TRAWL SHRIMP INDEX FISHING IN THE SOUTHERN DISTRICT OF THE COOK INLET AREA

SPRING 1991

By: Lee F. Hammarstrom

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TRAWL SHRIMP INDEX FISHING IN THE SOUTHERN DISTRICT OF THE COOK INLET AREA

MAY 6 - MAY 23, 1991

Lower Cook Inlet Data Report Number 91-04

by

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INTRODUCTION

The commercial trawl shrimp fishery in the Cook Inlet Management Area (H) began with intermittent harvests in the 1950's and early 1960's, but the small catches did not accurately reflect the size of the stocks in the area. In the late 1960's trawl catches reached the five million pound level annually and remained near that level through the early 1980's (Table 1, Figure 1). More recently, the commercial fishery has been closed since the fall of 1986 due to low abundance levels. Pink shrimp (*Pandalus borealis*) historically made up the bulk of the commercial catch, with sidestripes (*Pandalopsis dispar*) seasonally making up a lower but still significant portion of the catch. Humpy shrimp (*Pandalus goniurus*) at times comprised up to 50 percent of the annual commercial harvest, but this species appears to undergo the most erratic population fluctuations and their contribution to the most recent fisheries were minor. Finally, coonstripes (*P. hypsinotus*) consistently made up approximately five percent or less of the harvest. Effort has varied from a low of one vessel during 1968 to a high of 23 in 1981.

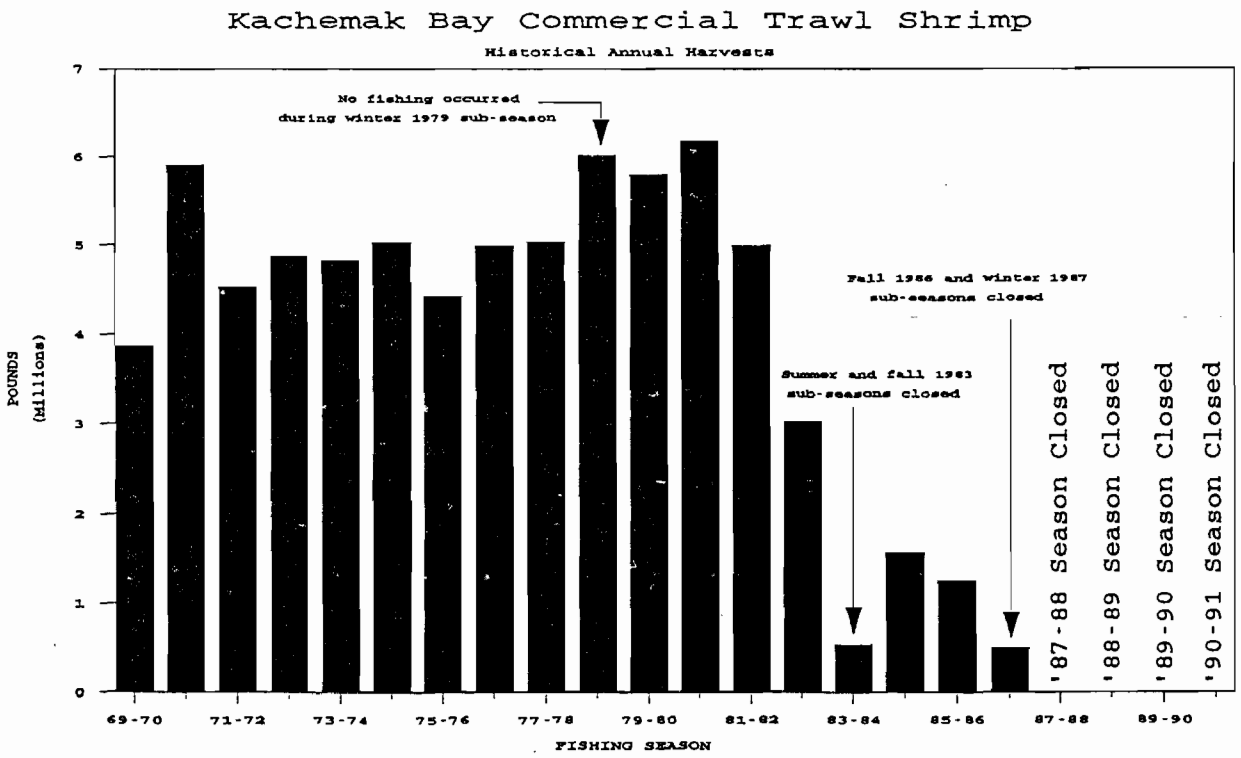

Figure 1. Commercial trawl shrimp harvests in Area H of the Cook Inlet Management Area, 1969-1991.

Trawl shrimp population abundance index surveys have been conducted by the Department in the Southern District once each year (May) from 1971 through 1975 and twice annually (May and October) since then. Results of the surveys have been used to monitor stock

status and establish harvest guidelines for each of the three regulatory sub-seasons (summer, fall, and winter) during the fishing year. Eight new sampling stations were added to the survey during the spring of 1988 east of the Homer Spit because this area had become the major area of shrimp occurrence. Expanding the number of stations in this area also increased the statistical accuracy of the survey estimate of abundance.

METHODS

The spring 1991 trawl index survey was conducted aboard the state research vessel **PANDALUS** during the period May 6 through May 10 and May 20 through May 23. No trawling occurred during the week of May 13 through May 17 due to a series of very large tidal fluctuations, making trawling more difficult and the results unreliable. The survey utilizes a 61-foot National Marine Fisheries Service (NMFS) designed high opening shrimp net. This particular style of net, used in the surveys since 1975, replaced a 66-foot Nordby trawl net utilized for the surveys between 1971 through 1974. Based on comparative tows, the older Nordby net was assumed to be 50 percent as efficient as the newer NMFS net (Davis, 1982).

Individual one nautical mile tows were made in systematically selected one-square mile stations throughout Kachemak Bay, Tutka Bay, and Sadie Cove. In recent years, to reduce the potential of net damage, one-half mile tows were utilized in stations west of Homer Spit which have had a recent history of no shrimp catch. If tows in the one-half mile stations indicated presence of shrimp, the tow was repeated with a length increase to the standard distance of one mile.

Upon completion of each tow, the total catch was weighed to the nearest two pounds using a digital electronic hanging scale and subsequently dumped on the rear deck. All very large non-shrimp objects (rocks, stumps, pots, large fish, etc.) were removed from the catch, weighed directly, and returned over the side of the vessel. Additionally, all Pacific halibut (*Hippoglossus stenolepis*) and large Pacific cod (*Gadus macrocephalus*) were sorted out of the catch prior to sampling. These two species were then counted and weighed.

For those catches containing shrimp, generally two random samples of approximately 10,000 grams each (3 gallon bucket) were collected from individual tows of five hundred pounds or more; for catches of less than five hundred pounds, one such sample was collected. Each 10,000 gram bucket sample was then separated by fish and other non-shrimp material (which included finfish, flatfish, shellfish other than shrimp, and any miscellaneous debris), and shrimp. Each of these groups was weighed on an electronic platform scale to obtain percentages of the total catch.

A 2,500 gram subsample was next randomly selected from the shrimp in the original 10,000 gram sample. The shrimp were further separated by species. Each species was weighed separately for species composition. In addition, small quantities of shrimp from the subsample were labelled and retained for later length frequency analysis in the laboratory. In the case of pink shrimp, which generally comprise the highest percentage of each shrimp subsample, a quantity of approximately 350 to 400 grams was retained from each station. For the other species, normally all individuals were retained since they usually amounted to a relatively small number of shrimp per station subsample.

For those tows which contained no shrimp or relatively few shrimp, one or two basket samples of approximately 15,000 to 25,000 grams each were collected randomly from the catch. Fish and other non-shrimp material were subsequently separated by species, counted, and weighed in order to obtain a more accurate estimate of fish species composition in areas of little or no shrimp occurrence.

RESULTS

A total of 33 successful tows from those stations utilized in the survey design prior to the spring of 1988 ("traditional stations") yielded an overall average catch of 79.5 pounds of Pandalid shrimp per one nautical mile towed (Table 2). When the data from the eight stations added to the surveys in 1988 ("non-traditional" stations) east of Homer Spit were included in the survey results, the average catch of shrimp increased to 82.7 pounds per nautical mile towed. These figures do not include any catch data from the Tutka Bay/Sadie Cove areas since those areas are closed to commercial trawling. It should also be noted that two separate attempts were made to sample station K15, west of Homer Spit, but both attempts were unsuccessful and both resulted in rather extensive net and hardware damage.

