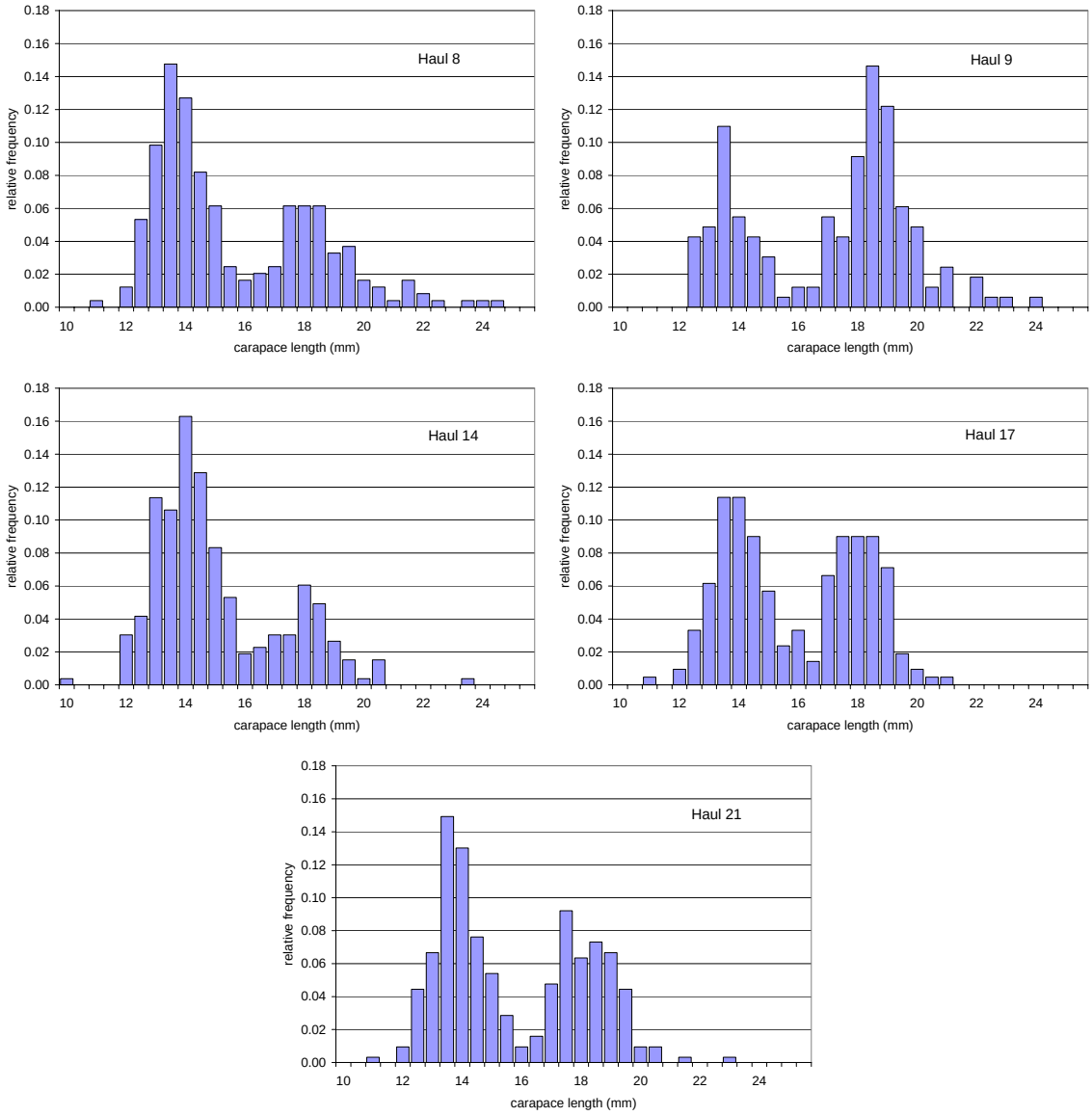

Figure 13.– Size distribution of northern pink shrimp caught in the hauls with 1.5 inch bar spacing in the excluder.

