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Kachemak Bay Small-Mesh Trawl Survey, 2000

by

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and

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October 2005

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

Symbols and Abbreviations

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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 small-mesh net bottom trawl survey for shrimp and associated fish populations in Kachemak Bay, Alaska during May 9 to 15, 2000. This survey continued a time series extending to the 1970s that has been used by ADF&G to monitor stock status and establish harvest guidelines of pandalid shrimp stocks in the Southern District of the Cook Inlet Management Area. The fishery primary targeted northern shrimp *Pandalus borealis*. Following the collapse of the commercial shrimp fishery in the 1980s, survey frequency declined from annually to triennially with the previous survey conducted in 1997.

The 2000 survey indicated that pandalid shrimp population abundance in Kachemak Bay remains insufficient to support a commercial fishery. Although the stratified biomass index of 1,870,000 lb of pandalid shrimp was the greatest biomass index since 1990 and represented a 10-fold increase from the previous survey in 1997, the 2000 index was substantially lower than the 4.5 to 13 million lb level that sustained the fishery from the late 1960s until the fishery started to collapse in the early 1980s. At the peak of the fishery, mean survey catch rates for the East Open, Near West, and Far West strata were typically above 500 lb/nmi. As the shrimp population declined in the early 1980s, mean catch declined in the west and catch increased in the East Open stratum prior to a complete collapse. The highest pandalid shrimp catch rates in the 2000 survey occurred in the East Closed stratum.

The stratified biomass index for fish and non-shrimp invertebrates increased 4.0% from the 1997 survey to 2000, with the increase primarily resulting in groundfish indices (Table 7; Gustafson and Bechtol 2001). Groundfish species yielding the greatest catch were flathead sole *Hippoglossoides elassodon* (25.0% of total) and walleye pollock *Theragra chalcogramma* (21.9% of total).

The next small-mesh survey in Kachemak Bay is scheduled for May 2003.

Key words: Shrimp, forage fish, small-mesh trawl, time series, population, assessment.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) conducted a small-mesh net bottom trawl survey for shrimp and associated fish populations in Kachemak Bay during May 9 to 15, 2000. Trawl shrimp index surveys have been conducted by ADF&G to monitor stock status and establish harvest guidelines of shrimp stocks in the Southern District of the Cook Inlet Management Area. During the development of the commercial fishery, surveys were conducted annually in May from 1971 to 1975. After the fishery was fully developed, surveys were conducted in May and October from 1975 to 1990. Following 5 years of fishery closures due to low stock abundance, surveys were conducted annually in May during 1991 and 1992. With continued low shrimp abundances and reduced funding levels, the survey frequency was reduced to biennially in May from 1993 to 1997, and subsequently triennially.

The commercial trawl shrimp fishery in the Cook Inlet Management Area began with intermittent harvests in the late 1950s. Annual catches were approximately 5 million pounds from the late 1960s through the early 1980s, achieving a maximum of 6.2 million lb during the 1980-1981 season (Davis 1982; Table 1). Shrimp stocks declined drastically in the early 1980s and the Cook Inlet commercial fishery has remained closed since the fall of 1986 (Hammarstrom 1991). Fishing effort ranged from one vessel during 1968 to 23 vessels in 1981 (Trowbridge et al. 2000). In 1997 the Alaska Board of Fisheries (BOF) adopted 5 AAC 31.390. Cook Inlet Area Shrimp Fisheries Management Plan, which closed all commercial, sport, and subsistence shrimp fisheries in Cook Inlet until stocks recover and more comprehensive management aspects are considered. Key components of the plan include: minimum stock thresholds for implementing fisheries; maximum harvest rates; regular stock assessment; and fishing seasons.

Table 1.–Historical trawl shrimp harvests by season from Kachemak Bay in the Cook Inlet Management Area, 1969 to present.

Season	Vessels	June 1 to Oct. 31	Nov. 1 to March 31	April 1 to May 31	Total
1969-70[a]	7	1,289,656	1,692,854	889,330	3,871,840
1970-71[a]	3	3,211,924	2,076,228	617,836	5,905,988
1971-72[a]	7	2,618,630	1,761,569	140,707	4,520,906
1972-73[a]	10	2,772,422	2,109,660		4,882,082
1973-74[b]	13	2,502,154	2,323,780		4,825,934
1974-75	4	2,512,764	2,519,148		5,031,912
1975-76	4	1,997,563	2,421,456		4,419,019
1976-77	5	2,545,885	2,453,101		4,998,986
1977-78	7	2,490,969	2,546,977		5,037,946
1978-79	6	2,952,733	3,060,066		6,012,799

		July 1 to Sep. 30	Oct. 1 to Dec. 31	Jan. 1 to March 31	Total
1979-80	7	2,013,298	2,052,646	1,731,483	5,797,427
1980-81	15	1,780,677	2,691,746	1,704,706	6,177,129
1981-82	23	1,614,868	1,686,781	1,693,850	4,995,499
1982-83	15	998,522	1,012,388	1,009,857	3,020,767
1983-84	10	Closed	Closed	525,508	525,508
1984-85	10	519,651	528,506	518,529	1,566,686
1985-86	2	488,606	257,782	503,340	1,249,728
1986-87	3	504,206	Closed	Closed	504,206
1987-88	0	Closed	Closed	Closed	
1988-89	0	Closed	Closed	Closed	
1989-90	0	Closed	Closed	Closed	
1990-91	0	Closed	Closed	Closed	
1991-92	0	Closed	Closed	Closed	
1992-93	0	Closed	Closed	Closed	
1993-94	0	Closed	Closed	Closed	
1994-95	0	Closed	Closed	Closed	
1995-96	0	Closed	Closed	Closed	
1996-97	0	Closed	Closed	Closed	
1997-present		Closed by Alaska Board of Fisheries regulation			

[a] Seasonal harvests established in 1973.

[b] June 1 to October 31 and November 1 to March 3 seasons with respective guidelines established.

Shrimp population declines near Kodiak and the Alaska Peninsula preceded declines in Kachemak Bay (Davis 1982; Ruccio 1999). Although excessive harvest rates were likely a contributing factor (Trowbridge et al. 2000), these declines have been attributed to a broad ecological shift caused by warming of northern Gulf of Alaska waters as part of the Pacific Decadal Oscillation (Anderson et al. 1997; Anderson and Paitt 1999; Loy 1999). This shift favored groundfish populations over shellfish stocks (Bechtol 1997; Gustafson and Bechtol 2001).

The Cook Inlet commercial fishery targeted pandalid shrimp species *Pandalus* and *Pandolopsis* (Table 2). Within this report, "pandalid shrimp" refers only to northern (or pink), sidestripe, coonstripe, and humpy shrimps, targets of the commercial fishery. The term "other shrimp" refers to non-commercial shrimp such as *Lebbeus*, *Crangon*, *Sclerocrangon*, and *Eualus* species. Northern shrimp typically comprised over 50% of the commercial harvest. Humpy shrimp comprised up to 50% of the harvest in some years, but exhibited erratic population fluctuations. Coonstripe shrimp and sidestripe shrimp seasonally contributed up to 5% annual harvest, with spot shrimp comprised less than 0.01% of the pandalid shrimp catch.

SURVEY GOALS AND OBJECTIVES

The objective of the 2000 small-mesh trawl survey was to assess Kachemak Bay shrimp and groundfish stocks for comparison with historic levels. Although other shrimp species were caught, the pandalid species, particularly northern shrimp, were of particular interest. Specific survey goals were to:

1. Estimate the biomass of pandalid shrimp in Kachemak Bay.
2. Document the species composition of pandalid shrimp caught during the surveys.
3. Determine the carapace length frequency and sex ratio of northern shrimp caught during the survey.
4. Estimate the biomass of groundfish and Pacific halibut (Table 2).

GENERAL NORTHERN SHRIMP BIOLOGY

Northern shrimp exhibit a discontinuous circumboreal distribution from California into the Bering Sea and south to Japan in the North Pacific, and from Maine to the Arctic Ocean and to the Barents Sea in the North Atlantic (Shumway et al. 1985). They occur from estuaries to the continental shelf at depths 9 to 1,450 m, exhibiting a preference for soft mud, silt, and sand bottoms with high organic content (Barr 1970; Haynes and Wigley 1969), but also encountered in habitats with occasional rocks. Northern shrimp have been found in water temperatures ranging from 1.6° to 12°C, although optimum temperatures for egg and larval survival are between 3º to 6°C (Nunes 1984). Northern shrimp generally occur in salinities of 23 to 35 $^{0}/_{00}$ (Butler 1964; Barr 1970).

Northern shrimp are protandric hermaphrodites in which each individual matures as a functional male then transitions to a functional female (Butler 1964). A small percentage of shrimp may skip the male phase and mature early to female. There is considerable spatial and temporal variation in the age of sexual transition from male to female. For example, more intensive fishing pressure can induce maturity at a younger age (Charnov 1978). Because shrimp have no permanent body structures that can be aged, shrimp age is determined by laboratory studies or by growth studies measuring oblique carapace lengths and statistically looking at changes over time (Kimker et al. 1996). In Kachemak Bay, Northern shrimp live at least 5 years (Davis 1982). Eggs are carried on

Table 2.–List of the most prevalent species encountered during the Kachemak Bay small-mesh trawl survey, 2000.

Common Name	Scientific Name
Northern shrimp	*Pandalus borealis*
Sidestripe shrimp	*Pandalopsis dispar*
Humpy shrimp	*Pandalus goniurus*
Coonstripe shrimp	*Pandalus hypsinotus*
Spot shrimp	*Pandalus platyceros*
Lebbeid shrimp	*Lebbeus sp.*
Crangon shrimp	*Crangon sp.*
Tank shrimp	*Sclerocrangon sp.*
Eualid shrimp	*Eualus sp.*
Tanner crab	*Chionoecetes bairdi*
Red king crab	*Paralithodes camtschatica*
Dungeness crab	*Cancer magister*
Weathervane scallop	*Patinopecten caurinus*
Hind's scallop	*Chlamys rubida*
Octopus	*Octopus dofleini*
Hairy triton	*Fusitriton oregonensis*
Neptune snail	*Neptunea sp.*
Sea cucumber	*Cucumaria sp.*
Hermit crab	*Pagurus sp.*
Decorator crab	*Oregonia gracilis*
Lyre crab	*Hyas sp.*
Pygmy Cancer crab	*Cancer oregonensis*
Green urchin	*Stronglyocentrotus droebachiensis*
Sea star	
Anemone	
Jellyfish	
Horse mussel	*Modiolus modiolus*
Pacific halibut	*Hippoglossus stenolepis*
Sablefish	*Anoplopoma fimbria*
Skate	Family Rajidae
Giant wrymouth	*Delolepis gigantea*
Rockfish species	*Sebastes* species
Eelpout	*Lycodes sp.*
Pacific cod	*Gadus macrocephalus*
Walleye pollock	*Theragra chalcogramma*
Flathead sole	*Hippoglossoides elassodon*
Arrowtooth flounder	*Atheresthes stomias*
Starry flounder	*Platichthys stellatus*
Sturgeon poacher	*Agonus acipenserinus*
Pacific tomcod	*Microgadus proximus*
Sculpin	Family Cottidae

the female abdominal appendages for about 6 months, hatching in March or April (Barr 1970). The larvae remain pelagic for about 3 months and molt through 6 stages. Stage I zoea are about 5 mm total length and do not resemble the adults, whereas stage VI zoea (meglops) are 19 mm total length and closely resemble the adults. At the initial post-larval stage, with a carapace length (CL) of 6 to 9 mm, the shrimp assume a benthic existence in which they walk or swim above the bottom. Most post larval shrimp remain males for first 3 or 4 years, during which time they undergo several molts and become reproductively functional at 9 mm CL. Sexual transition from male to female occurs during March to August. Prior to the late September to mid-October spawning season, females molt into an exoskeleton that has longer lateral abdominal plates and specialized setae on the pleopods for depositing eggs. Soon after the pre-spawn molt, the male deposits a sperm packet on the underside of the female. Eggs are extruded by the female from pores at the base of a pair of legs, fertilized as they pass over the sperm packet, and deposited on the setae protected by the deep abdominal plates. Fecundity varies from 600 to 4,900 eggs as a function of geography and shrimp size (Haynes and Wigley 1969). Large northern shrimp in Kachemak Bay may produce over 2,000 eggs that remain attached to the setae for up to 6 months before hatching (Davis 1982).

Northern shrimp are an opportunistic omnivore functioning as both a predator and scavenger on benthic animals and detritus, but also make diel vertical migrations for feeding (Barr 1970). Crow (1977) found stomachs from northern, coonstripe and sidestripe shrimp that contained amorphous organic matter (detritus), algae, diatoms, and invertebrate parts, cannibalism has also been noted (Shumway et al. 1985). Northern shrimp are important prey species for groundfish, such as walleye pollock, Pacific cod, flathead sole, and arrowtooth flounder (Yang 1993).

METHODS

STUDY AREA AND SURVEY DESIGN

The Southern District is largely composed of Kachemak Bay, an embayment of Cook Inlet along the northern Gulf of Alaska (Figure 1). Habitat in this district is typified by mud or sand with occasional hard bottoms, particularly shale or coal. Depths are typically shallower than 35 fathom (64 m), although some areas exceed 90 fathom (165 m). This area is subject to high current flows and tidal fluctuations to 25 feet (46 m). Oceanic currents largely flow counterclockwise in the district, and Kachemak Bay waters frequently contain glacial silt (Burbank 1977).

The survey design delineated Kachemak Bay into a grid of 1.0-nautical mile (nmi) squares (3.4-km^2). Survey stations were selected from the pool of potential stations with water depth greater than 20 fathom (36.6 m). From 1971-1974, selected stations were sampled by single 1.0-nmi tows of a 66-foot Nordby net. Beginning in 1975, the net was changed to a 61-foot headrope, high-rise net designed by the National Marine Fisheries Service (NMFS). The net style was changed because comparative tows showed the 66-foot Nordby trawl net was only 50% as efficient as the NMFS net (Davis 1982). The NMFS net was subsequently adopted as a standard for shrimp trawl research by NMFS, ADF&G, and Canadian researchers in British Columbia (Watson and Bernard 1986; Watson 1987).