The average catches of Pandalid shrimp per nautical mile by respective area were 252.5 pounds per tow east of the Homer Spit in traditional stations only (Table 3, Figure 2), 178.8 pounds per tow east of the Homer Spit (all stations combined), 14.5 pounds per tow west of the Spit (Table 3, Figure 3), and 107.1 pounds per tow in Tutka Bay/Sadie Cove (Table 3, Figure 4). The abundance index estimate for the Southern District based on the results of the spring 1991 survey for the traditional stations only ranged from 0.7 to 1.9 million pounds with a midpoint of 1.3 million pounds (Table 2, Figure 5). Calculating in the non-traditional stations, the abundance index midpoint estimate was 1.4 million pounds, with a range of 0.9 to 1.9 million pounds. Formulas and explanations used to calculate the midpoint estimate and range are shown in Appendix Table 1.

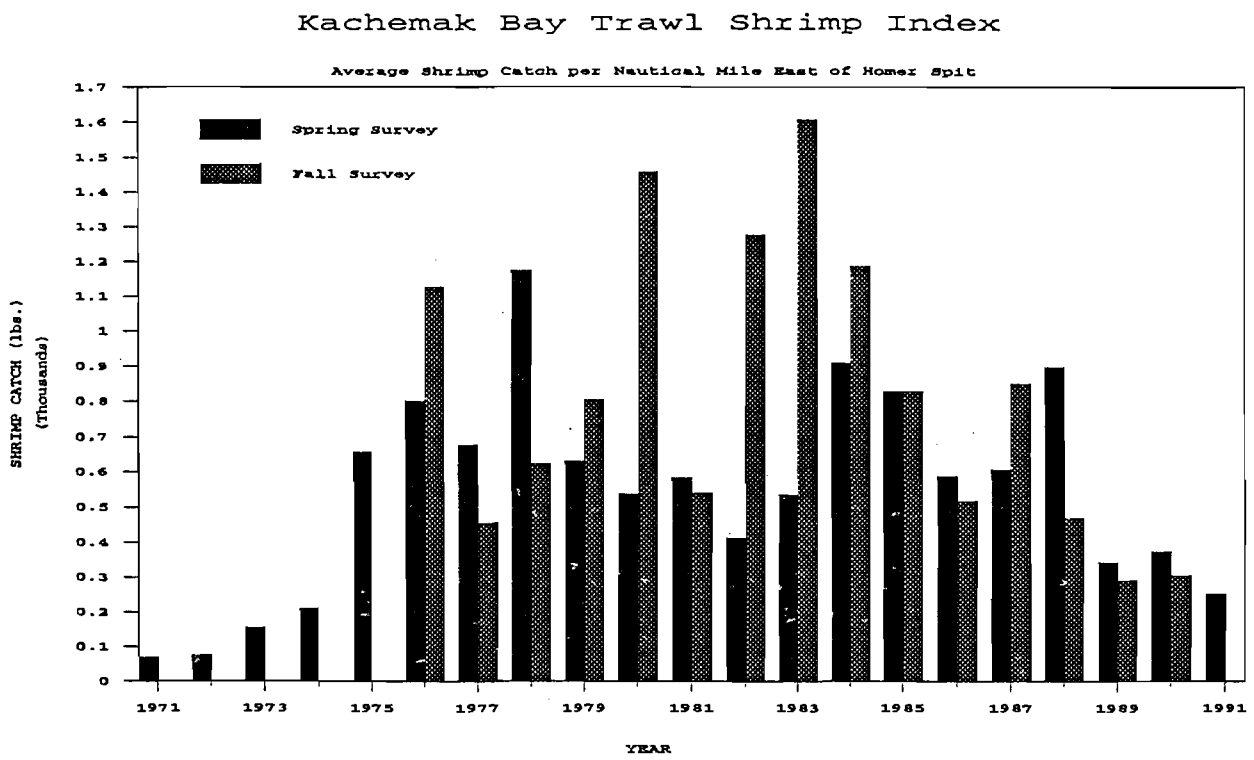

Figure 2. Catches of Pandalid shrimp per one nautical mile east of the Homer Spit in the Kachemak Bay, Alaska trawl shrimp index of abundance surveys.

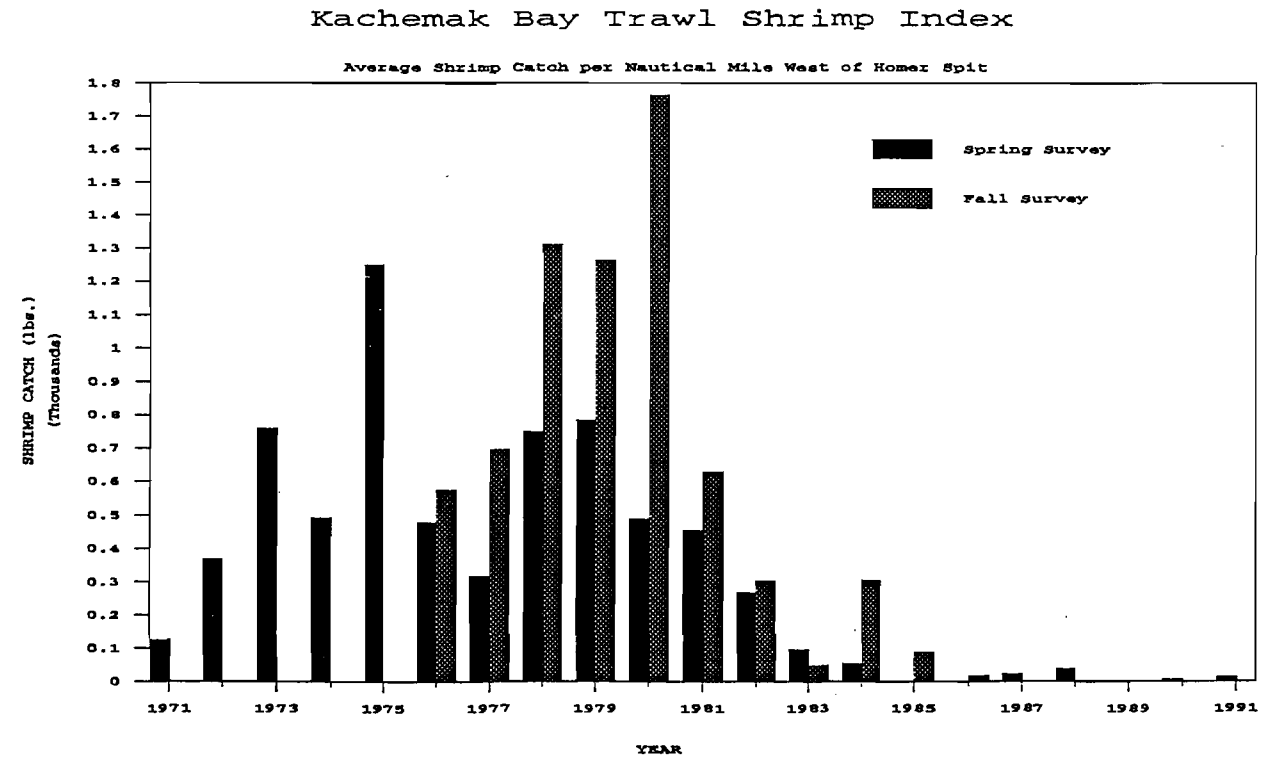

Figure 3. Catches of Pandalid shrimp per one nautical mile west of the Homer Spit in the Kachemak Bay, Alaska trawl shrimp index of abundance surveys.