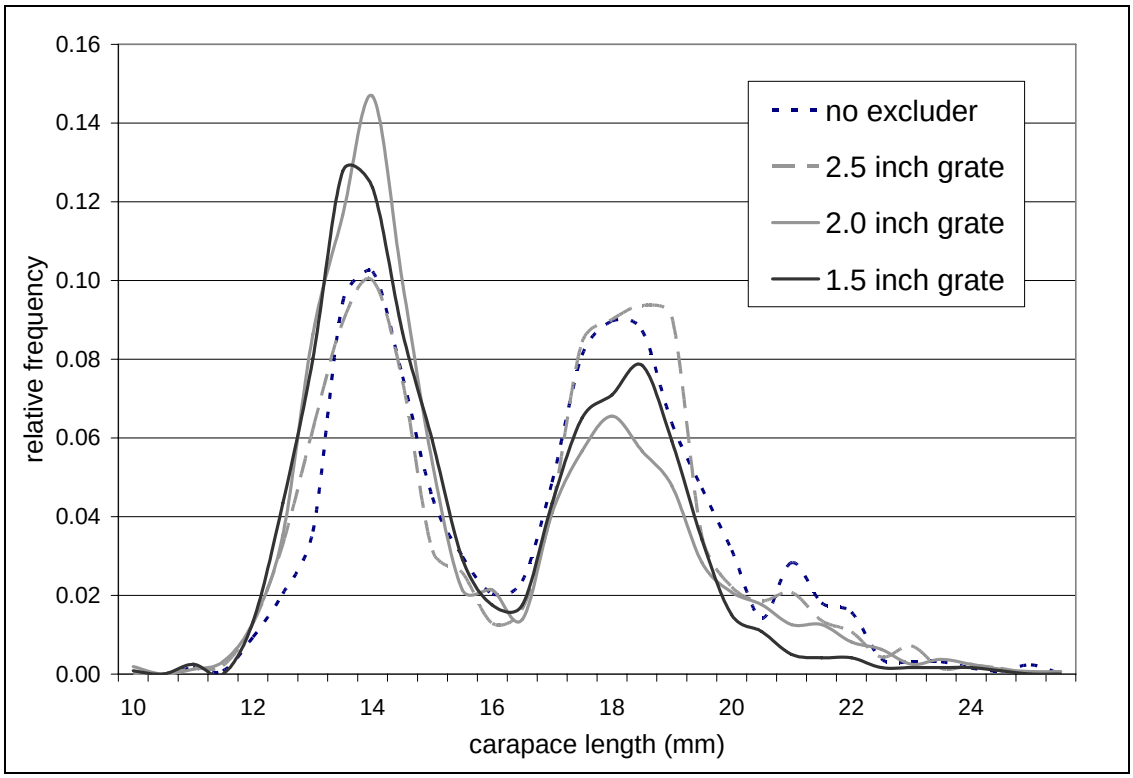

Figure 14.–Size distribution of northern pink shrimp caught by treatment type from the 2007 finfish-excluder device study.