The study design has remained relatively consistent throughout the survey time series except for station selection. Stations were originally selected at random from the pool of potential stations.

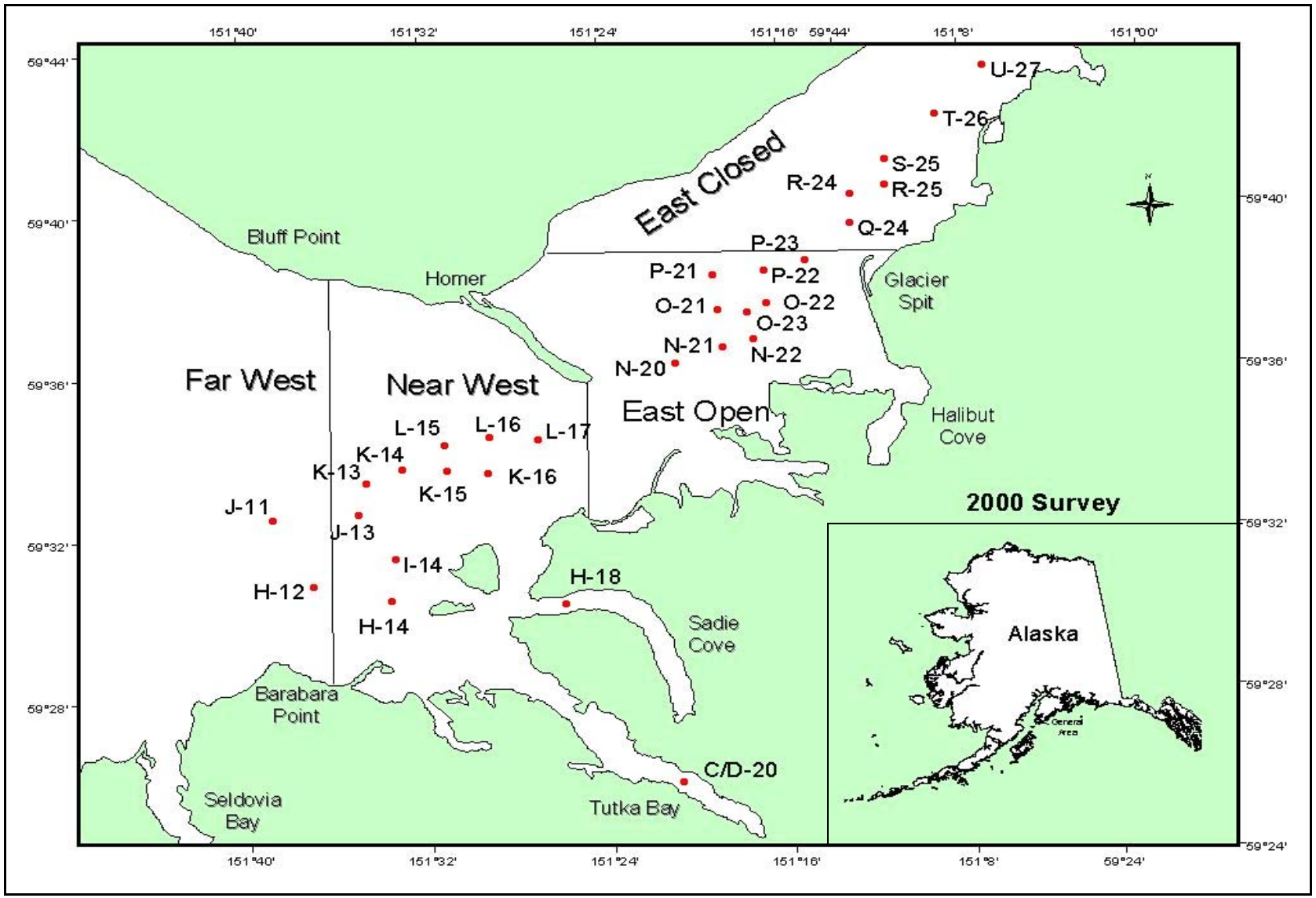

Figure 1.–Survey strata and tow midpoints of the Kachemak Bay small-mesh trawl shrimp survey, 2000.

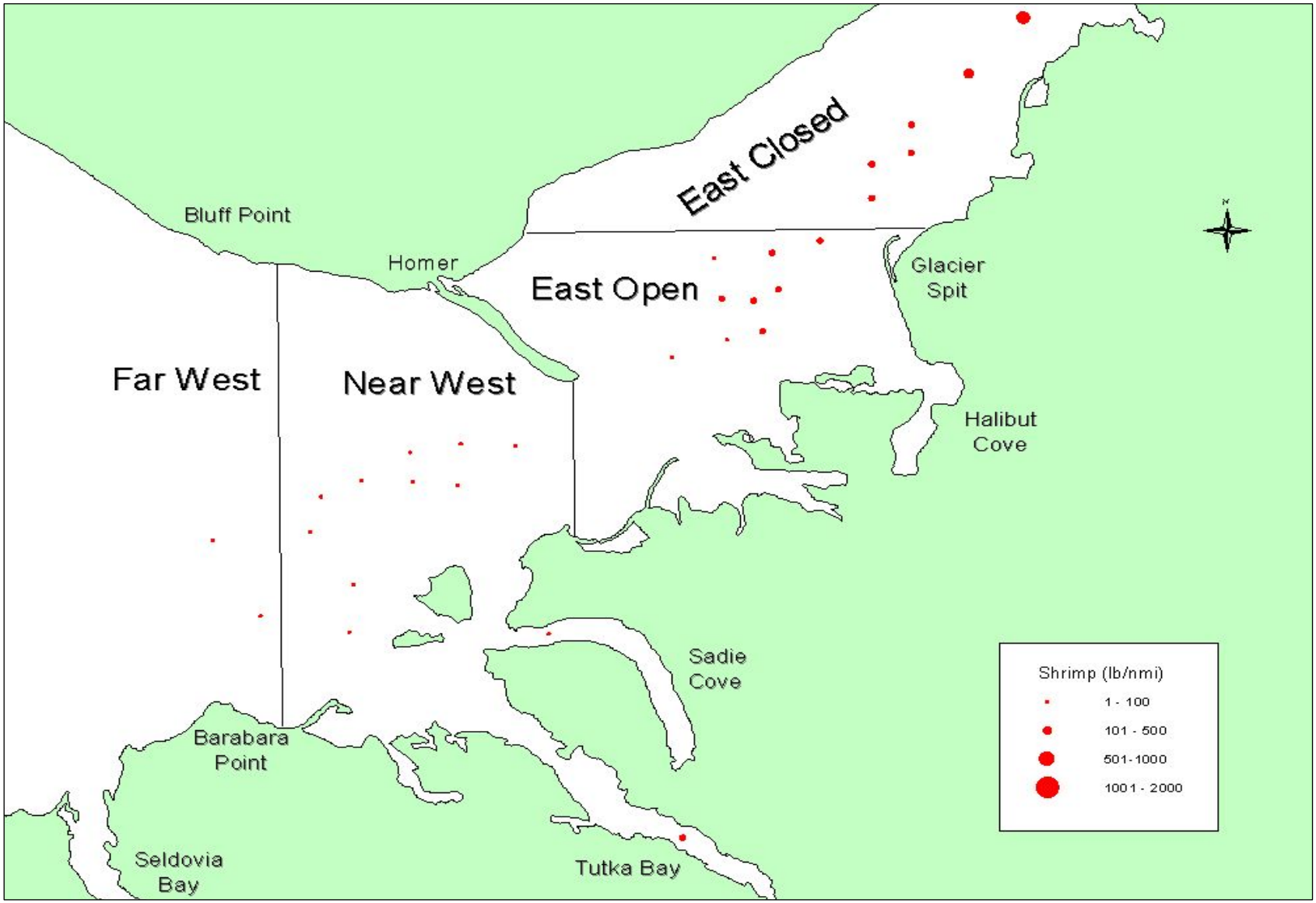

Figure 2.–Pandalid shrimp catch rates in the Kachemak Bay small-mesh trawl survey, 2000.

Beginning in spring 1984, the survey design was changed from random to an index estimator with the same stations sampled in an effort to reduce net damage. In 1988, additional stations east of Homer Spit were added to allay industry concerns that the survey did not adequately sample shrimp concentration areas. These additions increased the total area sampled by 2 square nautical miles. Exploratory tows have also been added in Tutka Bay and Sadie Cove, although these tows were not used in the historical or current biomass estimates.

A stratified index estimator (Cochran 1977) was used to estimate shrimp and fish biomass beginning in 1994. Kachemak Bay was divided into 4 strata: Far West, Near West, East Open, and East Closed (Gustafson 1994; Figure 1). Stratification was based on habitat type, geographic location, and observed shrimp sex and size. The Far West stratum historically contained few shrimp. The Near West stratum catch contained relatively sparse densities of predominately large female shrimp. The East Open stratum contained moderate densities of both shrimp sexes. The East Closed stratum, which was historically closed to trawl fishing, appeared to be a nursery area mostly containing male shrimp. Index stations in the East Closed, East Open, and Near West strata were sampled with 1.0-nmi tows, whereas 0.5-nmi tows were made in the Far West stratum to reduce potential net damage and complete the survey in a timely manner. Location and depth of trawl tows in 2000 was similar to previous surveys (Appendix A1; Figure 1).

VESSEL, GEAR, AND TRAWLING PROCEDURES

The state research vessel *Pandalus* conducted the trawl shrimp surveys from May 9 through May 17, 2000. The *Pandalus* has an overall length of 66 feet (20.2 m), a 100-ton displacement, and is powered by a 365-hp diesel engine. The vessel fished the high-rise shrimp trawl with 5.5-feet x 8.5-feet, 800-lb, Astoria V-doors attached by triple 10-fathom, 3/8-inch diameter wire bridles (dandy lines). The dandy lines attached to the net headrope with a 24-inch extension chain, to the mid-rib with an 18-inch extension chain, and to the footrope by hammerlocks. The net had 55 feet of 3/8-inch tickler chain attached to the footrope wing tips and suspended under the footrope center by a 4-foot piece of 5/16-inch dropper chain. Sixty-one feet of 3/8-inch height regulating chain connects to the wing tips and is suspended 12 inches under the footrope by six 5/16-inch dropper chains. The whole net, wing, intermediate, and cod end is built with 1.25-inch stretch mesh nylon and the cod end is also covered with polypropylene chafing mesh. Twenty-nine 8-inch plastic floats were attached to the head rope for flotation. Estimated fishing width is 32 feet and height is 11.5 feet (Watson 1987). Tows were made for 1 nmi and at a speed of 2.0-2.2 nmi/hr (kts) on a path into the tide. Trawl warp lengths were set at a 3:1 ratio with depth.

Bottom Temperature

In past surveys, bottom temperature was recorded approximately once daily using a time-specific temperature logger attached to the trawl headrope. This temperature logger was only deployed twice during the 2000 survey.

CATCH SAMPLING

Upon completion of each successful tow, the total catch was weighed and all large non-shrimp objects such as rocks, stumps, and crab pots, were removed from the catch, weighed, and discarded. All Pacific halibut, target groundfish, and target invertebrates were removed, counted, and weighed in aggregate by species (Table 2). Target groundfish included Pacific cod, walleye pollock, sablefish, skate Family Rajidae, giant wrymouth, and rockfish species; target

invertebrates included Tanner crab, red king crab, Dungeness crab, weathervane scallop, and octopus. Pacific cod, walleye pollock, sablefish, and rockfish species were further sampled for individual weight, length, sex, maturity, and age. Groundfish size, sex, maturity, and age data have been described in separate reports (Bechtol 1995, 1998). The remaining catch was either sorted in its entirety or a random subsample of 1-3 bushel baskets, weighing approximately 50 lb (23 kg each), was sorted into species or taxonomic groups (Table 2). Abundance and aggregate weight was determined for each non-shrimp species or taxonomic group from the subsample. Shrimp separated from the bushel samples were sorted, weighed, and counted by species or weighed in aggregate and further subsampled. This involved sorting a 2.5-kg subsample by shrimp species. Each species was weighed separately for species composition. In addition, up to 400 g of each shrimp species from the subsample were labeled and retained for later length frequency analysis in the laboratory.

During the 2000 survey, the entire catch was sorted, enumerated, and weighed by species or taxonomic group for the 16 tows in which net catch exceeded 150 lb (68 kg).

LABORATORY ANALYSIS

In the laboratory, shrimp were measured for oblique carapace length (Butler 1980). Northern shrimp were further assessed as male, transitional, female, or ovigerous female sex type based on characteristics of the first and second pleopods (Butler 1980). Size data were pooled within species and also within sex category for northern shrimp.

DATA ANALYSIS

Mean catch rates of shrimp or fish species (lb/nmi) was estimated by:

$$\bar{x} = \frac{\sum_{j=1}^{n} \frac{x_j}{d_j}}{n} \tag{1}$$

where n was the number of tows sampled, x_j is the catch (lb) and d_j is the distance (nmi) of tow j.

Stratification of the historic population data has been shown to reduce the percent error in the shrimp estimates (Gustafson 1994). However, stratification did not improve statistical precision of the fish estimates. Therefore both stratified and unstratified biomass index estimates are presented in this report.

Population biomass (P) for the unstratified sample design was estimated by:

$$\hat{P} = A \ \frac{6076}{32} \ \bar{x} \tag{2}$$

where the total area (A) in the study was 88 nmi^2 from 1977 through spring 1988 and 90 nmi^2 from fall 1988 through spring 2000, the length of a nautical mile in feet was 6,076 and 32 is the effective net width in feet.