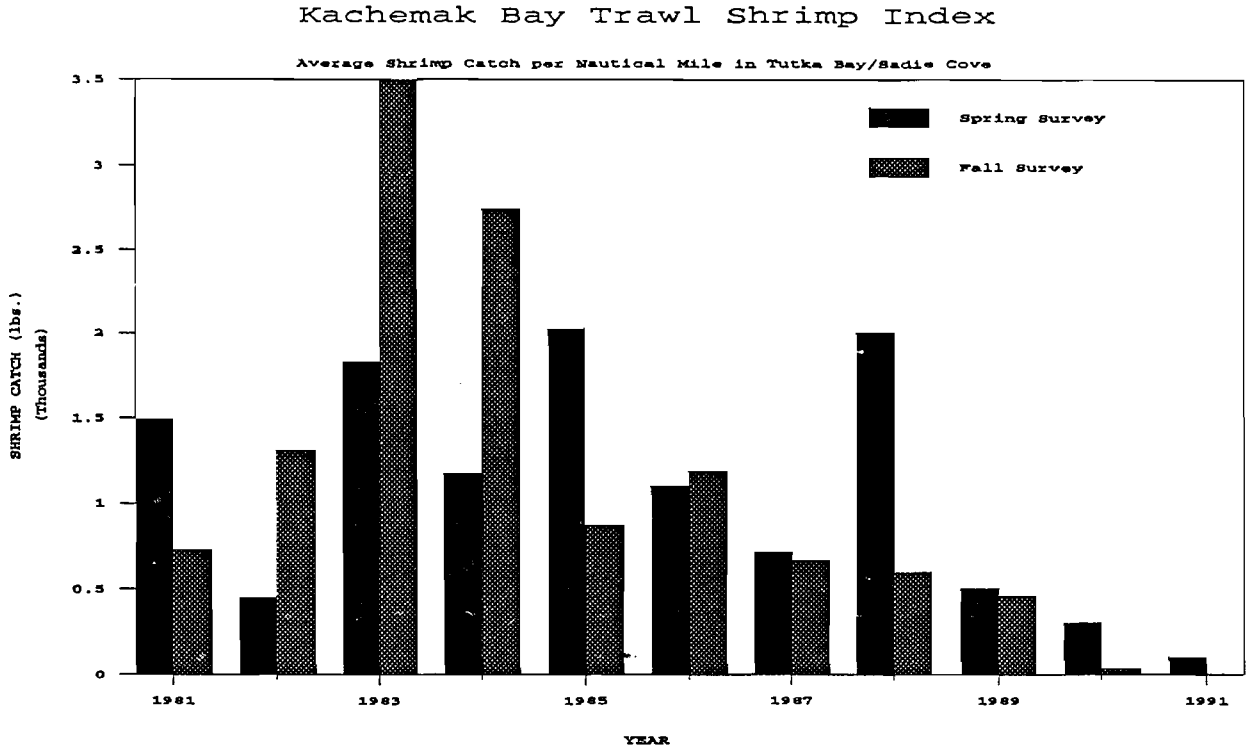

Figure 4. Catches of Pandalid shrimp per one nautical mile in Tutka Bay/Sadie Cove during the Kachemak Bay, Alaska trawl shrimp index of abundance surveys.

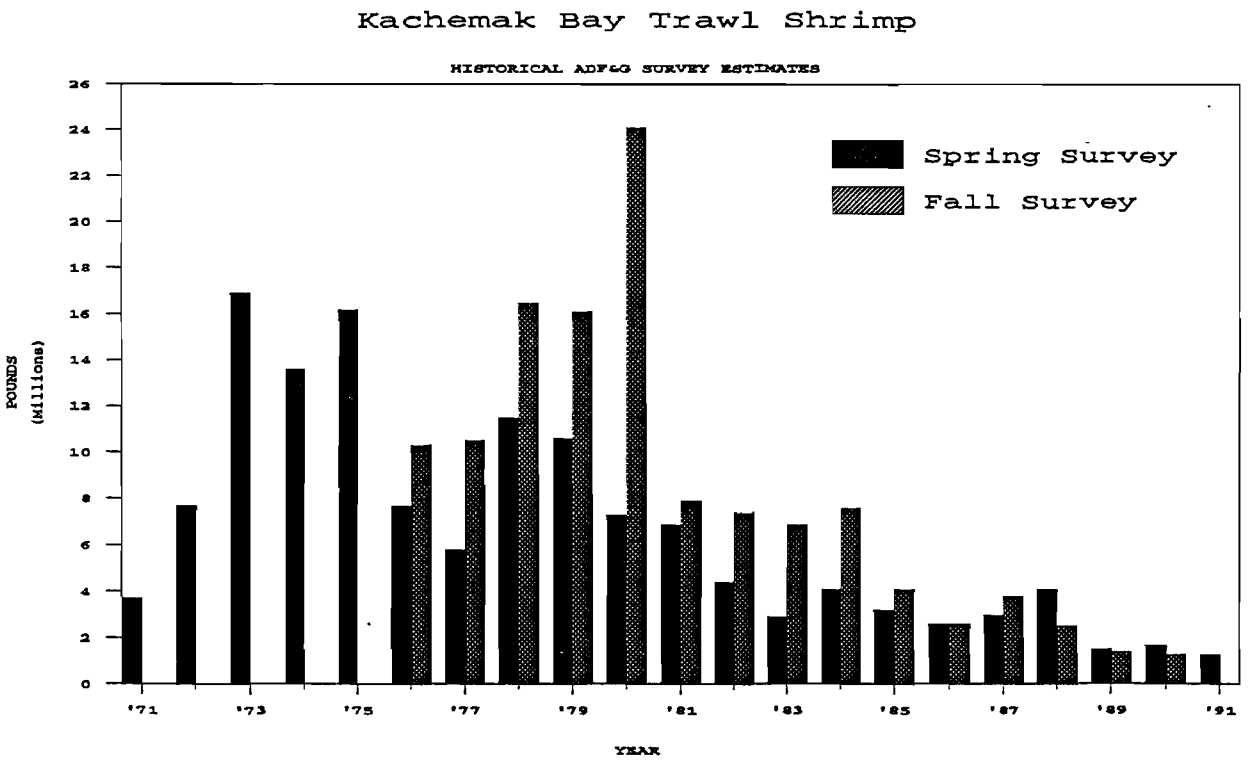

Figure 5. Mid-point estimates of abundance for Pandalid shrimp from trawl surveys in Kachemak Bay, Alaska.

As expected, pinks dominated the catches at 88 percent of all shrimp caught in the traditional stations. Humpies comprised 7.5 percent of the catches, while sidestripes contributed 1.3 percent of the total, the lowest percentage for this species in the history of both the spring or fall surveys. Finally, coonstripes contributed 1.9 percent to the catches (Table 4). Incidence of "other" shrimp, such as *Crangon* sp. and *Eualis* sp. was approximately 2.5 percent. Preliminary average counts per pound for pink shrimp in all stations east of the Homer Spit were 164 for the closed commercial waters north and northeast of Glacier Spit and 108 for the open commercial waters south and west of Glacier Spit. West of Homer Spit, the preliminary average pink shrimp count was 132 for the fifteen stations in which shrimp were caught.

The largest single catch of Pandalid shrimp, totalling 796 pounds, occurred in station T26, a traditional station located approximately 1.0 mile west/northwest of Aurora Spit (Table 6, Figure 6). The shrimp catch from station T26 was dominated by pinks at 85 percent. Station R25, approximately two miles due west of Mallard Bay, had the next highest catch of Pandalid shrimp at 416 pounds. This catch was comprised primarily of pinks at over 88 percent. Twelve stations had a zero catch of shrimp, all west of Homer Spit. The catches from the two tows in Tutka Bay and Sadie Cove were nearly identical, averaging 107 pounds of Pandalid shrimp, with 92 percent pink shrimp and 13.5 percent (12 pounds) coonstripes.

Percentages of fish and other non-shrimp species by weight in the catches of the traditional stations were 73.6 and 97.4 percent for the areas east and west of the Homer Spit, respectively (Table 7, Figure 7). The former figure is the highest ever recorded for the spring survey. For the waters east of the Homer Spit, the largest single station catch of fish and non-shrimp species occurred at station O20, a non-traditional station located approximately two miles northeast of the tip of the Homer Spit (Figure 8). The catch of non-shrimp species at this station, totalling 1,582 pounds, was dominated by Tanner crab (*Chionocetes bairdi*) at 25 percent of the non-shrimp total, followed by starry flounder (*Platichthys stellatus*) at 15 percent and Dungeness crab (*Cancer magister*) at 13 percent. One other station east of the Spit had a non-shrimp catch in excess of 1,000 pounds.