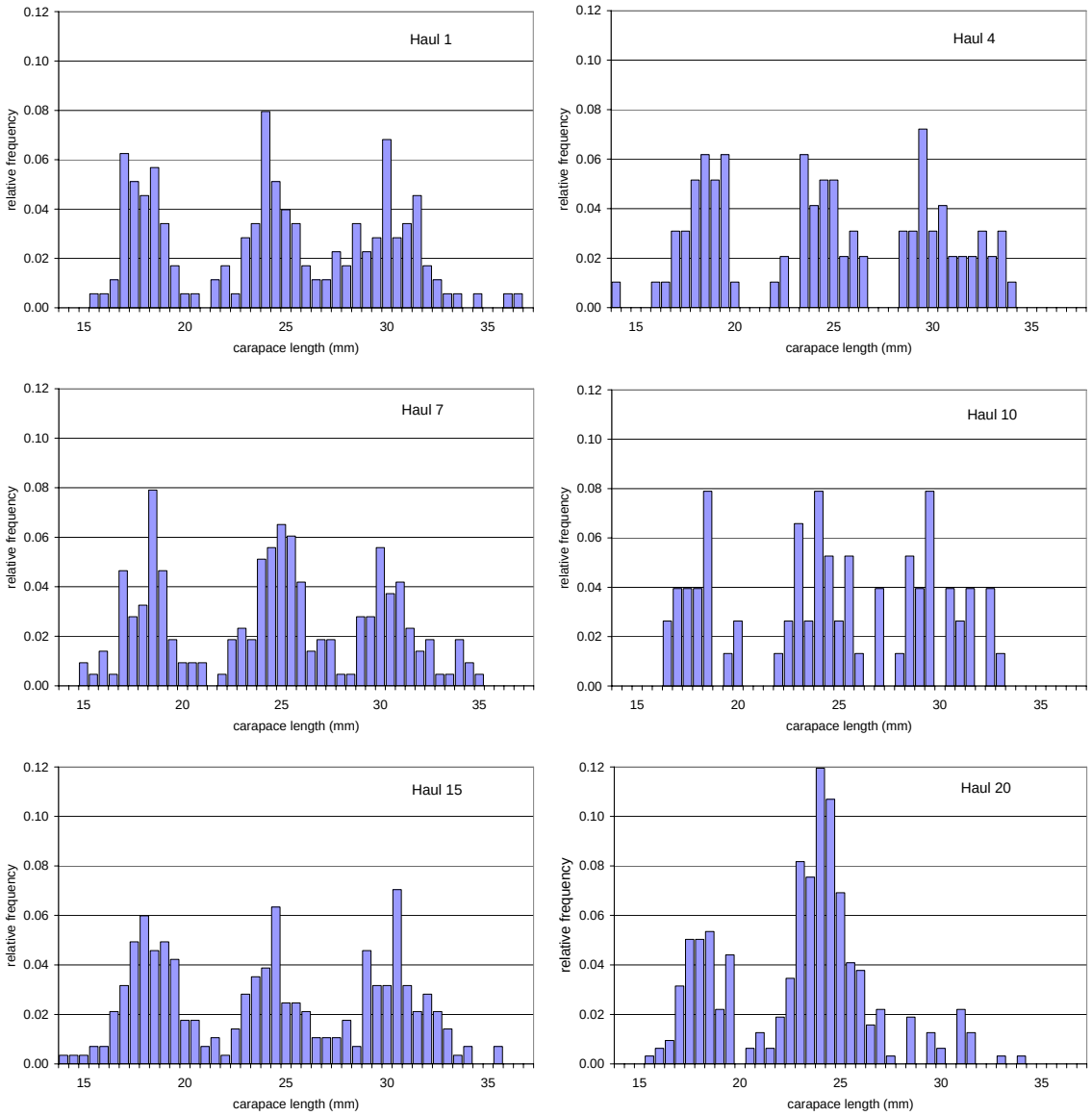

Figure 15.–Size distribution of sidestriped shrimp caught in the hauls with no excluder device.

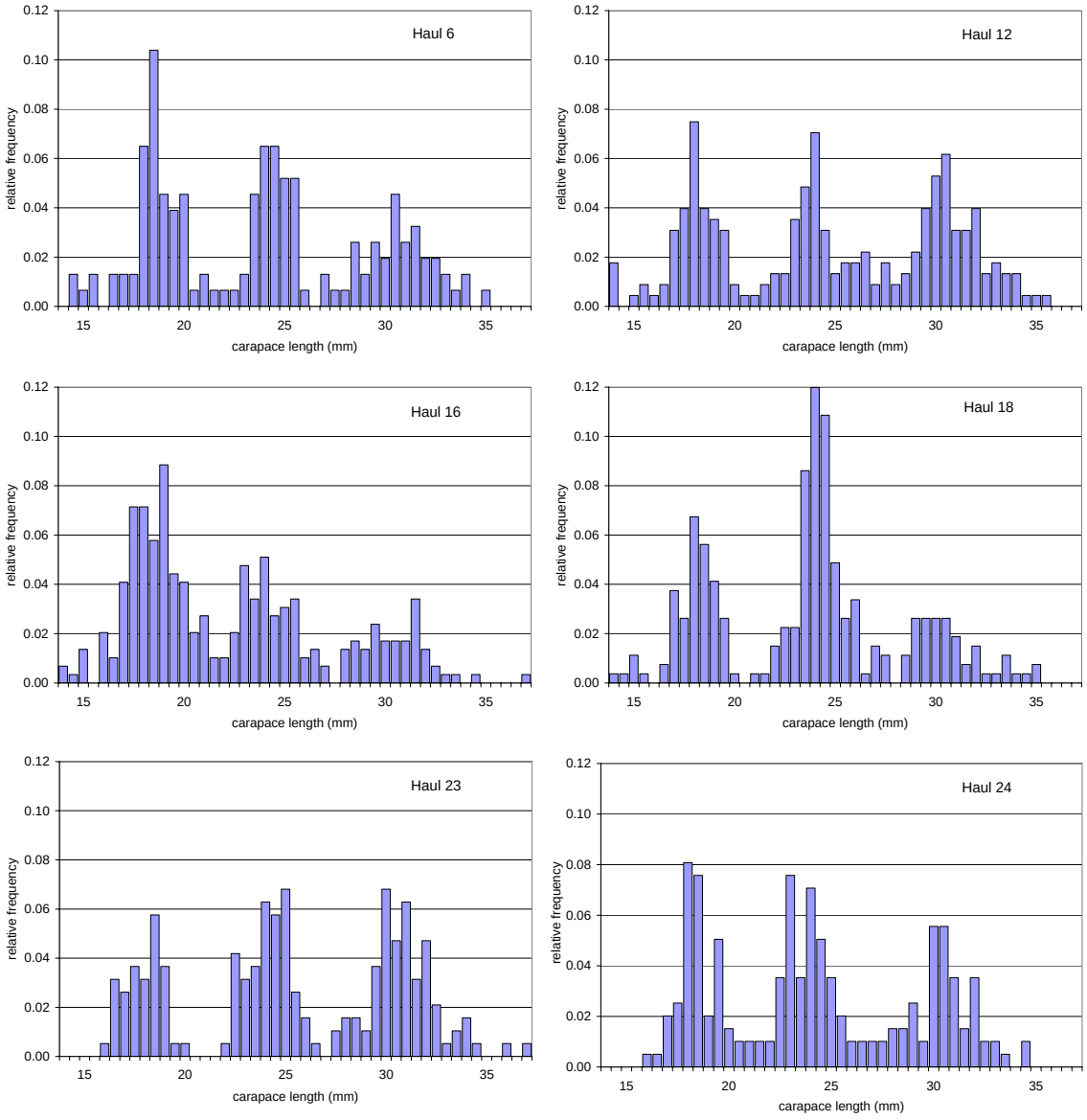

Figure 16.–Size distribution of sidestriped shrimp caught in the hauls with 2.5 inch bar spacing in the excluder.