The variance of the biomass estimate for the unstratified design ($V\left(\hat{P}\right)$) was calculated by:

$$V\left(\hat{P}\right) = \left(\frac{6076}{32}\right)^2 \ s^2 \tag{3}$$

where,

$$s^2 = \frac{\sum_{j=1}^{n} \left(x_j - \bar{x}\right)^2}{n-1}$$

Ninety-five percent confidence bounds for the unstratified biomass estimate were calculated as:

$$\hat{P} \pm t_{(1-\alpha/2,n-1)} SE$$

where *SE* (standard error) is the square root of the sample variance.

Population biomass (P_s) for the stratified sample design was estimated by:

$$\hat{P}_S = \left(6076/32\right) \sum_{i=1}^{4} A_i \frac{\sum_{j=1}^{n_i} \frac{x_{ij}}{d_{ij}}}{n_i} \tag{4}$$

where A_i is the area of stratum i in nmi^2, and x_{ij} is the catch (lb) and d_{ij} is the distance (nmi) of tow j in stratum i.

The variance of the biomass estimate for the stratified design ($V\left(\hat{P}_S\right)$) was estimated by:

$$V(\hat{P}_S) = \left(\frac{6076}{32}\right)^2 \sum_{i=1}^{4} A_i^2 \frac{s_i^2}{n_i} \tag{5}$$

where,

$$s_i^2 = \sum_{j=1}^{n_i} \frac{\left(x_{ij} - \bar{x}\right)^2}{n_i - 1}.$$

Ninety-five percent confidence bounds for the stratified biomass estimate were approximated by:

$$\hat{P} \pm t_{(1-\alpha/2,n-4)} SE\,,$$

where *SE* (standard error) is the square root of the variance.

Relative precision (RP) of the 95% confidence bounds was calculated for all estimates using:

$$RP = \frac{Upper\ bound - Lower\ bound}{\hat{P}} \tag{6}$$

RESULTS

A total of 29 successful tows were completed during the May 2000 survey, including tows in Tutka Bay and Sadie Cove (Appendix A1; Figure 1). Catches from 3 additional tows were discarded because the net did not fish correctly. Standardized catches among all tows totaled 21,809 lb (Table 3). Catch rates ranged from 246.4 to 2,174.2 lb/nmi (mean 752.0 lb/nmi). Debris totaled 331.9 lb (11.4 lb/nmi), 1.5% of the total catch.

Table 3.–Standardized catch rates by station and strata during the Kachemak Bay small-mesh trawl survey, 2000.

	Invertebrates				Fish										
Station	Pandalid Shrimp	Tanner Crab	Dungeness Crab	Other Invert.	Pacific Cod	Walleye Pollock	Halibut	Flathead Sole	Arrowtooth Flounder	Starry Flounder	Skate	Sculpin	Other Fish	Debris	Total Catch
							lb/nmi								
Far West															
J-11	4.5	0.1	0.0	0.3	0.0	132.0	0.0	72.0	24.0	0.0	0.0	0.0	13.3	0.0	246.4
H-12	24.2	<0.1	0.0	6.8	18.0	172.0	0.0	190.3	33.1	0.0	0.0	0.0	81.6	0.0	526.0
Subtotal	28.7	0.1	0.0	7.1	18.0	304.0	0.0	262.3	57.1	0.0	0.0	0.0	94.9	0.0	772.4
Mean	14.4	<0.1	0.0	3.6	9.0	152.0	0.0	131.2	28.6	0.0	0.0	0.0	47.5	0.0	386.2
Near West															
J-13	50.7	1.1	0.0	1.9	5.9	120.8	0.0	186.1	75.2	0.0	43.6	1.6	43.1	0.0	530.8
K-13	1.2	0.0	0.0	0.5	0.0	899.0	0.0	249.5	13.2	0.0	0.0	1.6	9.9	0.2	1175.2
H-14	9.7	0.1	0.0	183.6	116.0	980.0	2.0	142.0	24.0	0.0	0.0	51.5	118.0	2.0	1629.2
K-14	33.2	46.5	0.0	22.2	7.9	148.5	0.0	281.2	0.0	0.0	72.7	8.1	31.0	14.9	667.3
I-14	1.5	1.3	0.0	15.8	4.4	0.0	16.1	377.0	18.4	0.0	0.0	13.8	36.7	13.8	499.1
K-15	57.3	6.9	0.0	23.3	17.6	72.5	5.9	245.1	68.6	0.0	17.6	3.9	114.5	0.3	633.5
L-15	14.7	0.7	0.0	0.8	68.8	287.5	0.0	379.5	70.3	0.0	0.0	0.8	56.1	0.0	880.0
K-16	7.4	1.3	0.0	6.5	22.8	126.1	0.0	217.4	69.6	0.0	30.4	0.5	84.6	10.2	578.8
L-16	22.8	3.7	0.0	0.4	24.5	183.6	0.0	216.2	151.0	0.0	0.0	0.8	33.5	16.5	653.3
L-17	31.1	4.0	0.0	9.1	19.4	68.0	0.0	223.3	126.2	0.0	48.5	0.3	25.4	15.0	570.8
Subtotal	229.6	65.6	0.0	264.2	287.3	2,886.0	24.0	2,517.3	616.5	0.0	212.8	82.9	552.8	72.9	7,817.9
Mean	23.0	6.6	0.0	26.4	28.7	288.6	2.4	251.7	61.7	0.0	21.3	8.3	55.3	7.3	781.8
East Open															
N-20	31.6	1.7	0.0	3.1	10.0	68.0	11.0	440.0	41.5	0.0	104	33.2	19.8	5.8	770.2
N-21	70.7	2.3	0.0	8.0	11.8	246.1	31.4	270.6	19.6	0.0	0.0	5.9	78.1	0.0	752.2
O-21	139.8	6.7	2.1	4.0	26.9	15.4	14.4	209.6	19.2	19.2	0.0	21.2	22.7	6.9	508.1
P-21	7.2	2.0	0.0	3.1	0.0	25.7	19.8	15.8	2	57.4	0.0	33.7	107.7	4.0	278.8
O-22	244.7	0.5	0.0	1.9	0.0	15.7	2.0	84.3	4.9	0.0	0.0	7.8	7.2	0.6	370.1
N-22	115.4	2.2	0.0	1.6	11.8	59.8	0.0	351.0	21.6	0.0	0.0	3.0	40.4	6.1	613.6
P-22	107.1	1.2	0.0	1.9	11.9	121.8	45.5	20.0	14.0	13.9	0.0	0.7	15.9	2.6	357.2
P-23	223.9	0.2	0.0	7.0	2.3	77.6	1.0	21.7	4.3	9.8	0.0	29.7	10.5	6.1	395.2
O-23	106.7	73.8	9.8	54.5	14.3	42.9	128.6	309.5	19.4	6.2	0.0	62.8	32.7	28.0	899.5
Subtotal	1,047.1	90.6	11.9	85.1	89.0	673.0	253.7	1,722.5	146.5	106.5	104.0	197.9	335.0	60.1	4,944.8
Mean	116.3	10.1	1.3	9.5	9.9	74.8	28.2	191.4	16.3	11.8	11.6	22.0	37.2	6.7	549.4

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Table 3.–Page 2 of 2.

	Invertebrates				Fish										
Station	Pandalid Shrimp	Tanner Crab	Dungeness Crab	Other Invert.	Pacific Cod	Walleye Pollock	Halibut	Flathead Sole	Arrowtooth Flounder	Starry Flounder	Skate	Sculpin	Other Fish	Debris	Total Catch
								lb/nmi							
East Closed															
Q-24	277.9	2.6	0.0	7.6	9.7	58.2	7.8	32.7	2.4	23.3	0.0	9.9	10.7	2.0	446.4
R-24	178.9	14.3	5.9	130.1	43.6	47.9	16.2	28.7	9.6	112.9	21.8	7.2	18.7	75.6	715.1
R-25	473.8	0.0	0.0	2.9	76.6	123.7	21.3	80.5	14.2	76.6	0.0	3.0	32.1	12.4	920.0
S-25	364.3	5.8	2.9	23.4	0.0	63.6	9.8	35.4	5.4	233.3	0.0	21.9	66.0	44.5	879.2
T-26	643.1	1.1	0.8	17.6	58.8	6.5	44.1	69.0	10.8	241.2	0.0	28.1	52.9	25.9	1,209.8
U-27	1,760.3	0.5	1.6	19.3	7.8	42.6	54.4	1.9	17.7	198.1	0.0	1.0	36.1	13.6	2,174.2
Subtotal	3,698.3	24.3	11.2	200.9	196.5	342.5	153.6	248.2	60.1	885.4	21.8	71.1	216.5	174.0	6,344.7
Mean	616.4	4.0	1.9	33.5	32.8	57.1	25.6	41.4	10.0	147.6	3.6	11.9	36.1	29.0	1,057.4
Tutka Bay/Sadie Cove															
H-18	24.5	4.3	0.0	108.9	0.0	305.2	12.4	383.3	13.1	0.0	28.9	36.5	104.7	2.0	1,024.4
C/D-20	106.6	10.9	0.0	17.5	7.1	246.8	4.0	304.9	5.7	53.4	0.1	61.0	61.4	22.9	904.7
Subtotal	131.1	15.2	0.0	126.4	7.1	552.0	16.4	688.2	18.8	53.4	29.0	97.5	166.1	24.9	1,929.1
Mean	65.6	7.6	0.0	63.2	3.6	276.0	8.2	344.1	9.4	26.7	14.5	48.8	83.1	12.45	964.6
Among all stations															
Total	5,134.9	195.7	23.1	683.7	597.9	4,757.5	447.7	5,438.5	899.0	1,045.3	367.6	449.5	1,365.4	331.9	21,809.0
Mean	177.1	6.7	0.8	23.6	20.6	164.1	15.4	187.5	31.0	36.0	12.7	15.5	47.1	11.4	752.0
Percent	23.5%	0.9%	0.1%	3.1%	2.7%	21.8%	2.1%	24.9%	4.1%	4.8%	1.7%	2.1%	6.3%	1.5%	100.0%
Among Index Stations															
Total	5,004	180.5	23	557.3	590.8	4,205.5	431.3	4,750.3	880.2	991.9	338.6	352.0	1,199.3	307.0	19,879.9
Mean	185.3	6.7	0.9	20.6	21.9	155.8	16.0	175.9	32.6	36.7	12.5	13.0	44.4	11.4	736.3
Percent	25.3%	0.9%	0.1%	2.8%	3.0%	21.2%	2.2%	23.9%	4.4%	5.0%	1.7%	1.8%	6.0%	1.5%	100.0%

SHRIMP

The mean catch rate of all pandalid shrimp was 185.3 lb/nmi among the 27 index stations used in the population estimate (Table 4). The unstratified biomass estimate, with 95% confidence intervals, was 3,166,964 ±2,339,591 lb (*SE* = 1,137,933, *RP* = 0.74) and the stratified biomass estimate was 1,878,795 ±1,057,587 lb (*SE* = 514,390, *RP* = 0.55; Table 5).

Pandalid shrimp catch rates were greatest at the head of Kachemak Bay and decreased toward the mouth of the bay (Figure 2). Mean catches within stratum were: 616 lb/nmi in East Closed; 116 lb/nmi in East Open; 23 lb/nmi in Near West; and 14 lb/nmi in Far West (Table 6). East Closed stratum had the greatest catch rates, stations U-27 (1,760 lb/nmi) and T-26 (643 lb/nmi), and smallest catch rates occurred in the Near West stratum, stations K-13 (1 lb/nmi) and I-14 (2 lb/nmi; Table 4; Figure 2).

Shrimp Composition

Pandalid species comprised 24.0% of the total trawl catch among all stations and 98.7% of the total shrimp catch (Table 4). Among all sample stations, pandalid species were comprised of 93.2% northern, 2.6% sidestripe, 2.2% humpy, 1.4% other, 0.6% coonstripe, and 0.1% spot shrimps. Shrimp species composition within stratum was:

Far West	99.3% northern, 0.7% other
Near West	62.8% northern, 34.1% sidestripe, 2.6% other, 0.3% spot, 0.2% humpy
East Open	91.9% northern, 3.7% sidestripe, 2.1% other, 1.3% humpy, 0.6% coonstripe, 0.3% spot
East Closed	95.3% northern, 2.6% humpy, 1.1% other, 0.6% coonstripe, 0.4% sidestripe
Tutka Bay/Sadie Cove	95.3% northern, 2.2% other, 1.6% humpy, 0.9% coonstripe

Northern Shrimp Sex and Length

Northern shrimp in the Far West stratum were comprised of 0.03% male, 28.4% transitional, 66.1% female, and 5.2% ovigerous female shrimp (Figure 3). Mean carapace length was 12.7 mm for male, 16.8 mm for transitional, 17.2 mm for female, and 17.1 mm for ovigerous female shrimp. In the Near West stratum, sex composition was 3.6% male 25.2% transitional, 67.4% female, and 3.8 % ovigerous female shrimp. Mean carapace length was 11.8 mm for male, 16.5 mm for transitional, 17.7 mm for female, and 17.5 mm for ovigerous female shrimp. Sex composition in the East Open stratum was comprised of 3.3% males, 22.7% transitionals, 61.2% females, and 3.5% ovigerous females. Mean carapace lengths were 11.8 mm for males, 16.5 mm for transitionals, 17.7 mm for females and 17.5 mm for ovigerous females. Northern shrimp in the East Closed stratum were comprised of 4.9% male, 49.2% transitional, 43.9 female, and 2.0% ovigerous female shrimp. Mean length was 12.3 mm for male, 15.2 mm for transitional, 16.9 mm for female, and 16.7 mm for ovigerous female shrimp. Tutka Bay/Sadie Cove northern shrimp were comprised of 13.1% male, 48.4% transitional, 41.6% female, and no ovigerous female shrimp. Mean carapace length was 13.5 mm for male, 16.2 mm for transitional, and 17.9 mm for female shrimp.