West of the Homer Spit, station K09, located approximately six miles due north of Seldovia, had a fish/non-shrimp catch of nearly 2,000 pounds. The catch was composed almost exclusively of pollock at 80 percent. Only one other tow west of the Spit had a non-shrimp catch in excess of 1,000 pounds. In Tutka Bay and Sadie Cove, the two tows averaged approximately 800 pounds of non-shrimp each. The Tutka tow was dominated by walleye pollock (*Theragra chalcogramma*) at 30 percent and flathead sole (*Hippoglossoides elassodon*) at 16 percent. The Sadie catch contained 54 percent flathead sole and 24 percent pollock.

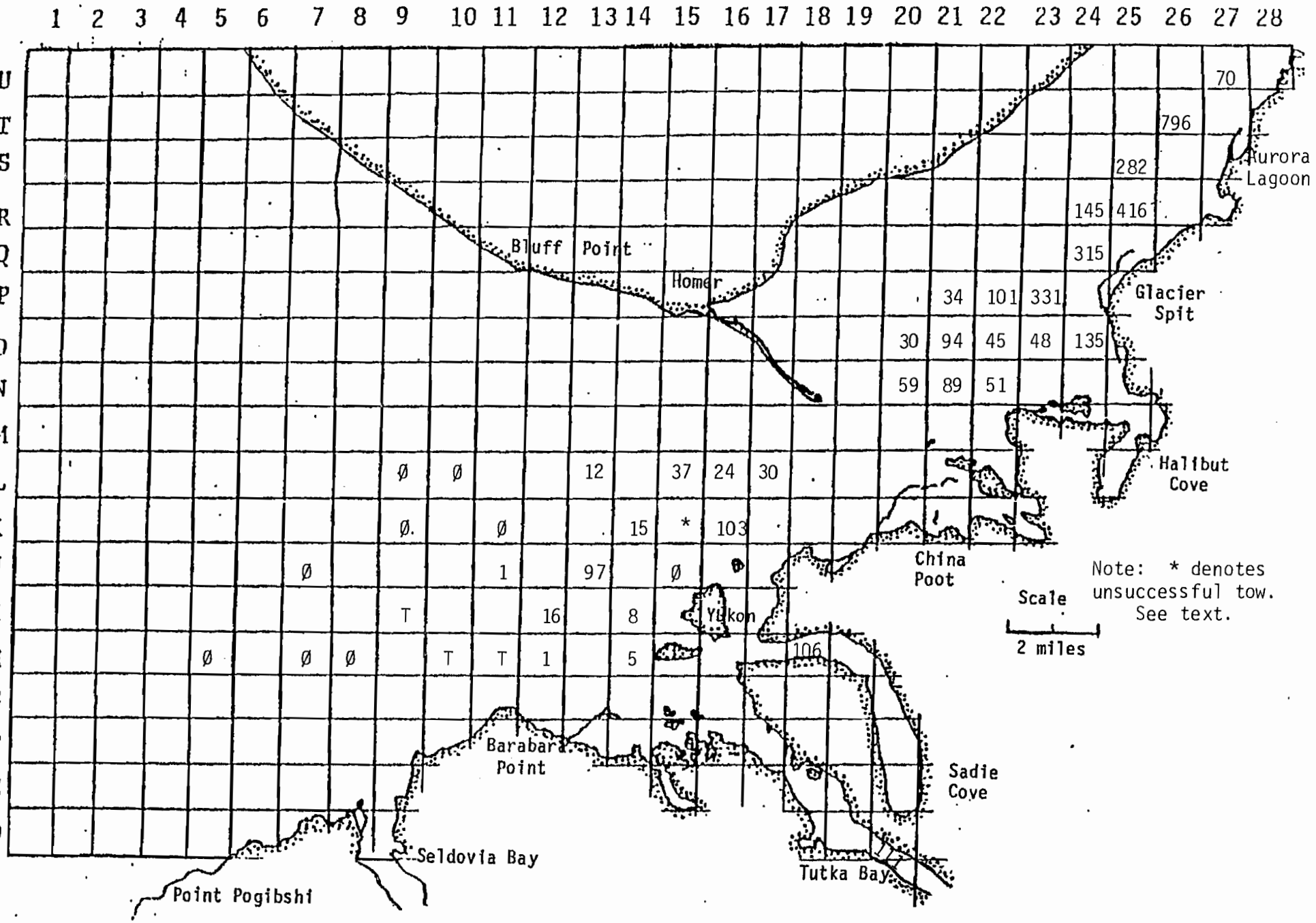

Figure 6. Kachemak Bay shrimp trawl survey catches in pounds of commercial Pandalid shrimp per one nautical mile tow (61' high opening NMFS net, R/V PANDALUS) during May 6 through May 23, 1991.

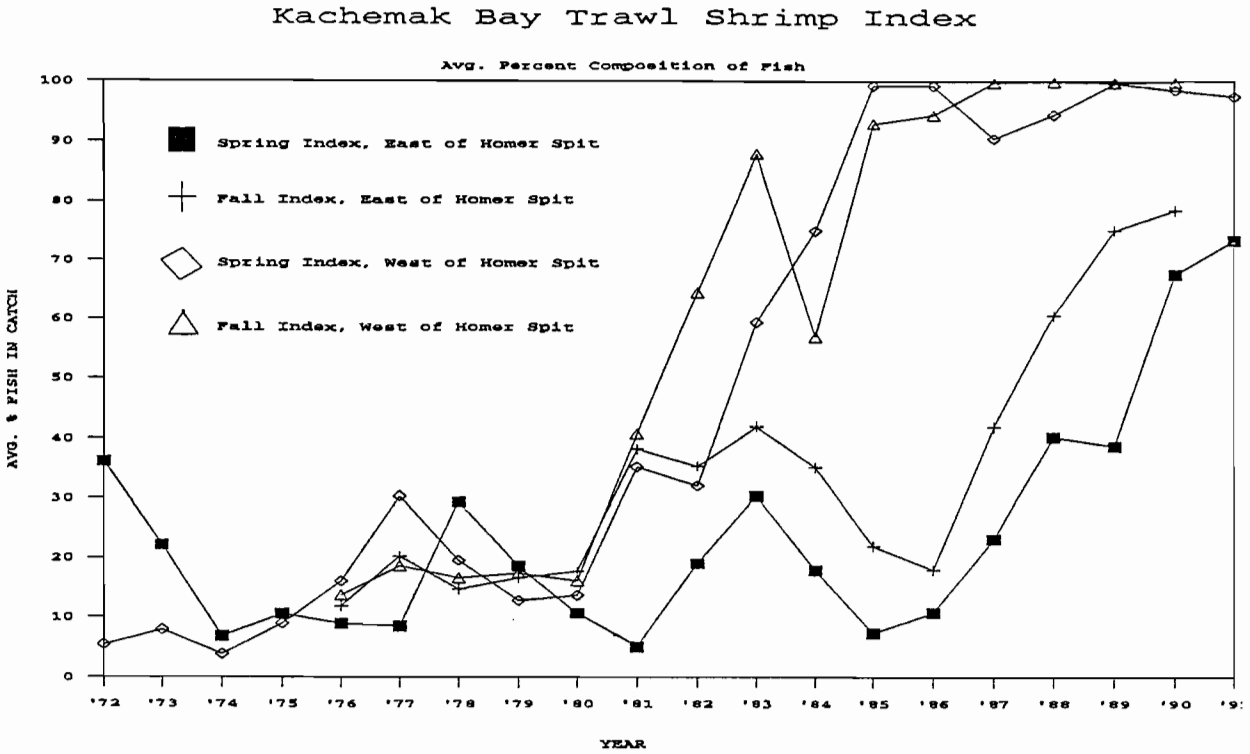

Figure 7. Percentages of fish and non-shrimp species in the catches of the Kachemak Bay, Alaska trawl shrimp index of abundance surveys.

The most commonly occurring non-shrimp species throughout the survey were flathead sole, pollock, and arrowtooth flounder (*Atheresthes stomias*). In terms of total weight, pollock represented the largest portion of the non-shrimp catches west of the Homer Spit (Table 8), followed by flathead sole and arrowtooth flounder. East of the spit, twelve tows were sampled for non-shrimp species, with flathead sole dominating the non-shrimp catches overall, followed by pollock, starry flounder, and Tanner crab.