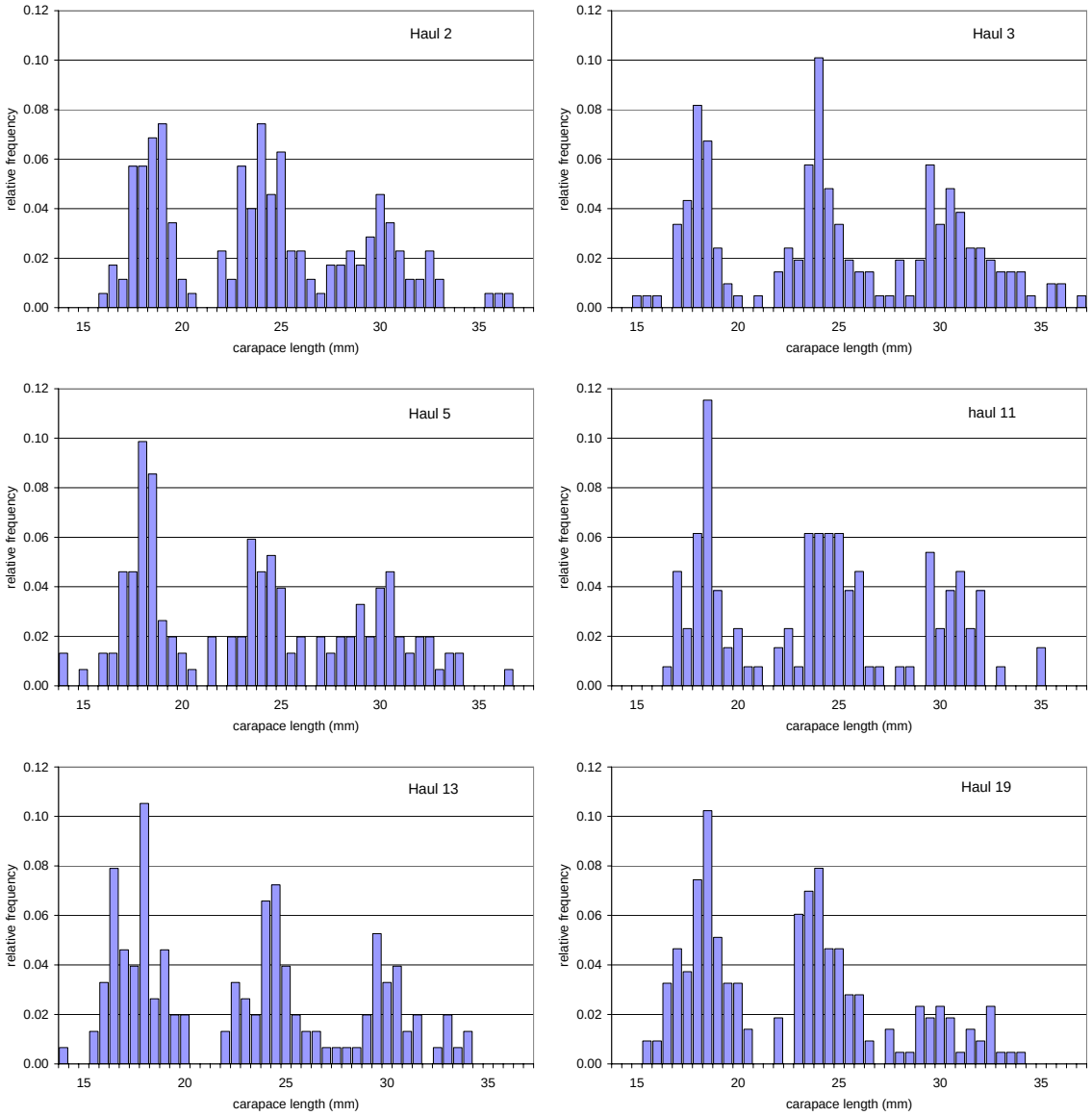

Figure 17.–Size distribution of sidestriped shrimp caught in the hauls with 2.0 inch bar spacing in the excluder.