Table 4.–Shrimp catch by station and strata in the Kachemak Bay index survey, May 2000.

Station	Northern Shrimp	Humpy Shrimp	Coonstripe Shrimp	Sidestripe Shrimp	Spot Shrimp	Commercial Pandalid Total	Other Shrimp Species
				lb/nmi			
Far West Stratum							
J-11	4.5	0.0	0.0	0.0	0.0	4.5	0.2
H-12	24.2	0.0	0.0	0.0	0.0	24.2	<0.1
Subtotal	28.7	0.0	0.0	0.0	0.0	28.7	0.2
Contribution	99.3%	0.0%	0.0%	0.0%	0.0%	99.3%	0.7%
Near West Stratum							
J-13	50.4	0.0	0.0	0.3	0.0	50.7	0.8
K-13	0.9	0.3	0.0	0.0	0.0	1.2	<0.1
H-14	9.7	0.0	0.0	0.0	0.0	9.7	0.2
K-14	32.7	0.0	0.0	0.5	0.0	33.2	1.1
I-14	1.5	0.0	0.0	0.0	0.0	1.5	0.3
K-15	19.5	0.0	0.0	37.8	0.0	57.3	0.0
L-15	12.4	0.0	0.0	1.5	0.8	14.7	0.8
K-16	3.7	<0.1	0.0	3.7	0.0	7.4	2.0
L-16	9.3	<0.1	0.0	13.5	0.0	22.8	0.3
L-17	7.9	0.1	0.0	23.1	0.0	31.1	0.5
Subtotal	148.0	0.4	0.0	80.4	0.8	229.6	6.1
Contribution	62.8%	0.2%	0.0%	34.1%	0.3%	97.4%	2.6%
East Open Stratum							
N-20	31.2	0.3	0.1	0.0	0.0	31.6	0.4
N-21	61.0	1.5	0.5	7.7	0.0	70.7	7.7
O-21	137.2	0.5	0.0	0.0	2.1	139.8	0.0
P-21	1.3	0.6	4.0	0.0	1.1	7.24	0.5
O-22	243.9	0.5	0.0	0.3	0.0	244.7	0.5
N-22	83.1	1.7	0.0	30.6	0.0	115.4	0.7
P-22	102.1	4.3	0.5	0.2	0.0	107.1	0.8
P-23	217.8	4.3	1.3	0.5	0.0	223.9	1.2
O-23	105.0	0.6	0.5	0.6	0.0	106.7	10.3
Subtotal	982.6	14.3	6.9	39.9	3.2	1047.1	22.1
Contribution	91.9%	1.3%	0.6%	3.7%	0.3%	97.9%	2.1%
East Closed Stratum							
Q-24	251.6	24.0	1.7	0.6	0.0	277.9	1.7
R-24	165	10.9	3.0	0.0	0.0	178.9	3.7
R-25	461.2	12.6	0.0	0.0	0.0	473.8	2.9
S-25	334.9	20.6	8.8	0.0	0.0	364.3	2.9
T-26	606.2	27.1	9.8	0.0	0.0	643.1	9.8
U-27	1,744.0	3.6	0.0	12.7	0.0	1,760.3	19.3
Subtotal	3,562.9	98.8	23.3	13.3	0.0	3,698.3	40.3
Contribution	95.3%	2.6%	0.6%	0.4%	0.0%	98.9%	1.1%

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Table 4.–(Page 2 of 2)

Station	Northern Shrimp	Humpy Shrimp	Coonstripe Shrimp	Sidestripe Shrimp	Spot Shrimp	Commercial Pandalid Total	Other Shrimp Species
				lb/nmi			
Tutka Bay/Sadie Cove							
H-18	24.1	0.2	0.2	0.0	0.0	24.5	0.6
C/D-20	103.7	1.9	1.0	0.0	0.0	106.6	2.4
Subtotal	127.8	2.1	1.2	0.0	0.0	131.1	3.0
Contribution	95.3%	1.6%	0.9%	0.0%	0.0%	97.8%	2.2%
Among All Stations							
Total lb/nmi	4,850.0	115.6	31.4	133.6	4.0	5134.6	71.6
Mean lb/nmi	167.2	4.0	1.1	4.6	0.1	177.1	2.5
Shrimp	93.2%	2.2%	0.6%	2.6%	0.1%	98.7%	1.4%
Total Catch	22.3%	0.5%	0.1%	0.6%	<0.1%	24.0%	0.3%
Among Index Stations							
Total lb/nmi	4,722.2	113.5	30.2	133.6	4.0	5,003.5	68.6
Mean lb/nmi	174.9	4.2	1.1	4.9	0.1	185.3	2.5
Shrimp	93.1%	2.2%	0.6%	2.6%	0.1%	98.7%	1.4%
Total Catch	23.8%	0.6%	0.2%	0.7%	<0.1%	25.3%	0.3%

Table 5.–Kachemak Bay unstratified and stratified pandalid shrimp population estimates, 1977-2000.

Year	Mean Catch (lb/nmi)	No. of Stations	Unstratified Estimate (million lb)	Relative Precision	Stratified Estimate (million lb)	Relative Precision	Relative Precision Difference	Commercial Harvest lb
Spring Surveys								
1977	407.9	40	6.82	0.26	6.45	0.22	0.04	5,037,946
1978	810.9	36	13.55	0.38	13.36	0.36	0.02	6,012,799
1979	743.9	41	12.43	0.31	12.26	0.33	-0.02	5,797,427
1980	500.9	40	8.37	0.26	8.06	0.28	-0.02	6,177,129
1981	486.1	37	8.12	0.27	7.17	0.23	0.04	4,995,499
1982	306.7	38	5.13	0.32	4.50	0.27	0.05	3,020,767
1983	204.0	37	3.41	0.37	3.28	0.23	0.14	525,508
1984	282.3	34	4.72	0.51	4.26	0.21	0.30	1,566,686
1985	221.7	34	3.70	0.59	3.49	0.23	0.36	1,249,728
1986	157.2	34	2.63	0.76	2.47	0.57	0.19	504,206
1987	178.9	34	2.99	0.67	2.69	0.25	0.42	0
1988	247.5	33	4.14	0.67	3.67	0.23	0.44	0
1989	119.5	39	2.04	0.90	1.73	0.66	0.24	0
1990	220.9	41	3.77	1.12	3.27	1.07	0.05	0
1991	83.0	41	1.42	0.55	1.11	0.44	0.11	0
1992	72.9	36	1.25	0.34	0.90	0.31	0.03	0
1993	10.4	35	0.18	0.41	0.12	0.39	0.02	0
1995	41.2	29	0.70	0.34	0.44	0.33	0.01	0
1997	18.8	28	0.32	0.44	0.24	0.37	0.07	0
2000	185.3	27	3.17	0.74	1.88	0.61	0.13	0
Fall Surveys								
1977	738.4	36	12.34	0.43	10.67	0.38	0.05	5,037,946
1978	1,160.3	32	19.39	0.38	17.2	0.42	-0.04	6,012,799
1979	1,133.3	32	18.94	0.35	18.33	0.36	-0.01	5,797,427
1980	1,689.4	37	28.23	0.29	27.19	0.32	-0.03	6,177,129
1981	604.8	35	10.11	0.40	9.71	0.44	-0.04	4,995,499
1982	519.2	36	8.68	0.39	8.22	0.27	0.12	3,020,767
1983	481.3	36	8.04	0.54	7.82	0.17	0.37	525,508
1984	532.0	35	8.89	0.39	7.47	0.21	0.18	1,566,686
1985	284.9	34	4.76	0.47	4.18	0.17	0.30	1,249,728
1986	153.6	34	2.57	0.56	2.35	0.27	0.29	504,206
1987	227.0	34	3.79	0.98	3.52	0.74	0.24	0
1988	161.9	35	2.77	0.76	2.05	0.49	0.27	0
1989	131.9	40	2.24	0.49	1.62	0.26	0.23	0
1990	104.5	42	1.78	0.67	1.50	0.37	0.30	0

Note: Fall survey discontinued in 1991.

Table 6.–Mean catch rates of pandalid shrimp, by stratum, 1977–2000.

	East Closed	East Open	Near West	Far West
	Catch by Stratum (lb/nmi)			
	Spring Surveys			
Year				
1977	585.2	772.2	495.7	214.4
1978	541.0	1,420.5	621.2	801.8
1979	474.0	718.1	858.0	744.1
1980	283.7	648.7	586.0	458.3
1981	572.3	590.8	836.5	207.3
1982	230.7	524.8	556.5	118.5
1983	521.3	543.6	195.8	42.4
1984	694.6	1,181.0	127.4	0.0
1985	786.0	886.0	5.8	0.0
1986	657.4	502.8	4.5	0.0
1987	976.0	150.0	54.5	0.0
1988	1,334.4	173.0	88.8	0.0
1989	729.3	22.3	5.5	0.1
1990	1,311.7	103.7	12.9	0.4
1991	337.2	92.5	34.3	1.3
1992	105.6	114.6	73.4	16.5
1993	10.9	17.1	13.4	1.4
1995	37.1	49.5	49.2	8.5
1997	22.9	7.7	29.8	7.1
2000	616.4	116.3	23.0	14.4
	Fall Surveys			
1977	731.3	961.2	1,595.4	189.4
1978	309.7	863.3	1,895.5	1,425.6
1979	376.9	616.2	1,540.2	1,127.5
1980	996.3	1,824.2	2,027.2	1,594.4
1981	378.3	623.7	759.9	556.1
1982	1,012.0	1,431.8	550.2	143.8
1983	2,101.6	1,322.5	152.9	0.0
1984	897.4	1,545.8	715.5	5.3
1985	612.8	1,101.5	201.7	0.0
1986	445.2	636.3	37.6	0.0
1987	1,403.8	162.3	4.5	0.0
1988	834.0	63.9	2.3	0.0
1989	499.0	197.0	6.8	0.5
1990	572.5	78.6	2.5	0.4

Note: Fall survey discontinued in 1991.

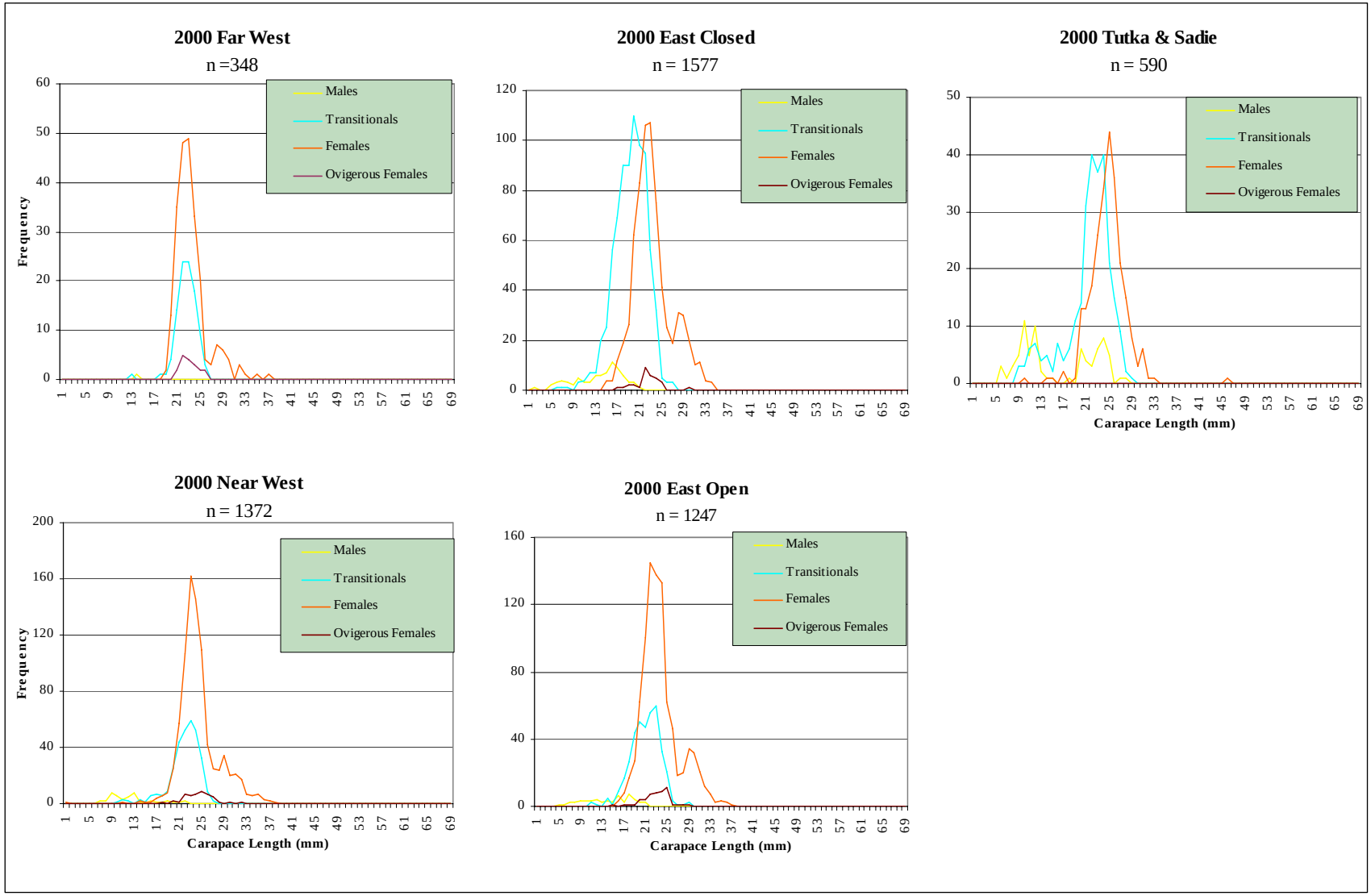


Figure 3.–Northern shrimp length distribution by sex and strata in the Kachemak Bay small-mesh trawl survey, 2000.