DISCUSSION

The average catch of shrimp from all traditional stations was nearly identical to that of the fall survey of 1990 but was a decrease from the average of the spring survey of one year earlier. The resulting abundance midpoint estimate of 1.3 million pounds was the same as that of the fall of 1990 (Table 2). When the non-traditional stations were considered, the calculated overall abundance midpoint of 1.4 million pounds was a decline from previous surveys which included the non-traditional stations. The average catch of shrimp from the Tutka/Sadie area was an increase over last fall's survey but is still considered low by historical standards for those bays.

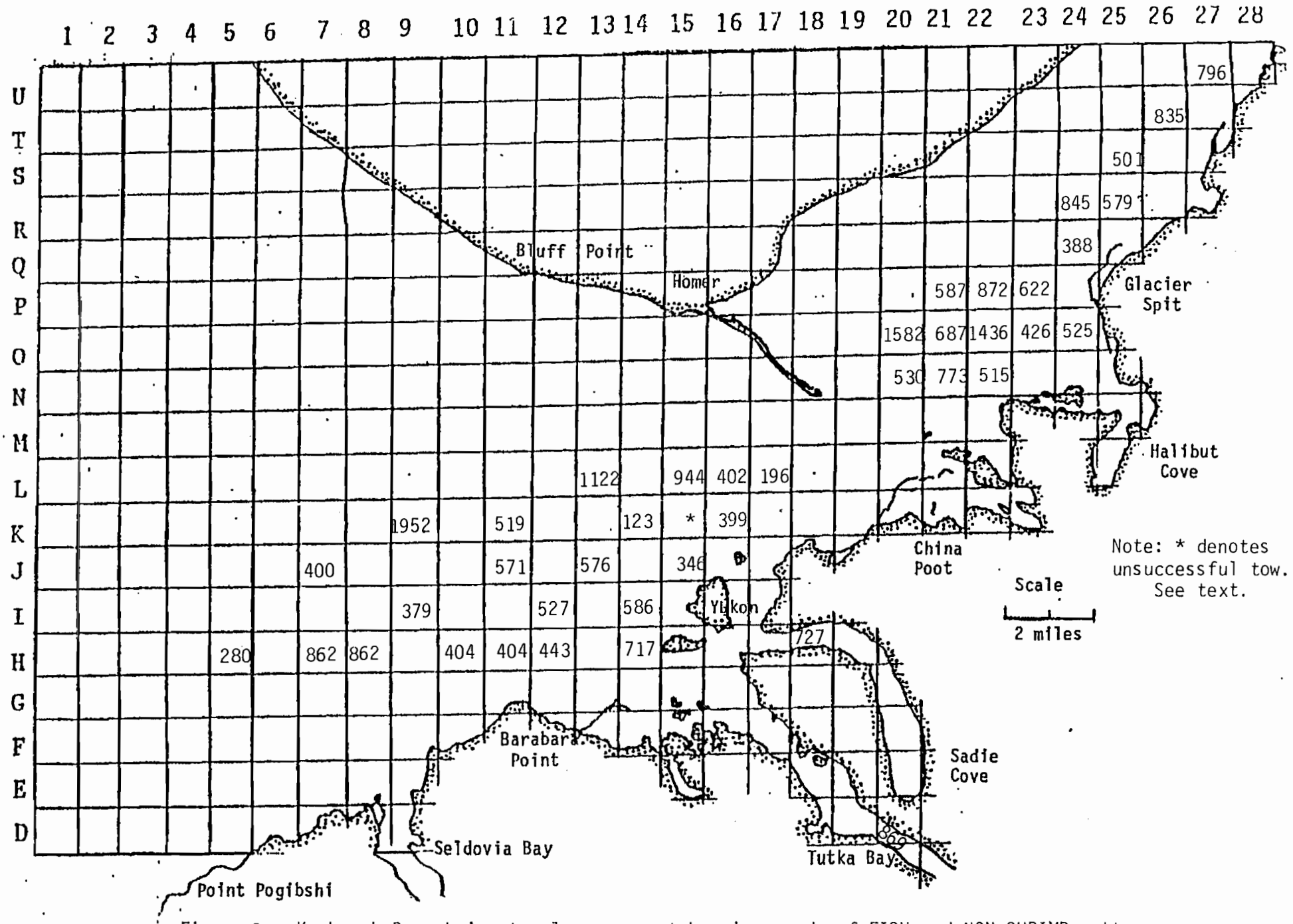

Figure 8. Kachemak Bay shrimp trawl survey catches in pounds of FISH and NON-SHRIMP matter per one nautical mile tow (61' high opening NMFS net, R/V PANDALUS) during May 6 through May 23, 1991.

The highest catches of shrimp occurred in the commercially closed area north and northeast of Glacier Spit (Figure 6). The six stations in this area averaged 337 pounds of shrimp per tow, which compared to approximately 573 pounds per tow for this area during the fall of 1990, 1,300 pounds in the spring of 1990, 500 pounds per tow in the fall of 1989, and 729 pounds per tow in the spring of 1989. One notable difference between this spring's survey and other recent shrimp surveys was that, for the first time in many years, the most northeasterly station in the survey area, station U27, did not have the highest shrimp catch. Overall for the ten stations west and southwest of Glacier Spit (open commercial area), the spring 1991 shrimp catches averaged 92 pounds per tow, compared with 84 pounds per tow for this area during the fall of 1990, 102 pounds per tow in the spring of 1990, 197 pounds per tow during the fall 1989 survey, and only 22 pounds per tow in the spring 1989 survey. West of the Spit, the areas of shrimp occurrence remained approximately the same as previous surveys but the average catch, 14.5 pounds per nautical mile, was the highest average since the spring survey of 1988.

Catches of fish and non-shrimp species, including crabs, in the closed commercial area east of the Spit averaged 657 pounds per tow, while those in the open area averaged 778 pounds. The former figure was more than that from the fall 1990 survey but was similar to averages for that area in recent surveys, while the latter figure was less than the fall survey but similar to previous averages. West of the Spit, fish and non-shrimp species catches averaged 577 pounds per tow, less than recent fall surveys but similar to recent spring surveys.

Count per pound information collected in the field suggested that the pink shrimp found in the closed commercial area east of the Homer Spit were some of largest occurring in that area in over a decade, probably a mixture of females, transitionals, males, and juveniles. In the past, the majority of shrimp caught in this area were males and juveniles, with small percentages of females and transitionals. In the open commercial area, field counts were the lowest on record, indicating very large shrimp, the majority of which were probably females. West of the Spit, field counts were some of the highest in recent surveys, indicating females, transitionals, and males with probably a few juveniles. The larger number of small shrimp west of the Spit was quite noticeable to samplers in the field and is a deviation from previous surveys in which large pink shrimp exclusively occurred in this area.

Shrimp survival over the winter appears to have been similar to that shown by recent surveys. Overall abundance remained stable but very low by historical standards. The majority of shrimp continued to be found in the northeast portion of Kachemak Bay. Counts per pound indicated fewer young, small shrimp in the area east of the Homer Spit but more such shrimp west of the Spit. The meaning of this shift in size class and geographical makeup is

unclear for the short term but could be indicative of environmental changes which may be occurring in Kachemak Bay. Examples of such changes include, but are not limited to, water temperature fluctuations, occurrence and abundance of food supplies, predator/prey relationships, and bottom/substrate changes. Incidence and abundance of fish species throughout Kachemak Bay continued to be high by historical standards.

Current environmental factors seem to be the primary element influencing the pink shrimp stocks in Kachemak Bay. Based on the results of the spring survey, the pink shrimp stocks would appear to be remaining stable but at a very depressed level due to either poor survival, poor reproductive success, or a combination of both. Stocks of fish, which potentially prey upon shrimp within Kachemak Bay, may be increasing and further encroaching into the areas of major shrimp abundance east of the Homer Spit. The shrimp stocks do not appear to be rebuilding and have not yet begun to return to levels seen in the 1970's, remaining very depressed by historical standards.

The staff is presently preparing an analysis of pink shrimp size frequencies from the Kachemak Bay trawl shrimp surveys. In addition to providing a compilation of historical information, this paper could help to determine annual growth for pink shrimp in Kachemak Bay.

LITERATURE CITED

Davis, Allen S. 1982. The commercial otter trawl shrimp fishery of Cook Inlet. ADF&G Informational Leaflet No. 205: 91 pp.

Table 1. Historical trawl shrimp catches by guideline harvest level for the Kachemak Bay trawl shrimp fishery in the Cook Inlet Management Area (H).