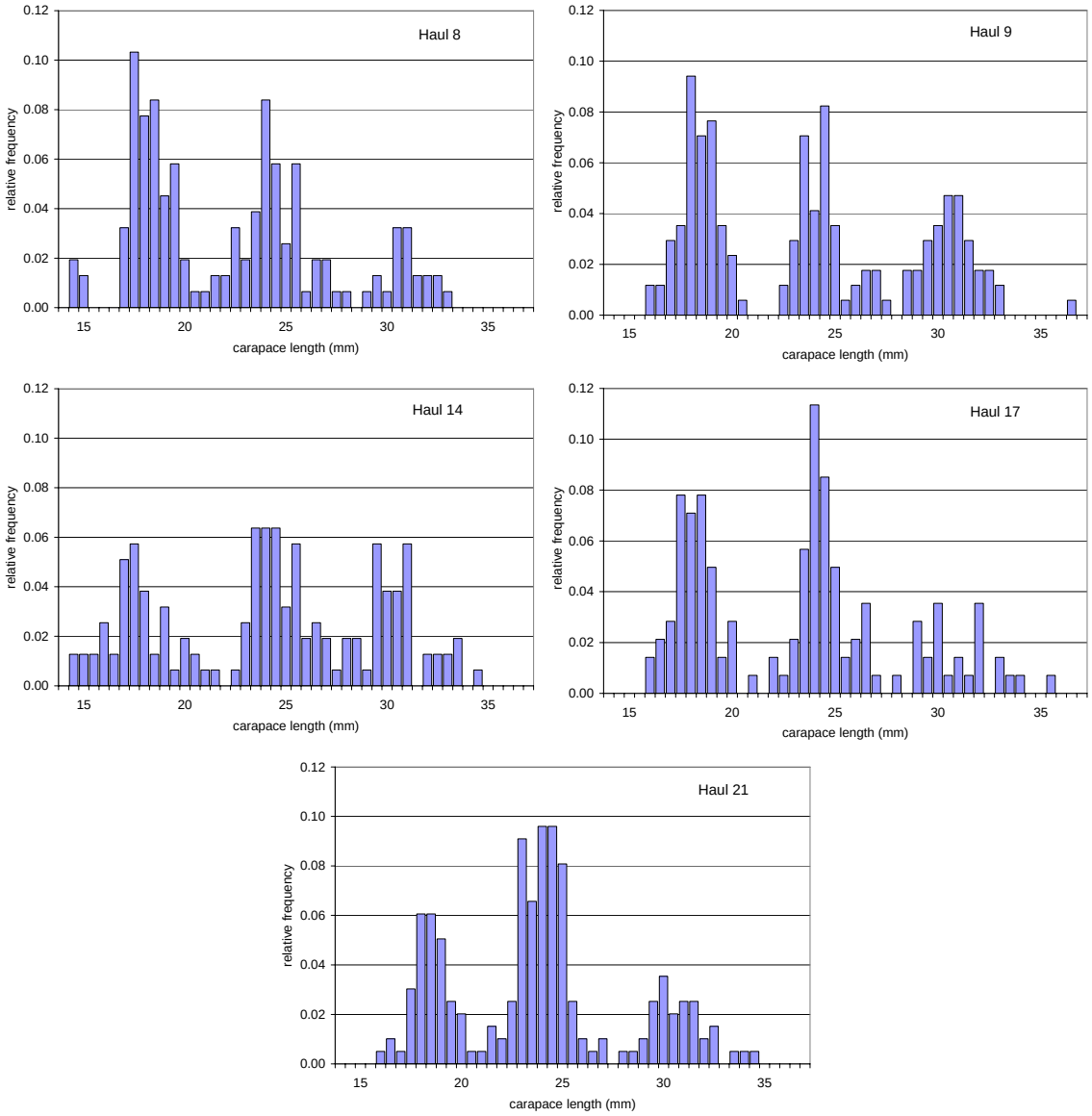

Figure 18.–Size distribution of sidestriped shrimp caught in the hauls with 1.5 inch bar spacing in the excluder.