FISH AND NON-PANDALID INVERTEBRATES

Fish and non-pandalid invertebrates mean catch rate was 537.1 lb/nmi among index stations (Figure 4) and comprised 73.2% of the total catch (Table 7). The unstratified biomass estimate was 9,177,788 ±2,089,275 (*SE* = 1,035,547, *RP* = 0.23), and the stratified biomass estimate was 7,814,981 ±2,611,492 (*SE* = 1,270,181, *RP* = 0.33). Maximum observed catch rates were 1,617.3 lb/nmi from station H-14 and 1,173.3 lb/nmi from station K-13, both in the Near West stratum. Groundfish species yielding the greatest catch were flathead sole (25.0% of total), walleye pollock (21.9% of total), starry flounder (4.8% of total), arrowtooth flounder (4.1% of total), Pacific cod (2.8% of total), Sculpin (2.1% of total) and halibut (2.1% of total). Tanner crab comprised 0.9% and Dungeness crab 0.1% of the total catch (Appendix B1).

Flathead Sole

Catch rates of flat head sole ranged from 1.9 to 440.0 lb/nmi (Table 3; Figure 5) with a mean catch rate of 175.9 lb/nmi among index stations. The greatest observed catch rate was 440.0 lb/nmi at station N-20 in the East Open stratum. Mean catch rate by stratum was 344.1 lb/nmi in Tutka Bay/Sadie Cove, 251.7 lb/nmi in Near West, 191.4 lb/nmi in East Open, 131.2 in Far West, and 41.4 lb/nmi in East Closed. The unstratified biomass estimate among index stations was 3,006,544 ±883,823 lb/nmi (*SE* = 429,875, *RP* = 0.29) and the stratified biomass estimate was 2,585,985 ±1,153,833 lb/nmi (*SE* = 561,203, *RP* = 0.34).

Walleye Pollock

Walleye pollock catch rates ranged from 0 to 980.0 lb/nmi (Table 3; Figure 6) with a mean catch rate of 155.8 lb/nmi among all index stations. Maximum observed catches were 980.0 lb/nmi from station H-14 and 899.0 lb/nmi from station K-13. Mean catch rates by stratum were 288.6 lb/nmi in Near West, 276.0 lb/nmi in Tutka Bay/Sadie Cove, 152.0 lb/nmi in Far West, 74.8 lb/nmi in East Open, and 57.1 lb/nmi in East Closed. The unstratified biomass estimate among index stations was 2,661,718 ±1,601,661 lb (*SE* = 764,449, *RP* = 0.60), and the stratified biomass estimate was 2,672,129 ±878,066 lb (*SE* = 426,841, *RP* = 0.32).

Arrowtooth Flounder

Arrowtooth flounder catch rates ranged from 0 to 151.0 lb/nmi with a mean catch rate of 32.6 lb/nmi among index stations (Table 3; Figure 7). The greatest observed catch rates were 151.0 lb/nmi from station L-16 and 126.2lb/nmi from station L-17. Mean catch rates among strata were 61.7 lb/nmi in Near West, 28.6 lb/nmi in Far West, 16.3 lb/nmi in East Open, 10.0 lb/nmi in East Closed, and 9.4 lb/nmi from Tutka Bay/Sadie Cove. The unstratified biomass estimate was 557,093 ±255,967 (*SE* = 124,498, *RP* = 0.46) and the stratified estimate was 530,821 ±140,771 (*SE* = 68,469, *RP* = 0.26).

Pacific Cod

Pacific cod catch rates ranged from 0 to 116.0 lb/nmi with a mean catch of 21.9 lb/nmi among index stations (Table 3; Figure 8). Maximum catch rates were in Near West stratum at station H-14 (116.0 lb/nmi) and station L-15 (68.8 lb/nmi). Mean catch rates among strata were 32.8 lb/nmi in East Closed, 28.7 lb/nmi in Near West, 9.9 lb/nmi in East Open, 9.0 lb/nmi in Far West, and 3.6 lb/nmi in Tutka Bay/Sadie Cove. The unstratified biomass estimate among index stations was 373,927 ±189,135 (*SE* = 91,992, *RP* = 0.51) and the stratified estimate was 277,371 ±195,562 (*SE* = 95,118, *RP* = 0.69).

Table 7.–Kachemak Bay stratified and unstratified biomass estimates of fish and non-pandalid invertebrate species, 1977–2000.

Year	Mean Catch of Index Stations (lb/nmi)	No. of Stations	Unstratified Biomass Estimate (million lb)	Relative Precision (*RP* 95%CI)	Stratified Biomass Estimate (million lb)	Relative Precision (*RP* 95%CI)	Difference In Relative Precision
Spring Surveys							
1977	104.5	37	1.75	0.40	1.83	0.14	0.26
1978	150.5	31	2.51	0.28	2.63	0.12	0.16
1979	157.3	41	2.63	0.26	2.53	0.17	0.09
1980	82.9	34	1.38	0.26	1.47	0.18	0.08
1981	262.8	36	4.39	0.29	4.28	0.39	-0.10
1982	No data	34					
1983	132.0	37	2.99	0.31	2.16	0.39	-0.08
1984	179.1	34	4.91	0.21	3.15	0.16	0.05
1985	293.9	34	4.07	0.58	5.38	0.21	0.37
1986	243.4	34	3.60	0.59	4.06	0.71	-0.12
1987	215.2	34	11.03	0.33	3.37	0.38	-0.05
1988	660.3	33	9.48	0.13	10.83	0.14	-0.01
1989	554.8	39	8.82	0.35	9.71	0.45	-0.10
1990	516.1	41	10.98	0.18	7.59	0.20	-0.02
1991	642.3	41	10.23	0.17	10.6	0.17	0
1992	598.8	36	9.32	0.20	8.62	0.16	0.04
1993	545.7	35	14.19	0.15	8.99	0.18	-0.03
1995	826.5	29	15.63	0.16	12.87	0.36	-0.19
1997	515.3	28	8.81	0.18	7.54	0.44	-0.26
2000	537.1	27	9.18	0.23	7.81	0.33	-0.10
Fall Surveys							
1977	177.4	36	2.96	0.26	2.69	0.27	-0.01
1978	471.2	24	7.87	0.35	7.22	0.52	-0.17
1979	267.3	29	4.48	0.34	4.18	0.41	-0.07
1980	402.4	32	6.72	0.27	6.27	0.36	-0.09
1981	507.2	28	8.47	0.29	8.35	0.43	-0.14
1982	664.4	32	11.10	0.34	9.65	0.51	-0.17
1983	705.6	32	11.79	0.27	10.74	0.24	0.03
1984	475.0	35	7.94	0.35	6.97	0.38	-0.03
1985	927.8	34	15.50	0.42	17.21	0.11	0.31
1986	259.3	34	4.33	0.30	3.93	0.34	-0.04
1987	1,004.9	34	16.79	0.26	16.25	0.31	-0.05
1988	1,048.0	35	17.91	0.22	16.07	0.33	-0.11
1989	1,160.1	40	19.82	0.19	21.46	0.21	-0.02
1990	1,050.0	40	17.95	0.21	15.55	0.33	-0.12

Note: Fall survey discontinued in 1991.

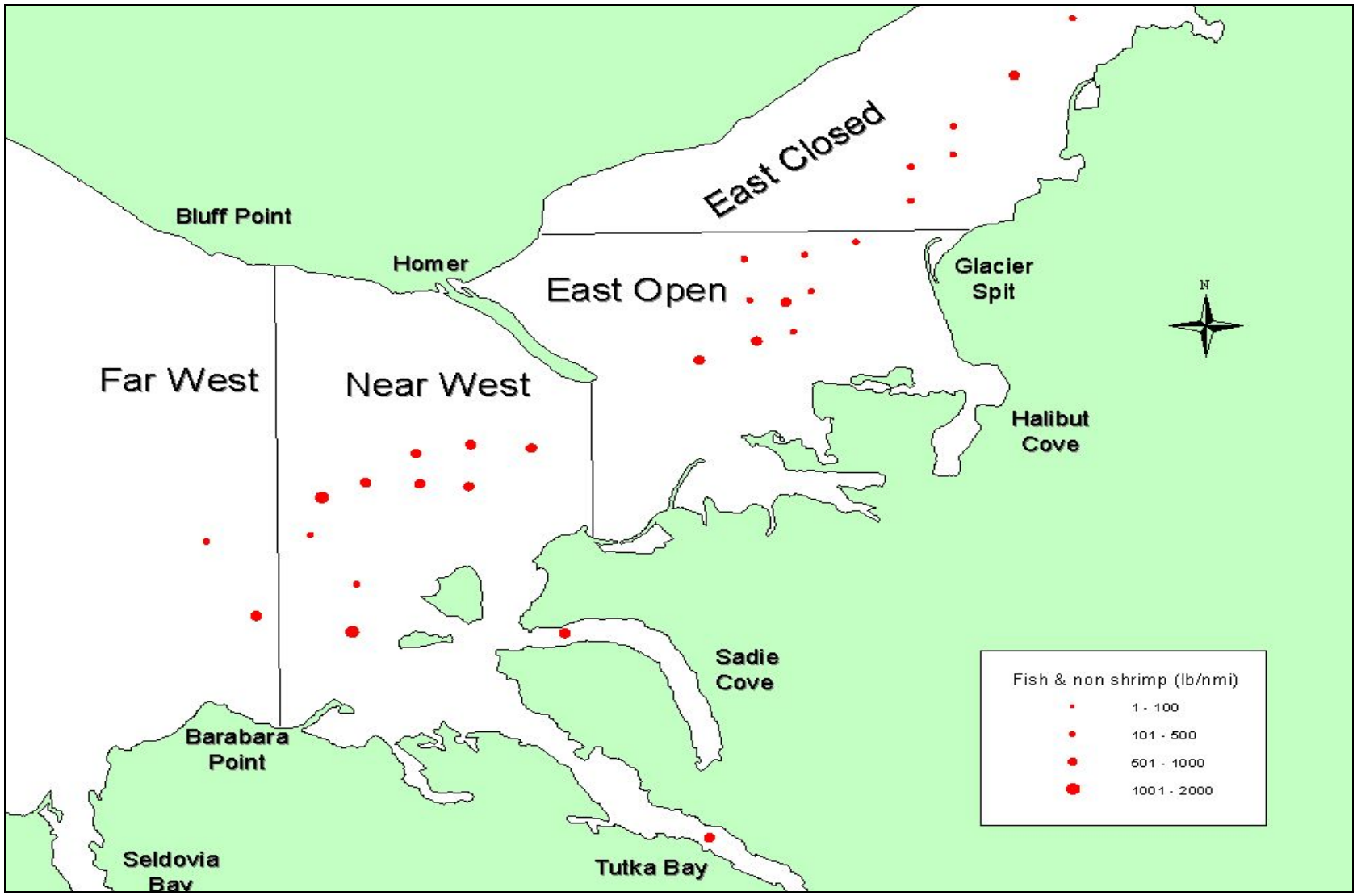


Figure 4.–Catch distribution of fish and non-pandalid invertebrates in the Kachemak Bay small-mesh trawl survey, 2000.

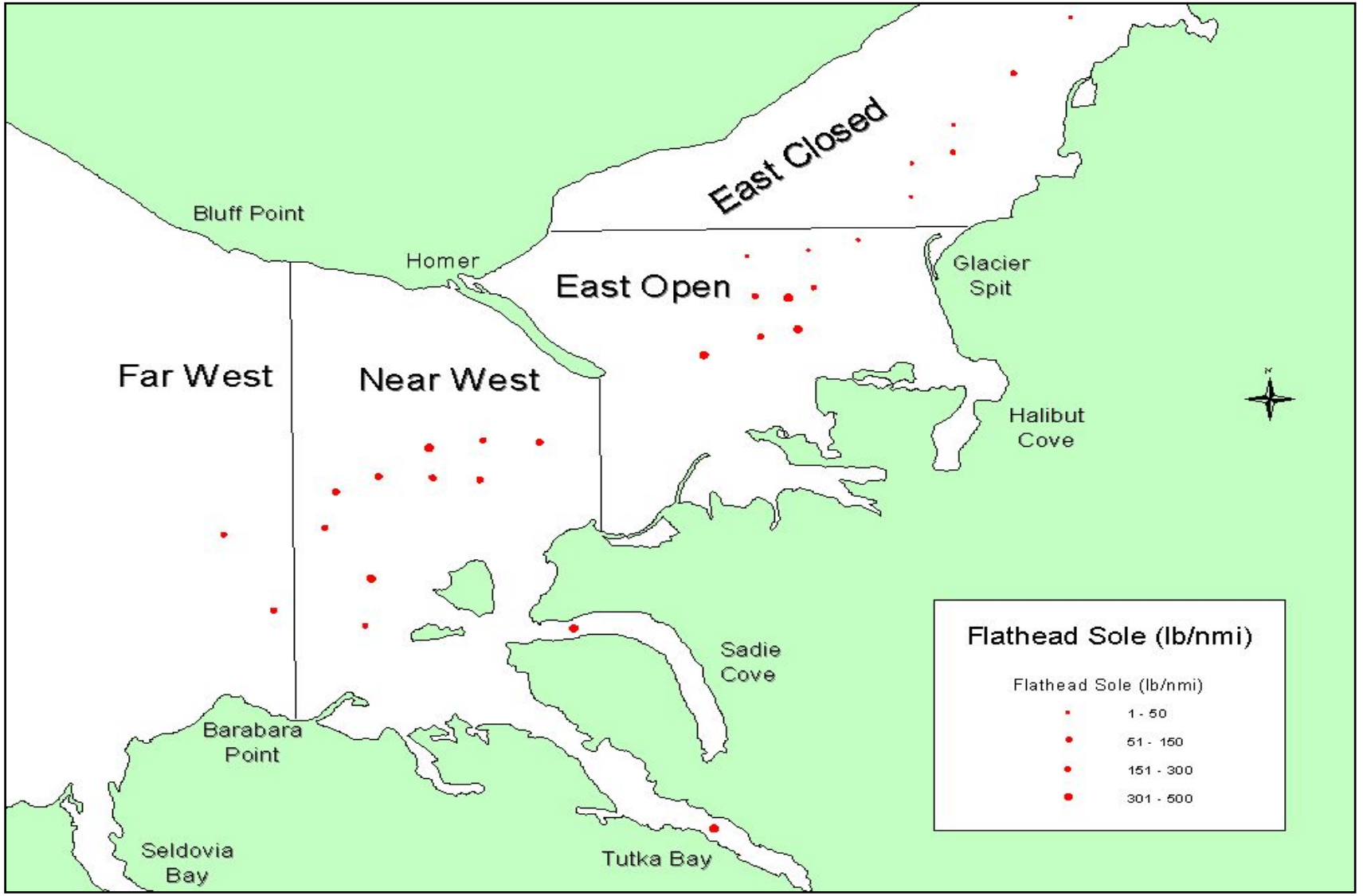


Figure 5.–Catch distribution of flathead sole in the Kachemak Bay small-mesh trawl survey, 2000.