SEASON	NUMBER OF VESSELS	CATCH (lbs) JUN 1-OCT 31	NOV 1-MAR 31	APR 1-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
		JUL 1-SEP 30	OCT 1-DEC 31	JAN 1-MAR 31	
1979-80	7	2,013,298	2,052,646	1,731,483	5,797,427
1980-81	15	1,780,298	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	5	488,606	257,782	503,340	1,249,728
1986-87	3	504,206	CLOSED	CLOSED	504,206
1987-88	0	CLOSED	CLOSED	CLOSED	0
1988-89	0	CLOSED	CLOSED	CLOSED	0
1989-90	0	CLOSED	CLOSED	CLOSED	0
1990-91	0	CLOSED	CLOSED	CLOSED	0

[a]Catches listed for comparative purposes by seasons established in 1973.
[b]June 1 - October 31 and November 1 - March 31 seasons with respective guidelines established.

Table 2. Abundance index estimates of commercial species of Pandalid shrimp (millions of pounds) in the Southern District (Kachemak Bay), by sampling period and year, based on pounds of shrimp caught per one nautical mile tow (traditional stations only).

MONTH	YEAR	MEAN CATCH (lbs/tow)	NUMBER OF STATIONS	% ERROR	ABUNDANCE INDEX (Mill. of lbs.)	(Mill. of lbs.)
SPRING						
May	1971	130.2[a]	56	20.0	3.7	3.0 to 4.5
May	1972	271.1[a]	66	35.5	7.7	5.0 to 10.5
May	1973	592.8[a]	59	27.8	16.9	12.2 to 21.6
Jun	1974	476.6[a]	30	22.8	13.6	10.5 to 15.7
May	1975	1,136.9[b]	37	27.9	16.2	11.7 to 20.7
May	1976	541.3	36	28.3	7.7	5.5 to 9.9
Jun	1977	407.9	40	17.1	5.8	4.8 to 6.8
May	1978	810.9	36	25.2	11.5	8.6 to 14.5
May	1979	743.7	41	20.9	10.6	8.4 to 12.8
May	1980	513.7	39	19.5	7.3	5.9 to 8.7
May	1981	486.1	37	18.4	6.9	5.6 to 8.2
May	1982	306.8	38	21.8	4.4	3.4 to 5.3
May	1983	204.0	37	24.8	2.9	2.2 to 3.6
May	1984	282.3	34	34.2	4.1	3.0 to 5.2
May	1985	197.5	34	39.7	3.2	1.9 to 4.5
May	1986	157.2	34	50.9	2.6	1.3 to 4.0
May	1987	178.8	34	45.2	3.0	1.6 to 4.3
May	1988	247.5	33	45.0	4.1	2.3 to 6.0
May	1989	90.5	31	65.9	1.5	0.5 to 2.5
May	1990	106.5	33	87.1	1.7	0.2 to 3.2
May	1991	79.5	33	46.5	1.3	0.7 to 1.9
FALL						
Oct	1976	719.8	33	21.6	10.3	8.0 to 12.5
Nov	1977	738.1	36	28.9	10.5	7.5 to 13.5
Oct	1978	1,160.3	32	25.5	16.5	12.3 to 20.7
Oct	1979	1,133.3	32	23.3	16.1	12.4 to 19.9
Oct	1980	1,689.4	37	19.3	24.1	19.4 to 28.7
Oct	1981	604.8	35	26.9	7.9	5.8 to 10.0
Oct	1982	519.2	36	26.3	7.4	5.4 to 9.3
Oct	1983	481.3	36	36.6	6.9	4.9 to 8.8
Oct	1984	531.9	35	26.3	7.6	6.1 to 9.1
Oct	1985	284.9	34	32.0	4.1	2.8 to 5.4
Sep	1986	154.0	34	37.9	2.6	1.6 to 3.6
Sep/Oct	1987	227.0	34	66.1	3.8	1.3 to 6.3
Nov	1988	152.3	28	64.8	2.5	0.9 to 4.2
Sep	1989	84.8	32	49.0	1.4	0.7 to 2.1
Sep/Oct	1990	80.3	34	54.5	1.3	0.6 to 2.1

[a]66' Nordby net, 50% assumed net efficiency.
[b]From this survey to present, a 61' NMFS net with 100% assumed net efficiency has been used.

Table 3. Mean catch of Pandalid shrimp in pounds per one nautical mile tow, by area (traditional stations only), by period, and by year, captured during trawl shrimp index surveys in the Southern District (Kachemak Bay) of the Cook Inlet Management Area (H).

Month	Year	MEAN CATCH OF PANDALID SHRIMP (lbs/tow) West of Spit	East of Spit[a]	Tutka/Sadie[b]
SPRING				
May	1971[c]	126.5	69.3	
May	1972[c]	366.9	75.7	
May	1973[c]	759.2	156.1	
Jun	1974[c]	492.1	211.2	
May	1975[d]	1,250.0	660.0	
May	1976	479.6	802.0	
Jun	1977	317.6	678.7	
May	1978	749.5	1,175.7	
May	1979	786.0	633.9	
May	1980	488.1	539.2	
May	1981	454.5	584.7	1,492.3
May	1982	268.6	413.3	452.0
May	1983	97.2	536.2	1,830.8
May	1984	56.0	910.0	1,179.8
May	1985	2.6[e]	830.4	2,027.0
May	1986	2.0[e]	588.4	1,102.9
May	1987	24.0[e]	609.0	714.3[f]
May	1988	39.1[e]	898.9	2,006.0[g]
May	1989	2.7	342.8	508.0[h]
May	1990	6.0	374.0	303.5[h]
May	1991	14.5	252.5	107.1[h]

[a]Traditional stations only.
[b]The Tutka/Sadie area was not surveyed prior to 1981.
[c]Nordby trawl net (66' ground rope, 53' head rope, 60' tickler chain) with 50% assumed net efficiency.
[d]From this survey to present, a 61' NMFS net with 100% assumed net efficiency has been used.
[e]Extremely small shrimp catches (less than 10% of total) were not processed for actual weight and are referred to as "trace shrimp", and are considered zero for calculations.
[f]Only 2 of the 3 tows in Sadie Cove included.
[g]Only one tow in Sadie Cove made and its weight was estimated due to a malfunctioning electronic scale.
[h]Only one tow made in Sadie Cove.

Month	Year	MEAN CATCH OF PANDALID SHRIMP (lbs/tow) West of Spit	East of Spit[a]	Tutka/Sadie[b]
FALL				
Oct	1976	574.7	1,127.0	
Nov	1977	695.6	456.6	
Oct	1978	1,310.2	626.0	
Oct	1979	1,263.7	805.6	
Oct	1980	1,764.4	1,456.2	
Oct	1981	626.6	541.9	734.0
Oct	1982	303.4	1,274.4	1,309.5
Oct	1983	48.1	1,607.6	3,492.3
Oct	1984	305.7	1,185.5	2,741.0
Oct	1985	88.8	829.8	876.9
Sep	1986	18.0[c]	518.9	1,188.9
Sep/Oct	1987	2.0[c]	852.0	667.7
Nov	1988	1.3[c]	471.0	597.5[d]
Sep	1989	3.5	292.6	461.5[d]
Sep/Oct	1990	1.4	306.7	33.0[d]

[a]Traditional stations only.
[b]The Tutka/Sadie area was not surveyed prior to 1981.
[c]Extremely small shrimp catches (less than 10% of total) were not processed for actual weight and are referred to as "trace shrimp", and are considered zero for calculations.
[d]Only 1 tow made in Sadie Cove.

Table 4. Catch composition (percent) of Pandalid shrimp species in the Southern District (Kachemak Bay) trawl abundance index surveys by sampling period and year (traditional stations only). "Other" shrimp (*Crangon* sp. and *Eualis* sp.) are additional to those years where figures do not add up to 100 percent.