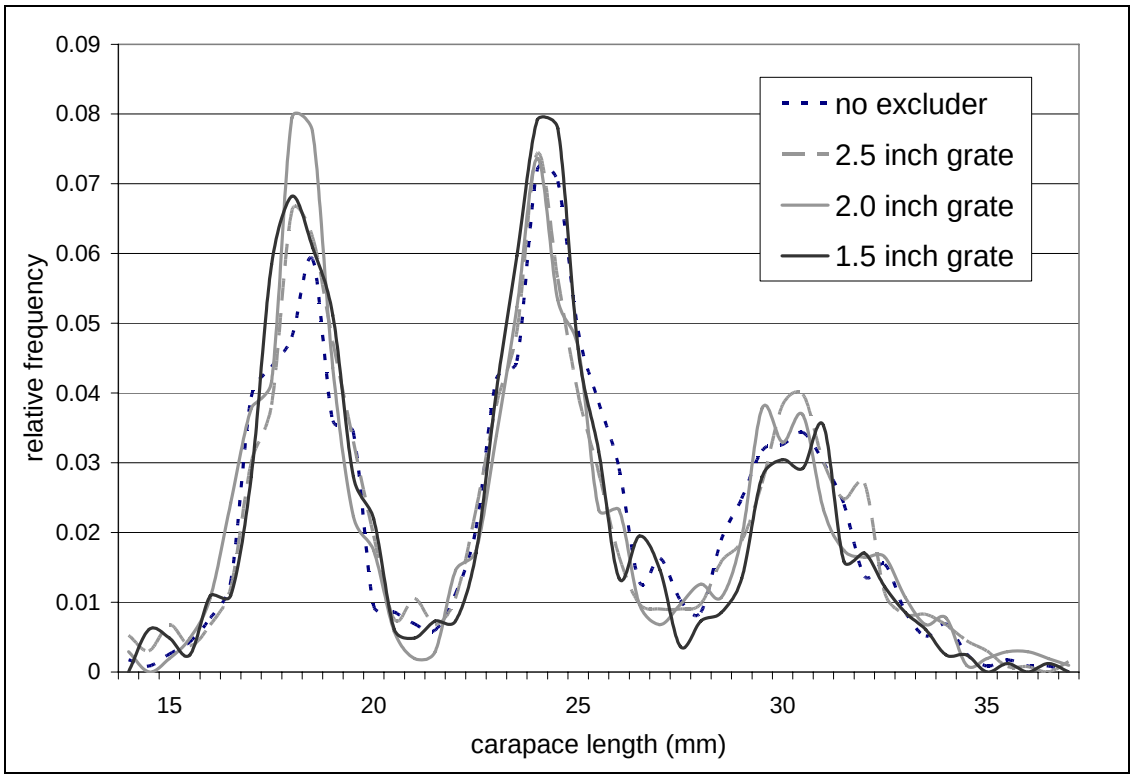

Figure 19.–Size distribution of sidestriped shrimp by treatment type from the 2007 finfish-excluder device study.

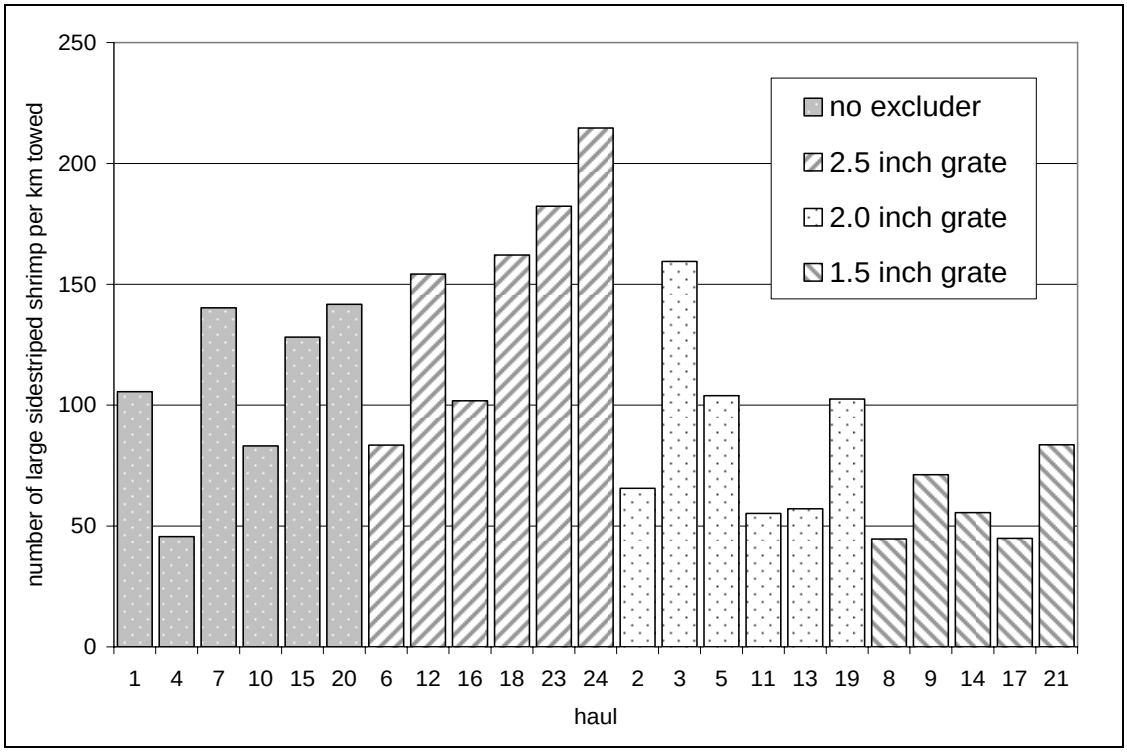

Figure 20.–Number of large (≥28 mm-CL) sidestriped shrimp caught per km towed by haul**.**

APPENDIX A. FISHING LOG AND CATCH DATA

Appendix A1.–Fishing log and catch data from the 2007 finfish-excluder device study.