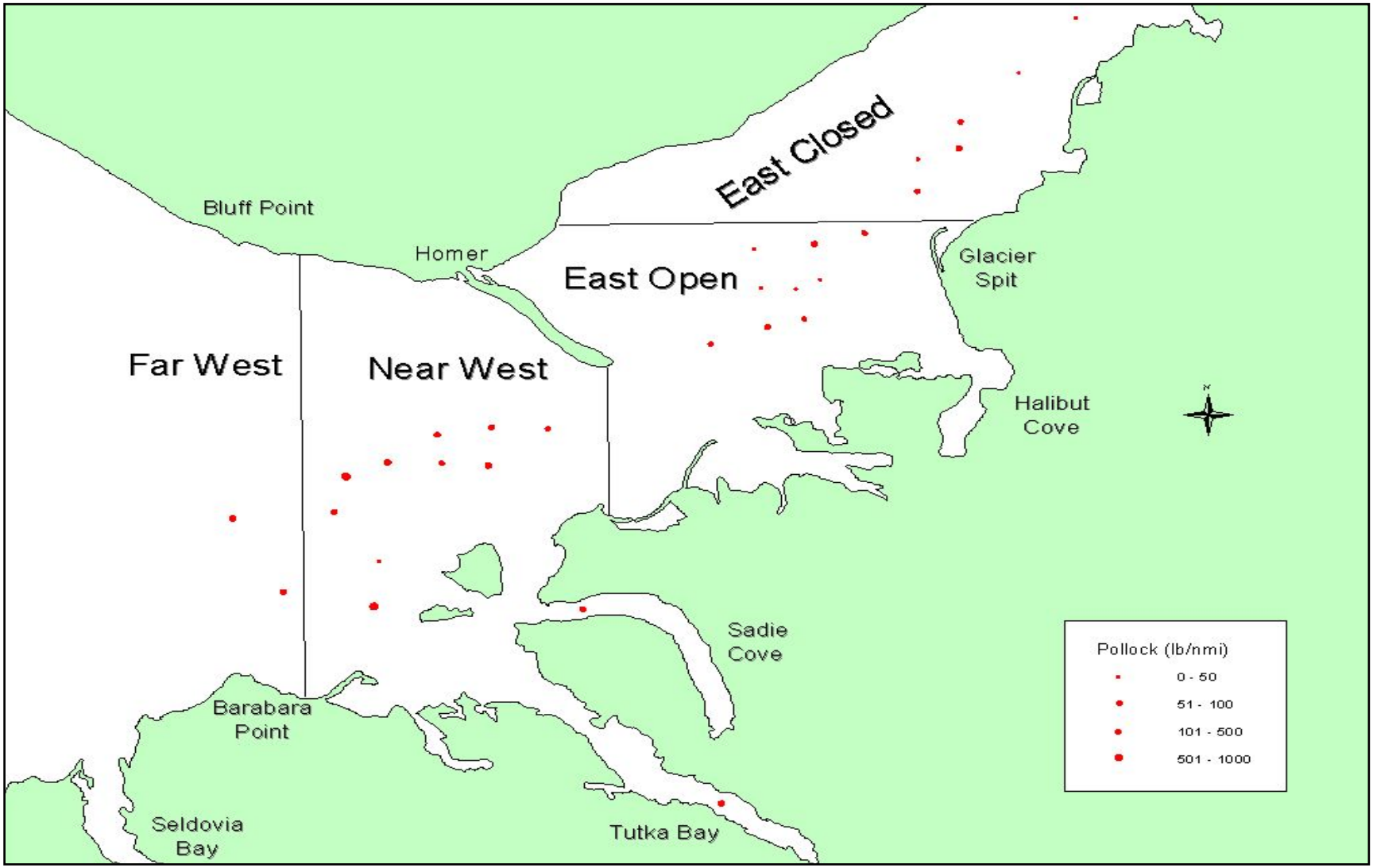


Figure 6.–Catch distribution of walleye pollock in the Kachemak Bay small-mesh trawl survey, 2000.

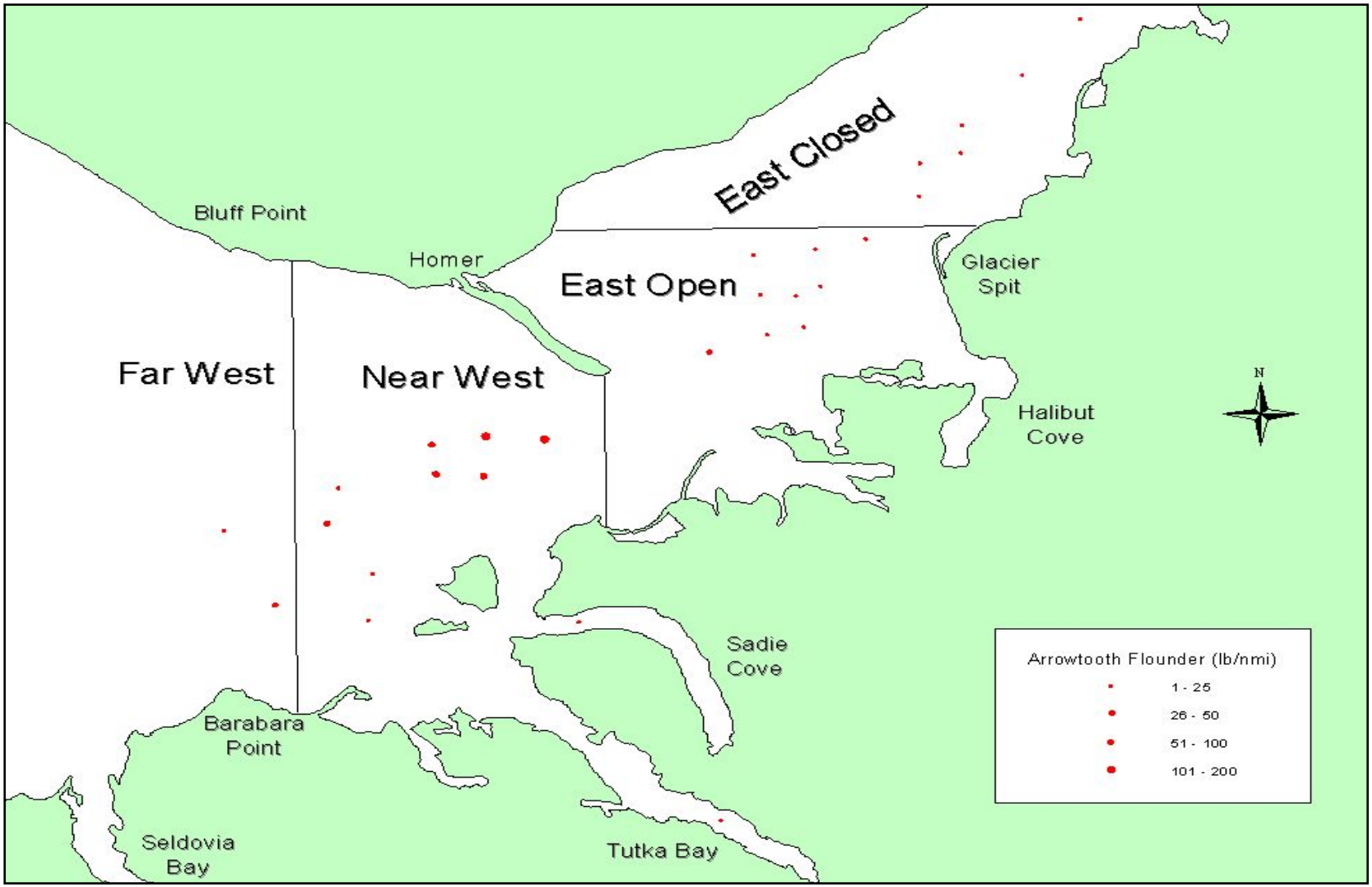


Figure 7.–Catch distribution of arrowtooth flounder in the Kachemak Bay small-mesh trawl survey, 2000.

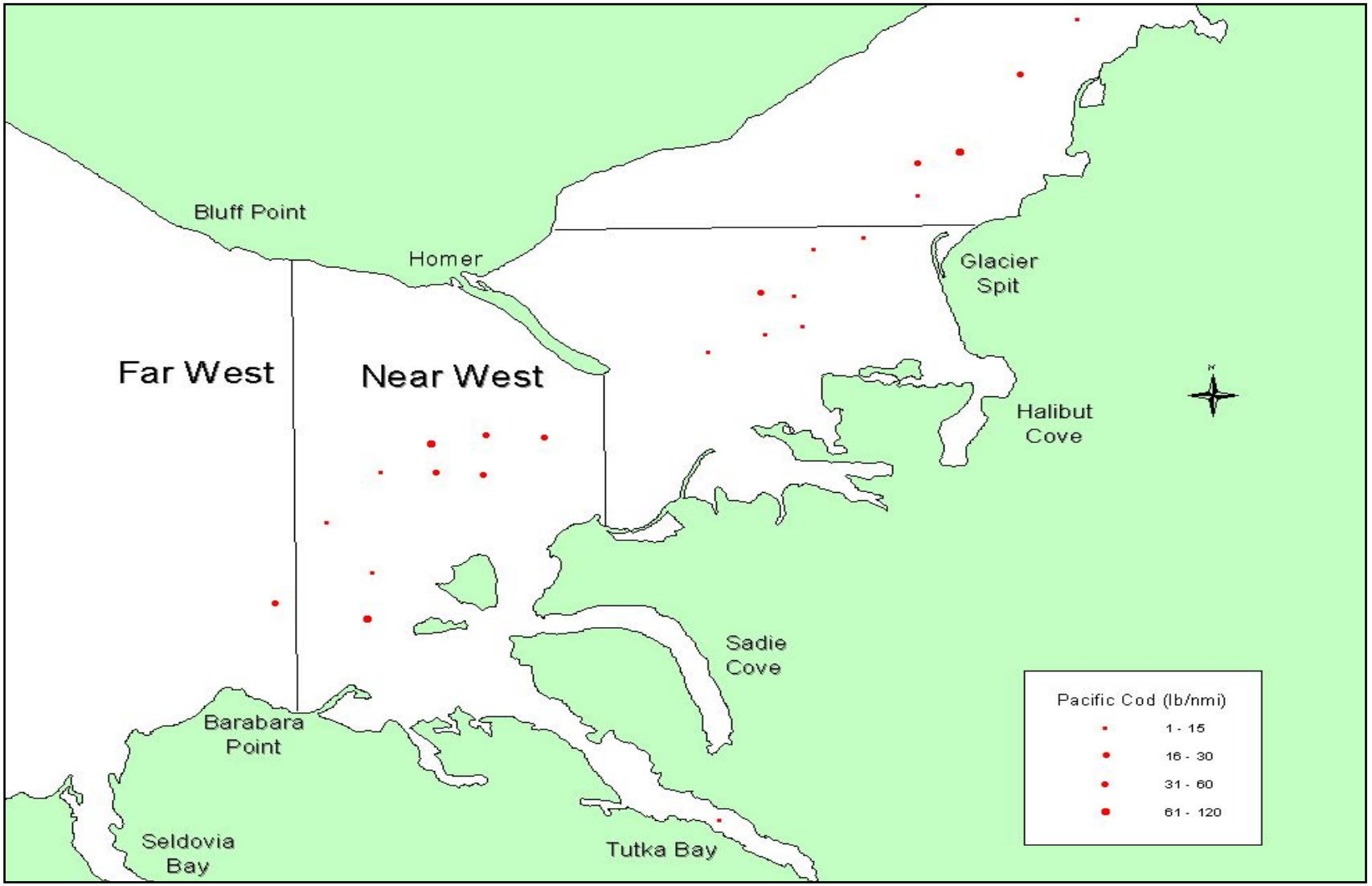


Figure 8.–Catch distribution of Pacific cod in the Kachemak Bay small-mesh trawl survey, 2000.

BOTTOM TEMPERATURE

Bottom temperatures were successfully recorded at the following stations and mean depths: 4.5°C at 35.5 fathoms from station Q-24; and 5.3°C at 41.5 fathoms at station H-18.

DISCUSSION

The 2000 survey indicated that pandalid shrimp population abundance in Kachemak Bay remains insufficient to support a commercial fishery. Although the stratified shrimp biomass index of 1,870,000 lb was the greatest biomass index since 1990 and represented a 10-fold increase from the previous survey in 1997, the 2000 index is substantially lower than the 4.5 to 13 million lb level that sustained the fishery from the late 1960s until the commercial fishery started to collapse in the early 1980s (Figure 9). It is encouraging that northern shrimp had the second largest biomass (22.3% of total catch biomass) species in the 2000 survey (Appendix B1). The highest pandalid shrimp catch rates occurred in the East Closed stratum (59% of total shrimp catch), with 21% of shrimp caught in the East Open stratum, 3% in the Near West stratum, 7% in Tutka Bay/Sadie Cove, and 4% caught in the Far West stratum (Appendices B2–B6). At the peak of the commercial fishery, mean survey catch rates for the East Open, Near West, and Far West Strata were typically above 500 lb/nmi (Table 6). As the shrimp population declined in the early 1980s, mean catch declined in the west and catch increased in the East Open stratum.