YEAR	MONTH	PINK	HUMPY	COON	SIDE	ABUNDANCE INDEX (Million lbs.)
SPRING						
1971	May	83.8	9.9	1.9	4.4	3.7
1972	May	62.0	33.2	1.3	3.5	7.7
1973	May	67.5	27.3	1.8	3.4	16.9
1974	Jun	81.6	7.9	2.2	8.3	13.6
1975	May	74.8	16.6	2.7	5.9	16.2
1976	May	82.6	5.3	3.6	8.5	7.7
1977	Jun	83.4	3.3	6.1	7.2	5.8
1978	May	67.9	24.8	1.3	6.1	11.5
1979	May	78.3	14.3	2.3	5.1	10.6
1980	May	63.4	23.6	1.9	11.1	7.3
1981	May	72.7	13.8	4.2	9.3	6.9
1982	May	73.2	12.6	3.4	10.8	4.4
1983	May	71.3	1.4	1.4	25.9	2.9
1984	May	85.4	1.8	0.9	11.8	4.1
1985	May	89.0	1.6	1.0	8.4	3.2
1986	May	70.6	7.4	1.3	20.1	2.6
1987	May	78.3	10.1	2.1	9.6	3.0
1988	May	67.5	17.9	2.2	10.5	4.1
1989	May	94.3	1.4	1.4	2.0	1.5
1990	May	74.4	17.9	4.0	2.6	1.7
1991	May	88.0	7.5	1.9	1.3	1.3
FALL						
1976	Oct-Dec	69.0	20.8	3.0	7.2	10.3
1977	Nov	58.1	29.2	2.0	10.7	10.5
1978	Oct	47.4	45.9	1.7	5.0	16.5
1979	Oct	45.2	50.4	0.7	3.7	16.1
1980	Oct	57.8	34.5	1.5	6.2	24.1
1981	Oct	57.8	30.4	1.6	10.2	7.9
1982	Oct	71.2	16.0	2.5	10.3	7.4
1983	Oct	72.1	15.4	2.6	9.8	6.9
1984	Oct	68.4	19.8	2.9	8.9	7.6
1985	Oct	71.7	1.1	2.9	19.2	4.1
1986	Sep	75.5	2.3	3.9	12.1	2.6
1987	Sep/Oct	63.6	8.5	3.0	19.4	3.8
1988	Nov	78.1	10.3	3.2	4.9	2.5
1989	Sep	86.7	3.1	2.9	2.0	1.4
1990	Sep/Oct	91.8	2.1	1.8	1.8	1.3

Table 5. Historical average numbers of pink shrimp (*Pandalus borealis*) per pound, by area, from laboratory measurements of samples taken during ADF&G trawl shrimp surveys in the Southern District (Kachemak Bay) of the Cook Inlet Management Area (H).

	East of Homer Spit				West of Spit	
	Closed area		Open Area			
Year	# shrimp per lb.	No. of Samples	# shrimp per lb.	No. of Samples	# shrimp per lb.	No. of Samples
SPRING SURVEY						
1971	213.4	23	230.3	13	159.6	54
1972	203.0	20	185.3	8	137.3	72
1973	167.2	15	230.4	4	152.0	55
1974	125.6	3	133.8	3	126.0	23
1975	143.5	2	154.6	5	135.9	25
1976	157.8	4	169.6	10	107.5	32
1977	142.7	11	144.7	8	109.0	33
1978	163.6	4	155.0	5	123.7	33
1979	203.3	5	170.7	6	126.6	21
1980	190.1	4	173.6	5	112.0	23
1981	190.9	4	193.1	5	111.7	20
1982	177.2	5	180.8	4	106.8	17
1983	176.2	4	151.3	5	102.6	10
1984	224.2	5	177.5	4	98.5	11
1985	244.3	5	193.8	4	199.0	1
1986	229.4	5	155.5	3		0
1987	275.9	5	134.2	4	111.8	2
1988	237.8	6	125.8	9	104.1	7
1989	201.8	6	131.4	8	98.9	7
1990	185.7	6	136.3	9	102.2	12
1991	SAMPLES	NOT	YET		ANALYZED	

-continued-

Table 5.
Page 2 of 2.

Year	East of Homer Spit				West of Spit	
	Closed area		Open Area			
	# shrimp per lb.	No. of Samples	# shrimp per lb.	No. of Samples	# shrimp per lb.	No. of Samples
FALL SURVEY						
1976	144.1	1			112.5	2
1977	164.0	2			144.1	3
1978	159.6	1	148.1	1	133.4	4
1979			149.8	2	135.0	5
1980	183.0	1	150.8	2	135.4	3
1981	182.0	5	112.9	4	127.7	13
1982	181.9	5	202.0	3	106.8	9
1983	232.7	5	198.9	4	146.2	2
1984	205.8	5	183.8	4	142.6	10
1985	246.7	4	190.0	1	247.5	4
1986	230.7	5	215.3	4	131.4	2
1987	184.4	5	114.3	4		0
1988	167.0	6	126.8	10	83.9	1
1989	193.0	6	167.4	9	109.0	6
1990	158.5	6	134.9	7	79.5	7

Table 6. Catches by station in pounds per one nautical mile tow in the Southern District (Kachemak Bay) during the spring trawl shrimp index survey, May 6 through May 23, 1991 (61-foot high opening NMFS net).

TOW NO.	DEPTH (fm)	STATION NO.	SHRIMP Pink	Humpy	Coon	Side	Other	Total[a] Lbs.	%	FISH Total Lbs.	%
West of Homer Spit											
18	62-67	L17	27	T	0	3	1	31	13.7	196	86.3
19	62-65	L16	19	0	0	5	2	2	6.0	402	94.0
20	50-58	L15	37	T	0	0	1	38	3.9	944	96.1
21	48-52	L13	11	0	0	0	T	12	1.0	1,122	99.0
22	54-65	K14	15	0	0	0	0	15	10.7	123	89.3
23	44-43	K11[b]	0	0	0	0	1	1	0.1	519	99.9
24	44-45	K09[b]	0	0	0	0	0	0	0.0	1,952	100.0
25	42-45	L09[b]	0	0	0	0	0	0	0.0	410	100.0
26	45-46	L10[b]	0	0	0	0	0	0	0.0	410	100.0
27	34	J07[b]	0	0	0	0	0	0	0.0	400	100.0
28	33-38	H05[b]	0	0	0	0	0	0	0.0	280	100.0
29	46-43	H07[b]	0	0	0	0	1	1	0.1	862	99.9
30	43	H08[b]	0	0	0	0	1	1	0.1	862	99.9
31	58-56	I09[b]	T	0	0	0	1	1	0.2	379	99.8
32	86-92	K16	86	0	0	16	3	106	20.9	399	79.1
33	57-66	J13	95	0	0	20	1	98	14.6	576	85.4
34	46	J11[b]	1	0	0	0	0	1	0.1	571	99.9
35	40-45	H10[b]	T	0	0	0	0	0	0.0	404	100.0
36	45-50	H11[b]	T	0	0	0	0	0	0.0	404	100.0
37	43-51	H12[b]	1	0	0	0	0	1	0.2	443	99.8
38	27-31	J15	0	0	0	0	0	0	0.0	346	100.0
39	62-61	I12[b]	16	0	T	0	1	17	3.1	527	96.9
40	50-43	I14	8	0	T	0	4	12	2.0	586	98.0
43	45-47	H14	4	0	1	0	T	5	0.7	717	99.3
Subarea											
Total			320	T	1	27	15	362	2.6	13,834	97.4
Percent			88.2	0.0	0.2	7.5	4.0				
Mean per tow			13.4	0.0	0.0	1.1	0.6	15.1	2.6	576.4	97.4

[a] Includes species such as *Crangon sp.* and *Eualis sp.*

[b] One-half mile tow doubled to represent standard on mile tow.