Haul	1	2	3	4	5	6	7	8	9	10
Date	10/8/07	10/8/07	10/8/07	10/8/07	10/8/07	10/8/07	10/8/07	10/9/07	10/9/07	10/9/07
Longitude Start	154°0.0'	153°59.8'	153°59.4'	153°59.1'	153°58.4'	154°0.5'	154°1.0'	154°0.0'	153°55.8'	153°53.6'
Latitude Start	57°59.2'	57°59.1'	57°59.2'	57°59.4'	57°59.7'	57°59.2'	57°59.9'	58°0.1'	58°0.4'	58°1.6'
Heading, Degrees	11	16	16	18	180	13	175	83	81	29
Average Depth (m)	199	199	199	199	197	197	197	197	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)	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.6	4.6
Treatment	no grate	2" grate	2" grate	no grate	2" grate	1.5" grate	no grate	2.5" grate	2.5" grate	no grate
					kg/km towed					
Pollock	17.82	2.48	2.16	8.86	1.13	1.94	1.78	1.4	0.81	22.31
Pacific Cod	0	0	0	0	0	0	0	0	0	6.26
Pacific Sandfish	0	0	0	0	0	0	0	0	0	0
Eulachon	0.65	0.76	1.67	4.43	1.78	1.57	3.24	3.73	1.03	0.94
Capelin	0	0	0	0	0	0	0	0	0	0
Rockfish	0	0.02	0.54	1.46	0	1.03	0.05	0	0.59	112.87
Herring	0	0	0	0	0	0	0	0	0	0
Sculpins	0	0.49	0	0.05	0.06	0	0	0.11	0.11	0.71
Other Forage Fish	0.11	0.49	0.11	0.11	0.38	0.11	0.11	0.22	0.03	0.12
Other Roundfish	0	0	0.01	0	0	0	0	0.05	0	0
TOTAL ROUNDFISH	18.57	4.23	4.49	14.9	3.36	4.64	5.18	5.51	2.57	143.22
Arrowtooth Flounder	12.1	7.88	0.59	11.34	2.05	5.67	7.18	3.83	0.65	16.41
Flathead Sole	5.13	5.83	4.37	10.26	5.45	6.53	7.13	1.35	5.4	16.88
Rock Sole	0	0	0	0	0	0	0	0	0	0
Rex Sole	0.11	0.86	0.38	0.22	0.7	0.22	0.22	0.43	0.92	0.94
Dover Sole	0	0	0	0	0	0	0	0	0	0
Pacific Halibut	0	0	0	0	0	0	0	0	0	47.25
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	17.33	14.58	5.35	21.81	8.21	12.42	14.52	5.62	6.97	81.49
Northern Pink Shrimp	3.54	9.14	7.72	4.79	13.02	4.17	5.11	9	5.59	2.71
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	3.85	2.47	5.47	1.47	3.78	3.26	5.37	2.6	2.63	2.77
Other Shrimp	0.82	1.29	1.22	1.03	1.07	0.89	0.33	0.65	0.41	0.59
TOTAL SHRIMP	8.21	12.9	14.42	7.29	17.87	8.32	10.8	12.26	8.64	6.06
Squid	7.34	3.62	4.37	4.7	3.62	12.8	11.07	5.51	1.67	4.37
Jellyfish	0.65	0.54	1.03	0.49	0.81	1.67	1.13	1.94	2.25	0.94
Other Inverts	0.05	2.12	0.46	0.05	0.12	0	0	0.03	0	0.45
TOTAL INVERTS	8.05	6.27	5.86	5.24	4.55	14.47	12.2	7.48	3.92	5.77
Skates	0	0	0	0	0	0	0	0	0	1.71
Spiny Dogfish	7.99	0	0	9.4	0	0	2.97	0	0	20.46
Other	0	0	0	0	0	0	0	0	0	0.47
TOTAL CATCH	60.15	37.99	30.11	58.64	33.98	39.85	45.68	30.86	22.1	259.18