The stratified biomass index for fish and non-shrimp invertebrates increased 4% from the 1997 survey to 2000, with the increase primarily resulting in groundfish indices (Gustafson and Bechtol 2001; Table 7).

The 2000 survey showed the first increase in the shrimp biomass index in a decade. Increases in the shrimp population in Kachemak Bay and other areas along the northern Gulf of Alaska are thought to be correlated with a negative Pacific Decadal Oscillation (PDO) index (Anderson and Piatt 1999). Researchers at the University of Washington derived this standardized index utilizing several oceanographic and atmospheric parameters. The PDO index was in a negative or cool phase between 1947 and 1976, followed by a warming or positive phase between 1977 and 1988. The PDO fluctuated between warm and cold until 1998 and has been cool the past 5 years (Figure 10). Although only two bottom temperatures, 4.5ºC and 5.3ºC, were measured during the 2000 Kachemak Bay survey, these temperatures were within the optimal northern shrimp range of 3ºC to 6ºC described by Nunes (1984). ADF&G trawl surveys in the Kodiak District in 2000 exhibited the highest percent shrimp composition since 1983, although two harvest areas were above ADF&G's established minimum biomass indices (Ruccio 2003). In order for shrimp populations to recover cooler climatic conditions need to continue and predator groundfish populations need to decline.

The next small-mesh survey in Kachemak Bay is scheduled for May 2003.

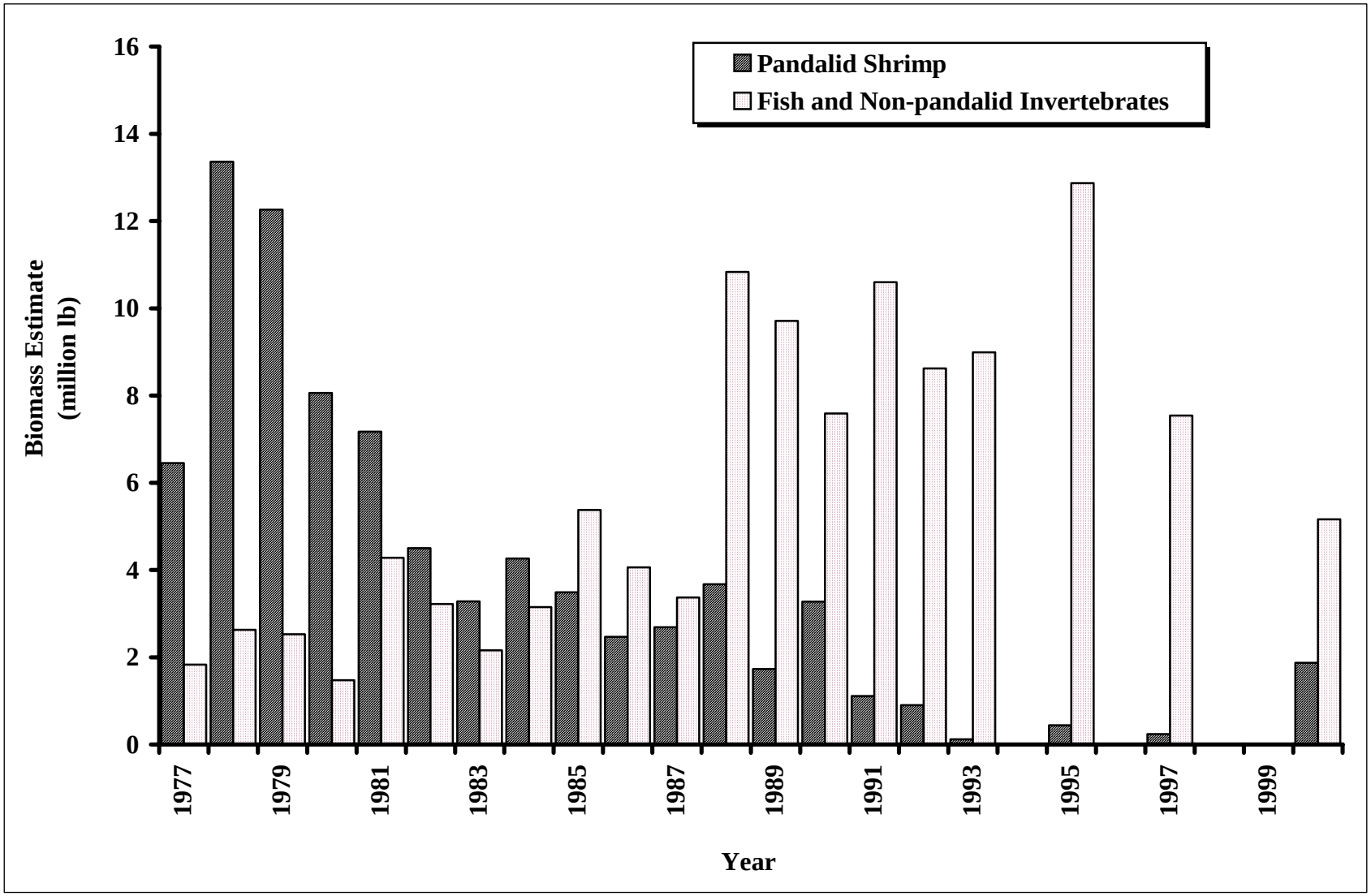
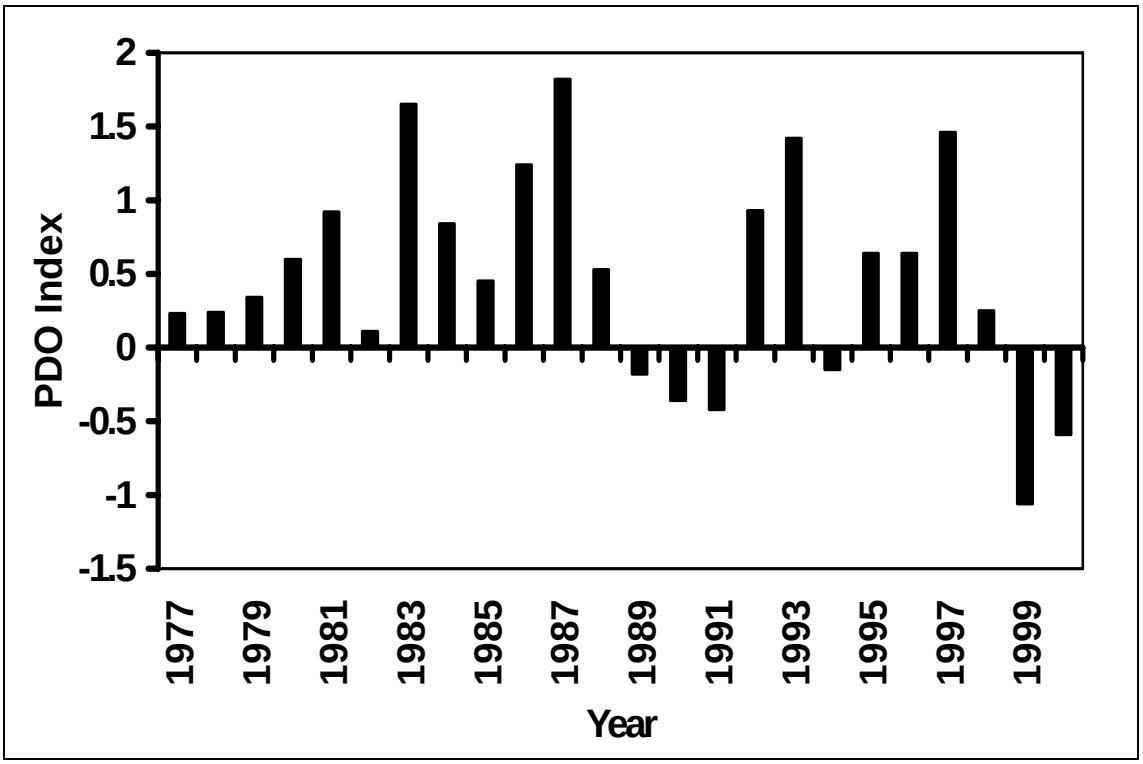


Figure 9.–Biomass index estimates of pandalid shrimp versus fish and non-pandalid invertebrates from the Kachemak Bay small-mesh trawl survey, 1997-2000.



Note: Source http://www.beringclimate.noaa.gov

Figure 10.–Pacific Decadal Oscillation Index, 1977–2000.

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Skipper Mark Hottmann and deckhands Frank Zellin and Tristan Demers of the research vessel *Pandalus* were highly proficient at gear setting and retrieval and a tremendous asset in sampling the survey catch. Richard Gustafson was responsible for most of the gear preparation and coordinated laboratory processing of shrimp samples. Sharon Delsack, Daisy Morton, and Tom Sigurdsson assisted with computer entry and error checking of field data. Individuals participating at various times in biological sampling of the catch included Ted Otis, Sharon Delsack, Greg Demers, Glenn Hollowell, Morris Lambdin, Scott Meyer, Marnee Beverage, Carolyn Bunker, Grace Thorton, Tom Sigurdsson, Nicky Szarzi, Chuck Adams, Richard Hocking, Dan Donnich, and students in the advanced science classes of Stan Eller at Homer High School. Critical review by several anonymous reviewers helped clarify this report.

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APPENDIX A.

Appendix A1.–Kachemak Bay small-mesh trawl survey tows, May 2000.

Tow No.	Date	Station	Tow Start Location Latitude (°N)	Tow Start Location Longitude (°W)	Tow End Location Latitude (°N)	Tow End Location Longitude (°W)	Duration (minutes)	Tow Length (nmi)	Compass Heading (° True)	Tow Depth (fathoms) Min.	Tow Depth (fathoms) Max.	Catch Weight (lb)
	5/09	J-11	59° 32.63’	151° 38.14’	59° 32.40’	151° 38.95’	14	0.50	236	44	46	Discarded
00101	5/09	J-11	59° 32.63’	151° 38.35’	59° 32.37’	151° 39.19’	13	0.50	240	45	46	123
00102	5/09	H-12	59° 30.61’	151° 36.16’	59° 31.07’	151° 37.90’	24	1.00	290	60	61	526
00103	5/09	K-13	59° 33.89’	151° 34.26’	59° 32.90’	151° 34.91’	30	1.05	195	51	56	1,233
	5/09	I-12	59° 31.70’	151° 36.42’	59° 31.25’	151° 36.88’	16	0.50	201	56	59	Discarded
00104	5/10	R-24	59° 40.15’	151° 13.81’	59° 40.50’	151° 11.95’	28	1.01	070	27	29	718
00105	5/10	U-27	59° 43.78’	151° 06.06’	59° 43.09’	151° 07.55’	28	1.03	226	25	35	2,220
00106	5/10	S-25	59° 40.96’	151° 12.16’	59° 41.37’	151° 10.37’	29	1.02	061	23	27	894
00107	5/10	T-26	59° 42.61’	151° 08.27’	59° 41.89’	151° 09.73’	28	1.02	225	28	35	1,224
00108	5/10	R-25	59° 40.81’	151° 10.55’	59° 40.26’	151° 12.12’	28	0.94	241	32	29	862
00109	5/11	N-21	59° 36.32’	151° 19.82’	59° 36.88’	151° 18.14’	28	1.02	060	42	43	759
00110	5/11	O-23	59° 37.07’	151° 15.95’	59° 37.81’	151° 15.20’	30	0.84	027	38	42	747
00111	5/12	N-22	59° 36.81’	151° 18.32’	59° 36.74’	151° 16.34’	26	1.02	089	43	54	623
00112	5/12	O-21	59° 37.73’	151° 17.96’	59° 37.28’	151° 19.78’	27	1.04	247	36	37	523
00113	5/12	P-21	59° 38.11’	151° 19.88’	59° 38.66’	151° 18.23’	26	1.01		17	21	281
	5/12	P-22	59° 38.29’	151° 17.70’	59° 38.73’	151° 15.94’	28	0.99	061	28	29	Discarded
00114	5/16	P-22	59° 38.68’	151° 15.90’	59° 38.24’	151° 17.69’	25	1.01	240	31	32	360
00115	5/13	L-15	59° 34.41’	151° 30.18’	59° 34.21’	151° 32.05’	27	0.96	250	57	58	844
00116	5/13	J-13	59° 32.76’	151° 34.05’	59° 32.47’	151° 35.96’	28	1.01	258	61	67	535
00117	5/13	K-15	59° 33.91’	151° 30.12’	59° 33.42’	151° 31.87’	27	1.02	233	73	82	646
00118	5/13	H-14	59° 30.97’	151° 33.76’	59° 29.97’	151° 33.48’	27	1.01	180	40	46	1,629

-continued-

Appendix A1.–Page 2 of 2.