TOW NO.	DEPTH (fm)	STATION NO.	SHRIMP Pink	Humpy	Coon	Side	Other	Total[a] Lbs.	%	FISH Total Lbs.	%
East of Homer Spit (Traditional)											
1	29	R24	118	16	11	0	5	150	15.0	845	85.0
2	30	R25	369	40	6	T	1	417	41.9	579	58.1
3	22-28	S25	250	26	6	0	3	285	36.3	501	63.7
4	25-29	T26	678	87	24	7	5	801	49.0	835	51.0
9	39	O22	44	T	T	0	T	45	3.0	1,436	97.0
12	30-36	O24	122	12	1	0	2	137	20.7	525	79.3
14	26-36	Q24	297	15	3	T	2	317	44.9	388	55.1
15	42-53	N22	49	T	0	2	T	51	9.0	515	91.0
16	46-44	N21	89	T	0	0	T	89	10.3	773	89.7
Subarea											
Total			2,016	198	51	9	19	2,292	26.4	6,397	73.6
Percent			88.0	8.6	2.2	0.4	0.8				
Mean per tow			224.0	22.0	5.6	0.9	2.1	254.6	26.4	710.8	73.6
Kachemak Bay Total											
Total			2,337	198	51	36	33	2,655	11.6	20,230	88.4
Percent			88.0	7.5	1.9	1.3	1.2				
Mean per tow			70.8	6.0	1.6	1.1	1.0	80.5	11.6	613.1	88.4
Tutka Bay/Sadie Cove											
41	42-48	C/D20	93	1	15	T	3[b]	112	11.4	869	88.6
42	45-35	H18	91	2	12	0	1	107	12.8	727	87.2
Total			184	3	27	T	4	219	12.0	1,596	88.0
Percent			84.3	1.3	12.3	0.1	2.0				
Mean per tow			92.1	1.4	13.5	0.2	2.2	109.3	12.0	798.1	88.0

[a] Includes species such as *Crangon sp.* and *Eualis sp.*

[b] Includes one pound of spot shrimp (*Pandalus platyceros*).

TOW NO.	DEPTH (fm)	STATION NO.	SHRIMP Pink	Humpy	Coon	Side	Other	Total[a] Lbs.	%	FISH Total Lbs.	%
East of Homer Spit (Non-traditional)											
5	24-26	P21	27	3	4	0	1	35	5.6	587	94.4
6	32-30	P22	95	4	2	0	2	103	10.5	872	89.5
7	33-34	P23	308	22	0	1	3	334	34.9	622	65.1
8	24-27	U27	35	2	32	1	4	74	8.5	796	91.5
10	35-36	021	93	1	0	0	0	94	12.1	687	87.9
11	42-37	023	45	2	0	1	T	48	10.1	426	89.9
13	29-28	020	28	T	2	0	T[b]	30	1.9	1,582	98.1
17	39-37	N20	59	1	1	0	2[b]	61	10.4	530	89.6
Subarea											
Total			689	35	40	3	12	779	11.3	6,102	88.7
Percent			88.5	4.5	5.2	0.3	1.5				
Mean per tow			86.2	4.4	5.0	0.3	1.4	97.4	11.3	762.8	88.7

[a] Includes species such as *Crangon sp.* and *Eualis sp.*

[b] Trace amounts of spot shrimp (*Pandalus platyceros*).

Table 7. Percent composition of fish during trawl shrimp index surveys in the Southern District (Kachemak Bay) based on catches of fish and shrimp per one nautical mile tow, by sampling period and year (traditional stations only).

YEAR	EAST OF SPIT (241-13, 14, 15) MAY	EAST OF SPIT (241-13, 14, 15) OCT	WEST OF SPIT (241-11 and 241-12) MAY	WEST OF SPIT (241-11 and 241-12) OCT
1972	36.2		5.5	
1973	22.2		7.9	
1974	6.9		3.9	
1975	10.6		9.0	
1976	9.0	11.9	16.1	13.8
1977	8.6	20.3	30.4	18.7
1978	29.4	14.8	19.6	16.7
1979	18.6	16.7	12.8	17.5
1980	10.7	17.7	13.7	16.1
1981	5.1	38.2	35.2	40.8
1982	19.1	35.4	32.1	64.5
1983	30.4	42.0	59.5	87.9
1984	18.0[a]	35.3	75.0[a]	57.0
1985	7.4	22.0	99.3	92.9
1986	10.8	18.1	99.3	94.3
1987	23.2	42.1	90.4	99.8
1988	40.4	60.6[b]	94.4	99.9[b]
1989	38.9	75.1	99.6	99.7
1990	67.7	78.5	98.5	99.8
1991	73.6		97.4	

[a]Does not include large cod and halibut.
[b]Survey actually occurred Nov. 13-19 aboard R/V RESOLUTION.

Table 8. Breakdown of fish catches by species in the Southern District (Kachemak Bay) trawl shrimp index of abundance survey, May 6 - May 23, 1991.

Fish Species	EAST OF SPIT (12 Tows) Occurrence # of Tows	Total Lbs.	% of Total	WEST OF SPIT (24 Tows) Occurrence # of Tows	Total Lbs.	% of Total
Halibut	11	469	5.1	16	486	3.5
Pacific cod	9	228	2.5	10	374	2.7
Pollock	12	1,543	16.7	23	6,150	44.5
Flathead sole	12	2,126	23.1	24	2,493	18.0
Arrowtooth flounder	5	27	0.3	23	1,474	10.7
Rex sole	0	0	0.0	11	267	1.9
Dover sole	0	0	0.0	17	560	4.0
Rock sole	3	6	0.1	4	87	0.6
Butter sole	1	5	0.1	2	18	0.1
Yellowfin sole	3	20	0.2	2	11	0.1
English sole	1	12	0.1	0	0	0.0
Blackcod	0	0	0.0	0	0	0.0
Tomcod	8	42	0.5	6	170	1.2
Smelt	7	21	0.2	4	17	0.1
Sculpins/ Irish Lords	9	841	9.1	13	358	2.6
Poachers	2	2	T	11	8	0.1
Tanner crab	10	1,020	11.1	5	109	0.8
Dungeness crab	5	542	5.9	0	0	0.0
King crab	4	199	2.2	0	0	0.0
Starry flounder	10	1,096	11.9	1	329	2.4
Pricklebacks	8	6	0.1	5	19	0.1
Skates	1	32	0.3	5	75	0.5
Herring	5	131	1.4	2	1	T
Ronquils	0	0	0.0	4	16	0.1
Rockfish	0	0	0.0	13	270	2.0
Eelpouts	6	12	0.1	14	187	1.4
Pink scallop	0	0	0.0	5	9	0.1
Weathervane scallop	0	0	0.0	0	0	0.0
Urchins	0	0	0.0	9	58	0.4
Squid	0	0	0.0	2	7	T
Starfish	0	0	0.0	5	5	T
Sandfish	1	1	T	0	0	0.0
Snailfish	0	0	0.0	2	2	T
Clams/snails	1	12	0.1	7	26	0.2
Alaska plaice	5	99	1.1	0	0	0.0
Sea Anemones	3	12	0.1	4	41	0.3
"Other" crab	1	2	T	6	4	T
Parastichopus	0	0	0.0	2	3	T
Molpadia	1	7	0.1	1	4	T
Greenling	1	3	T	0	0	0.0
Warbonnets	0	0	0.0	3	3	T
Sponges	0	0	0.0	1	2	T
Capelin	3	10	0.1	6	4	T
Jellyfish	0	0	0.0	1	2	T
Sand dollars	0	0	0.0	2	T	T
Modiolus	0	0	0.0	1	1	T
Kelp/rocks/ shells/debris	12	693	7.5	16	181	1.3
TOTALS	12	9,217	100.0	24	13,828	100.0

Appendix Table 1. Formulas and explanations for calculations of abundance estimate and range for Pandalid shrimp in the Southern District of the Cook Inlet Management Area (H).

$$\text{Mean shrimp catch} = \frac{\sum_{i=1}^{N} x_i}{N} = \bar{x}$$

$$\text{Area - total } (Nm^2) \text{ considered} = A$$

$$\text{Total number of tows} = N$$

$$\text{Sample variance } (SV) = \frac{1}{N-1}\sum_{i=1}^{N} (x_i - \bar{x})^2$$

where $x_1, x_2, \ldots, x_N$ are the standardized (1 Nm) catches of shrimp from each tow.

$$\text{Standard deviation } (SD) = \sqrt{SV}$$

$$\text{Standard error of the mean } (SE) = \frac{SD}{\sqrt{N}}$$

$$\text{Population estimate } (p) = \left(\frac{6076}{32} \times A\right) \bar{x}$$

$$\text{Standard deviation of the population estimate } (Sp) = \left(\frac{6076}{32} \times A\right) SE$$

$$\text{Percent error} = \frac{1.3 \times SE}{\bar{x}} \times 100$$

Notes: 6,076 is the number of feet in a nautical mile; 32 is the effective width of the net; 88 is the area of the stratum A in square nautical miles; and $\bar{x}$ is the mean catch.

Percent error: 1.3 is the value from the normal distribution statistical table giving an approximate 80% confidence interval.

Source: Watson, Leslie. 1981. Shrimp trawl survey manual. May 1, 1981. ADF&G, Kodiak, AK. 44 pp.