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Haul	11	12	13	14	15	16	17	18	19	20
Date	10/9/07	10/9/07	10/9/07	10/9/07	10/9/07	10/9/07	10/9/07	10/11/07	10/11/07	10/11/07
Longitude Start	153°53.9'	153°55.3'	153°54.8'	153°51.4'	153°46.7'	153°48.2'	153°50.8'	154°3.8'	154°0.9'	153°56.6'
Latitude Start	58°3.1'	58°1.3'	58°2.1'	58°2.4'	58°4.3'	58°2.1'	57°59.4'	57°52.6'	57°54.2'	57°55.4'
Heading, Degrees	312	170	8	63	38	197	182	54	55	53
Average Depth (m)	197	199	199	197	195	195	197	197	199	199
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)	4.6	4.6	4.6	4.5	4.5	4.5	4.5	4.5	4.5	4.6
Treatment	2" grate	1.5" grate	2" grate	2.5" grate	no grate	1.5" grate	2.5" grate	1.5" grate	2" grate	no grate
					kg/km towed					
Pollock	1.08	4.81	4.27	1.24	37.58	6.21	5.24	1.3	2.75	16.65
Pacific Cod	0	0.05	0.01	0	2.54	0	0	0	0	0
Pacific Sandfish	0	0	0	0	0	0	0	0	0	0
Eulachon	1.13	2.59	2.92	1.03	1.35	1.03	1.78	1.46	2.16	23.25
Capelin	0	0	0	0	0	0	0	0	0	0
Rockfish	0.05	1.46	0	0.03	0.02	0	0	0.11	0	2.81
Herring	0	0	0	0	0	0	0	0	0	0
Sculpins	0	0.11	0.11	0.04	0	0.11	0.03	0.16	0.16	0.09
Other Forage Fish	0.11	0.32	0.17	0.32	0.05	0.76	0.49	0.27	0.22	0
Other Roundfish	0	0	0	0	0	0	0.22	0	0	1.78
TOTAL ROUNDFISH	2.37	9.34	7.47	2.66	41.54	8.11	7.76	3.29	5.3	44.58
Arrowtooth Flounder	4.27	5.51	2.59	1.4	16.95	16.09	5.89	18.9	5.99	7.95
Flathead Sole	4.48	10.15	7.02	3.62	22.73	12.53	4.43	20.95	9.29	9.45
Rock Sole	0	0	0	0	0	0	0	0	0	0
Rex Sole	0.27	1.03	0.92	0.86	3.4	1.08	0.81	1.78	0.65	1.2
Dover Sole	0	0	0.16	0	0.38	0	0	0.76	0	0
Pacific Halibut	0	0	0	0	0	0	0	0	0	9.18
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	9.02	16.68	10.69	5.89	43.47	29.7	11.12	42.39	15.93	27.78
Northern Pink Shrimp	2.97	3.79	4.51	11.64	10.17	21.43	33.33	19	25.89	22.33
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	2.26	4.96	2.26	1.97	4.13	4.57	2.12	8.06	5.58	14.72
Other Shrimp	2.33	0.48	1	1.18	0.99	0.84	0.35	1.07	1.09	0.45
TOTAL SHRIMP	7.56	9.23	7.77	14.79	15.29	26.84	35.8	28.13	32.56	37.5
Squid	4.21	2.92	2.32	2.21	4.05	0.54	0.7	2.75	1.13	2.25
Jellyfish	6.48	0.59	1.62	0.49	0.05	1.13	1.78	3.73	0.27	24.6
Other Inverts	0	0.01	0.12	0.1	0.02	0	0.07	0.22	0.11	0.25
TOTAL INVERTS	10.69	3.52	4.06	2.79	4.12	1.67	2.55	6.7	1.51	27.1
Skates	0	0	0	0	1.71	0	0	0	0	16.09
Spiny Dogfish	0	5.56	0	0	21.49	0	0	0	0	2.16
Other	0	0	0	0	0	0	0	0	0	0.3
TOTAL CATCH	29.64	44.34	30	26.14	127.61	66.32	57.24	80.51	55.3	155.51

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Haul	21	22	23	24
Date	10/11/07	10/11/07	10/11/07	10/11/07
Longitude Start	153°53.7'	153°51.2'	153°49.2'	153°47.6'
Latitude Start	57°56.7'	57°59.2'	58°1.0'	58°1.2'
Heading, Degrees	35	27	50	50
Average Depth (m)	201	199	197	197
Distance Fished (km)	0.9	0.9	0.9	0.9
Bottom Temperature (°C)	4.6	4.6	4.6	4.6
Treatment	2.5" grate	2.5" grate	1.5" grate	1.5" grate
	kg/km towed			
Pollock	1.57		9.34	11.29
Pacific Cod	0		0	0
Pacific Sandfish	0		0	0
Eulachon	8.32		3.46	32.94
Capelin	0		0	0
Rockfish	0		0	0
Herring	0		0	0
Sculpins	0		0.32	0
Other Forage Fish	0.22		0.54	0.38
Other Roundfish	0		1.03	0.01
TOTAL ROUNDFISH	10.1		14.69	44.61
Arrowtooth Flounder	1.03		16.36	18.79
Flathead Sole	3.35		7.02	13.07
Rock Sole	0		0	0
Rex Sole	0.16		0.7	1.24
Dover Sole	0		0	0
Pacific Halibut	0		0	0
Starry Flounder	0		0	0
Yellowfin Sole	0		0	0
Other Flatfish	0		0	0
TOTAL FLATFISH	4.54		24.08	33.1
Northern Pink Shrimp	19.96		4.92	13.49
Humpy Shrimp	0		0	0
Coonstripe Shrimp	0		0	0
Sidestriped Shrimp	4.23		5.38	7.71
Other Shrimp	0.33		0.88	0.72
TOTAL SHRIMP	24.51		11.18	21.92
Squid	1.08		3.19	0.65
Jellyfish	4.48		6.1	0.54
Other Inverts	0.12		4.35	0.58
TOTAL INVERTS	5.68		13.63	1.77
Skates	0		0	0
Spiny Dogfish	0		0	0
Other	0		0	0
TOTAL CATCH	44.83		63.58	101.4

unacceptable gear performance