Tow No.	Date	Station	Tow Start Location Latitude (°N)	Tow Start Location Longitude (°W)	Tow End Location Latitude (°N)	Tow End Location Longitude (°W)	Duration (minutes)	Tow Length (nmi)	Compass Heading (° True)	Tow Depth (fathoms) Min.	Tow Depth (fathoms) Max.	Catch Weight (lb)
00119	5/15	L-16	59° 34.54’	151° 28.14’	59° 34.41’	151° 30.08’	28	1.02	260	55	56	640
00120	5/15	L-17	59° 34.48’	151° 25.96’	59° 34.32’	151° 27.98’	28	1.03	257	64	66	586
00121	5/15	K-16	59° 33.66’	151° 28.35’	59° 33.51’	151° 30.12’	26	0.92	259	92	95	531
00122	5/15	K-14	59° 33.57’	151° 33.93’	59° 33.86’	151° 32.05’	26	1.01	080	58	63	673
00123	5/15	I-14	59° 31.61’	151° 32.53’	59° 31.38’	151° 34.19’	23	0.87	252	46	52	434
00124	5/15	C/D-20	59° 26.27’	151° 21.70’	59° 25.76’	151° 20.06’	27	1.00	112	42	49	904
00125	5/16	N-20	59° 36.96’	151° 20.05’	59° 36.30’	151° 21.54’	28	1.00	220	37	40	770
00126	5/16	O-22	59° 38.02’	151° 15.99’	59° 37.28’	151° 17.35’	27	1.02	224	35	39	377
00127	5/16	P-23	59° 38.94’	151° 14.18’	59° 38.48’	151° 15.74’	27	1.02	235	29	33	402
00128	5/16	Q-24	59° 39.99’	151° 12.28’	59° 39.21’	151° 13.56’	28	1.03	214	32	37	458
00129	5/17	H-18	59° 30.52’	151° 24.95’	59° 30.36’	151° 26.82’	28	0.97	260	34	49	994

APPENDIX B.

Appendix B1.–Ranking of species biomass among stations during the Kachemak Bay small-mesh trawl survey, 2000.

Rank	Common Name	Species Name		Percent
1	Flathead sole	*Hippoglossoides elassodon*		25.0
2	**Northern shrimp**	***Pandalus borealis***		22.3
3	Walleye pollock	*Theragra chalcogramma*		21.9
4	Starry flounder	*Platichthys stellatus*		4.8
5	Arrowtooth flounder	*Atheresthes stomias*		4.1
6	Pacific cod	*Gadus macrocephalus*		2.8
7	Sculpin	family Cottidae		2.1
8	Pacific halibut	*Hippoglossus stenolepis*		2.1
9	Yellowfin sole	*Pleuronectes aspera*		1.3
10	Sea star	Phylum Echinodermata		1.2
11	Anemone	Order Actiniaria		1.2
12	Rex sole	*Errex zachirus*		1.1
13	Eulachon smelt	*Thaleichthys pacificus*		1.0
14	Big skate	*Raja binoculata*		1.0
15	Tanner crab	*Chionoecetes bairdi*		0.9
16	Longnose skate	*Raja rhina*		0.7
17	**Sidestripe shrimp**	***Pandalopsis dispar***		0.6
18	Eelpout	*Lycodes* species		0.6
19	**Humpy shrimp**	***Pandalus goniurus***		0.5
20	Dusky rockfish,	*Sebastes ciliatus*		0.5
21	Alaska Plaice	*Pleuronectes quadrituberculatus*		0.4
22	Other shrimp	*Crangon, Eualus, Lebbus, Sclerocrngon*		0.3
23	Butter Sole	*Pleuronectes isolepsis*		0.3
24	Rougheye rockfish	*Sebastes aleutianus*		0.2
25	**Coonstripe shrimp**	***Pandalus hypsinotus***		0.1
26	Wolf-eel	*Anarrhicthy ocellatus*		0.1
27	Pacific herring	*Clupea pallasi*		0.1
47	**Spot shrimp**	***Pandalus platyceros***		<0.1
NR	Other animals		n = 37 species	0.2
NR	Debris			1.5
	Total			100.0
			Total fish	70.6
			Pandalid shrimp	**23.6**

Note: NR = Not Ranking

Appendix B2.–Ranking of species biomass in the Far West stratum during the Kachemak Bay small-mesh trawl survey, 2000.

Rank	Common Name	Species Name	Percent
1	Walleye pollock	*Theragra chalcogramma*	39.4
2	Flathead sole	*Hippoglossoides elassodon*	34.0
3	Arrowtooth flounder	*Atheresthes stomias*	7.4
4	Rex sole	*Errex zachirus*	5.0
5	**Northern shrimp**	***Pandalus borealis***	3.7
6	Dusky rockfish	*Sebastes ciliatus*	2.7
7	Pacific cod	*Gadus macrocephalus*	2.3
8	Redbanded rockfish	*Sebastes babcocki*	2.1
9	English sole	*Pleuronectes vetulus*	1.1
10	Anemone	Order *Actiniaria*	0.9
11	Dover sole	*Microstomus pacificus*	0.6
12	Eulachon smelt	*Thaleichthys pacificus*	0.6
13	Rougheye rockfish	*Sebastes aleutianus*	0.2
14	Eelpout	*Lycodes species*	0.1
15	Other shrimp	*Crangon, Eualus, Lebbus, Sclerocrngon*	<0.1
16	Tanner crab	*Chionoecetes bairdi*	<0.1
17	Prickleback	Family Stichaeidae	<0.1
18	Sea star	Phylum Echinodermata	<0.1
19	Pentameria	*Pentamera species*	<0.1
20	Decorator crab	*Oregonia gracilis*	<0.1
		Total	100.0
		Total fish	95.4
		Pandalid shrimp	**3.7**

Appendix B3.–Ranking of species biomass in the Near West stratum during the Kachemak Bay small-mesh trawl survey, 2000.

Rank	Common Name	Species Name	Percent
1	Walleye pollock	*Theragra chalcogramma*	36.9
2	Flathead sole	*Hippoglossoides elassodon*	32.2
3	Arrowtooth flounder	*Atheresthes stomias*	7.9
4	Pacific cod	*Gadus macrocephalus*	3.7
5	Anemone	Order *Actiniaria*	2.5
6	Rex sole	*Errex zachirus*	1.9
7	**Northern shrimp**	***Pandalus borealis***	1.9
8	Longnose skate	*Raja rhina*	1.5
9	Eulachon smelt	*Thaleichthys pacificus*	1.3
10	Big skate	*Raja binoculata*	1.2
11	Sculpin	Family Cottidae	1.1
12	**Sidestripe shrimp**	***Pandalopsis dispar***	1.0
13	Dusky rockfish	*Sebastes ciliatus*	1.0
14	Tanner crab	*Chionoecetes bairdi*	0.8
15	Butter sole	*Pleuronectes isolepsis*	0.7
16	Rougheye rockfish	*Sebastes aleutianus*	0.5
17	Eelpout	*Lycodes species*	0.4
18	Alaska plaice	*Pleuronectes quadrituberculatus*	0.3
19	Pacific halibut	*Hippoglossus stenolepis*	0.3
20	Dover sole	*Microstomus pacificus*	0.3
21	Mussel	Genus *Modulis*	0.2
22	Octopus	*Octopus dofleini*	0.2
23	Snailfish	*Liparis species*	0.2
24	Green urchin	*Strongylocentrotus droebachiensis*	
25	Prickleback	Family Stichaeidae	0.1
26	Sea star	Phylum Echinodermata	0.1
27	Other shrimp	*Crangon, Eualus, Lebbus, Sclerocrangon*	0.1
41	**Spot shrimp**	***Pandalus platyceros***	<0.1
46	**Humpy shrimp**	***Pandalus goniurus***	<0.1
NR	Other animals	n = 25 species in this stratum	0.5
NR	Debris		0.9
	Total		100.0
		Total fish	91.7
		Pandalid Shrimp	**2.9**

Note: NR =Not Ranking

Appendix B4.–Ranking of species biomass in the East Open stratum during the Kachemak Bay small-mesh trawl survey, 2000**.**

Rank	Common Name	Species Name	Percent
1	Flathead sole	*Hippoglossoides elassodon*	35.0
2	**Northern shrimp**	***Pandalus borealis***	20.0
3	Walleye pollock	*Theragra chalcogramma*	13.7
4	Pacific halibut	*Hippoglossus stenolepis*	5.2
5	Sculpin	*family Cottidae*	4.0
6	Arrowtooth flounder	*Atheresthes stomias*	3.0
7	Starry flounder	*Platichthys stellatus*	2.2
8	Tanner crab	*Chionoecetes bairdi*	1.8
9	Big skate	*Raja binoculata*	1.8
10	Pacific cod	*Gadus macrocephalus*	1.8
11	Eelpout	*Lycodes species*	1.6
12	Eulachon smelt	*Thaleichthys pacificus*	1.3
13	Yellowfin sole	*Pleuronectes aspera*	1.2
14	**Sidestripe shrimp**	***Pandalopsis dispar***	0.8
15	Anemone	*Order Actiniaria*	0.7
16	Wolf-eel	*Anarrhicthy ocellatus*	0.6
17	Rex sole	*Errex zachirus*	0.5
18	Alaska plaice	*Pleuronectes quadrituberculatus*	0.4
19	Other shrimp	*Crangon, Eualus, Lebbus, Sclerocrngon*	0.4
20	Pacific herring	*Clupea pallasi*	0.4
21	Pacific tomcod	*Microgadus proximus*	0.4
22	**Humpy shrimp**	***Pandalus goniurus***	0.3
23	Longnose skate	*Raja rhina*	0.3
24	Sea star	*Phylum Echinodermata*	0.3
25	Dungeness crab	*Cancer magister*	0.2
26	**Coonstripe shrimp**	***Pandalus hypsinotus***	0.1
30	**Spot shrimp**	***Pandalus platyceros***	0.1
NR	Other animals	n = 25 species in this stratum	0.7
NR	Debris		1.2
	Total		100.0
		Total fish	73.7
		Pandalid shrimp	**21.3**

Note: NR = Not Ranking

Appendix B5.–Ranking of species biomass in the East Closed stratum during the Kachemak Bay small-mesh trawl survey, 2000.

Ranking	Common Name	Species Name	Percent
1	**Northern shrimp**	***Pandalus borealis***	56.5
2	Starry flounder	*Platichthys stellatus*	14.0
3	Walleye pollock	*Theragra chalcogramma*	5.4
4	Flathead sole	*Hippoglossoides elassodon*	3.9
5	Pacific cod	*Gadus macrocephalus*	3.1
6	Pacific halibut	*Hippoglossus stenolepis*	2.4
7	Sea star	Phylum *Echinodermata*	2.3
8	**Humpy shrimp**	***Pandalus goniurus***	1.6
9	Yellowfin sole	*Pleuronectes aspera*	1.3
10	Sculpin	Family *Cottidae*	1.1
11	Arrowtooth flounder	*Atheresthes stomias*	1.0
12	Eulachon smelt	*Thaleichthys pacificus*	0.7
13	Other shrimp	*Crangon, Eualus, Lebbus, Sclerocrngon*	0.6
14	Alaska plaice	*Pleuronectes quadrituberculatus*	0.5
15	Tanner crab	*Chionoecetes bairdi*	0.4
16	**Coonstripe shrimp**	***Pandalus hypsinotus***	0.4
17	Longnose skate	*Raja rhina*	0.3
18	**Sidestripe shrimp**	***Pandalopsis dispar***	0.2
19	Eelpout	*Lycodes species*	0.2
20	Pacific herring	*Clupea pallasi*	0.2
21	Dungeness crab	*Cancer magister*	0.2
22	Sea anemone	Order *Actiniaria*	0.2
23	Pacific tomcod	*Microgadus proximus*	0.1
24	Stugon poacher	*Agonus acipenserinus*	0.1
25	Butter sole	*Pleuronectes isolepsis*	0.1
26	Sablefish	*Anoplopoma fimbria*	<0.1
27	Pacific sandfish	*Trichodon trichodon*	<0.1
NR	Other animals	n = 9 species from this stratum	0.1
NR	Debris		2.8
	Total		100.0
		Total fish	34.8
		Pandalid shrimp	**58.7**

Note: NR = Not Ranking

Appendix B6.–Ranking of species biomass in the Tutka Bay and Sadie Cove stratum during the Kachemak Bay small-mesh trawl survey, 2000.

Rank	Common Name	Species Name	Percent
1	Flathead sole	*Hippoglossoides elassodon*	35.7
2	Walleye pollock	*Theragra chalcogramma*	28.7
3	Yellowfin sole	*Pleuronectes aspera*	7.1
4	**Northern shrimp**	***Pandalus borealis***	6.6
5	Sculpin	Family Cottidae	5.1
6	Sea star	*Phylum Echinodermata*	4.7
7	Starry flounder	*Platichthys stellatus*	2.8
8	Big skate	*Raja binoculata*	1.5
9	Rex sole	*Errex zachirus*	1.0
10	Arrowtooth flounder	*Atheresthes stomias*	1.0
11	Pacific halibut	*Hippoglossus stenolepis*	0.9
12	Tanner crab	*Chionoecetes bairdi*	0.8
13	Red king crab	*Paralithodes camtschaticus*	0.7
14	Pentameria	*Pentamera species*	0.7
15	Pacific cod	*Gadus macrocephalus*	0.4
16	Other shrimp	*Crangon, Eualus, Lebbus, Sclerocrngon*	0.2
17	Redbanded rockfish	*Sebastes babcocki*	0.1
18	Prickleback	Family Stichaeidae	0.1
19	**Humpy shrimp**	***Pandalus goniurus***	0.1
20	Sea anemone	Order Actiniaria	0.1
21	Dusky rockfish	*Sebastes ciliatus*	0.1
22	**Coonstripe shrimp**	***Pandalus hypsinotus***	0.1
23	Jellyfish	Class Scyphozoa	0.1
24	Eelpout	*Lycodes species*	<0.1
25	Pacific sandfish	*Trichodon trichodon*	<0.1
26	Eulachon smelt	*Thaleichthys Pacificus*	<0.1
27	Miscelaneous clam	Class Bivalva	<0.1
28	Rock sole	*Pleuronectes bilineatus*	<0.1
29	Capelin	*Mallotus villosus*	<0.1
30	Rougheye rockfish	*Sebastes aleutianus*	<0.1
NR	Debris		1.3
	Total		100.0
		Total fish	84.5
		Pandalid Shrimp	**6.8**

Note: NR = Not Ranking