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KING (Paralithodes camtschatica) AND TANNER CRAB (Chionoecetes bairdi) ASSESSMENT STUDIES IN LOWER COOK INLET, ALASKA, 1983

By

Margaret Merritt

STATE OF ALASKA

Bill Sheffield, Governor

DEPARTMENT OF FISH AND GAME

Don W. Collinsworth, Commissioner

P.O. Box 3-2000, Juneau 99802

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Alaska Department of Fish and Game
Division of Commercial Fisheries
Homer, Alaska

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ABSTRACT

King *(Paralithodes camtschatica)* and Tanner crab *(Chionoecetes bairdi)* investigations in Lower Cook Inlet, Alaska began in 1974 under joint Federal and State cooperation; studies in 1983 were funded solely by the State of Alaska.

The Southern District was closed to king crab fishing in 1983 and the Kamishak District was closed early by emergency order after a harvest of 85 metric ton (187,907 lb). The Southern District Tanner crab fishery harvested 452 t (996,763 lb) and in Kamishak, 621 t (1.37 million lb) were harvested in 1983.

The Southern District king crab index survey average catch of legal males per pot was 0.53, 75% less than the previous 9-year average of 2.1 legal males per pot. The Kamishak king crab index survey catch was a record low of 0.8 legal males per pot, indicating continued declines in king crab abundance. The majority of female king crab in both districts had partial egg clutches, a substantial decrease in ovigerity from previous years.

The average catch of legal male Tanner crab per pot in the Southern District index survey was 22.1, similar to the previous 9-year average of 22.5 legal males per pot. Peterson mark-recapture experiments in the Southern District gave a population estimate of 1.15 million legal male crab prior to harvest, based on a 34.3% tag recovery. The Kamishak legal Tanner crab index survey catch per pot was 1.9, about one-sixth of the previous 8-year average and warrants careful monitoring. The majority of female Tanner crab showed full egg clutches during the index cruise months of June and July.

KEY WORDS: king crab, *Paralithodes camtschatica*, Tanner crab, *Chionoecetes bairdi*, fisheries, biological sampling.

INTRODUCTION

The purpose of this report is to document the results of shellfish research concerning red king *(Paralithodes camtschatica)*, and Tanner *(Chionoecetes bairdi)* crab conducted in the Cook Inlet, Alaska area during 1983 and compare results with those of prior years. Detailed results from earlier years are found in Federal aid annual technical reports (Hennick 1974, Davis 1975, 1976, 1977a, 1977b, 1979, 1980, 1981, 1982) as funded jointly by the Commercial Fisheries Research and Development Act (PL 88-309 as amended) and the State of Alaska; and in the lower Cook Inlet Data Report series (Davis 1983). The project in 1983 was funded solely by the State of Alaska.

The Cook Inlet area (Figure 1) for king and Tanner crab fishing is described as Statistical Area H with its eastern boundary the longitude of Cape Fairfield (148° 50" W long.) and its southern boundary the latitude of Cape Douglas (58° 52" N lat.). No major commercial shellfish fisheries are located in the districts north of the latitude of Anchor Point including the Central and Northern Districts. The major commercial fisheries for king crab occur in the Southern, Kamishak, and Barren Islands Districts, while Tanner crab fisheries are found in those three districts as well as the Outer and Eastern Districts.

Management of the crab fisheries in the initial years of the commercial harvest was generally based on sampling of the commercial catch and fishermen interviews. The cooperative Federal-State research program in lower Cook Inlet, initiated in 1973 and completed in 1981, was designed to evaluate certain biological parameters which aided in the scientific management of the fisheries. The State assumed full funding of research in 1982. The increased marked demands for Alaskan shellfish products with resultant higher prices has attracted larger numbers of fishermen into the commercial crab fisheries. Management decisions in recent years concerning the Cook Inlet Tanner and king crab fisheries were implemented largely on the basis of information collected during this index.

HISTORY OF COOK INLET KING AND TANNER CRAB FISHERIES

King Crab

The target species found in the Cook Inlet Management Area is the red king crab. Occasionally brown king crab *(Lithodes aequispina)* will also be taken in the vicinity of the Barren Islands and Outer/Eastern Districts.

The earliest recorded commercial landing of king crab occurred in 1937 when crabs were canned at a Halibut Cove packing facility. Commercial fishing for this species remained at a relatively low level through the 1940's. By the mid-1950's harvest levels amounted to approximately 907 metric ton (t) (2 million lb) per year. The majority of the commercial harvest occurred in the Southern District. During the 1960's fishing expanded to the Kamishak Bay area and boats were harvesting up to 3,629 t (8 million lb) per year. During 1964-65 a significant drop in catch occurred in the Kamishak

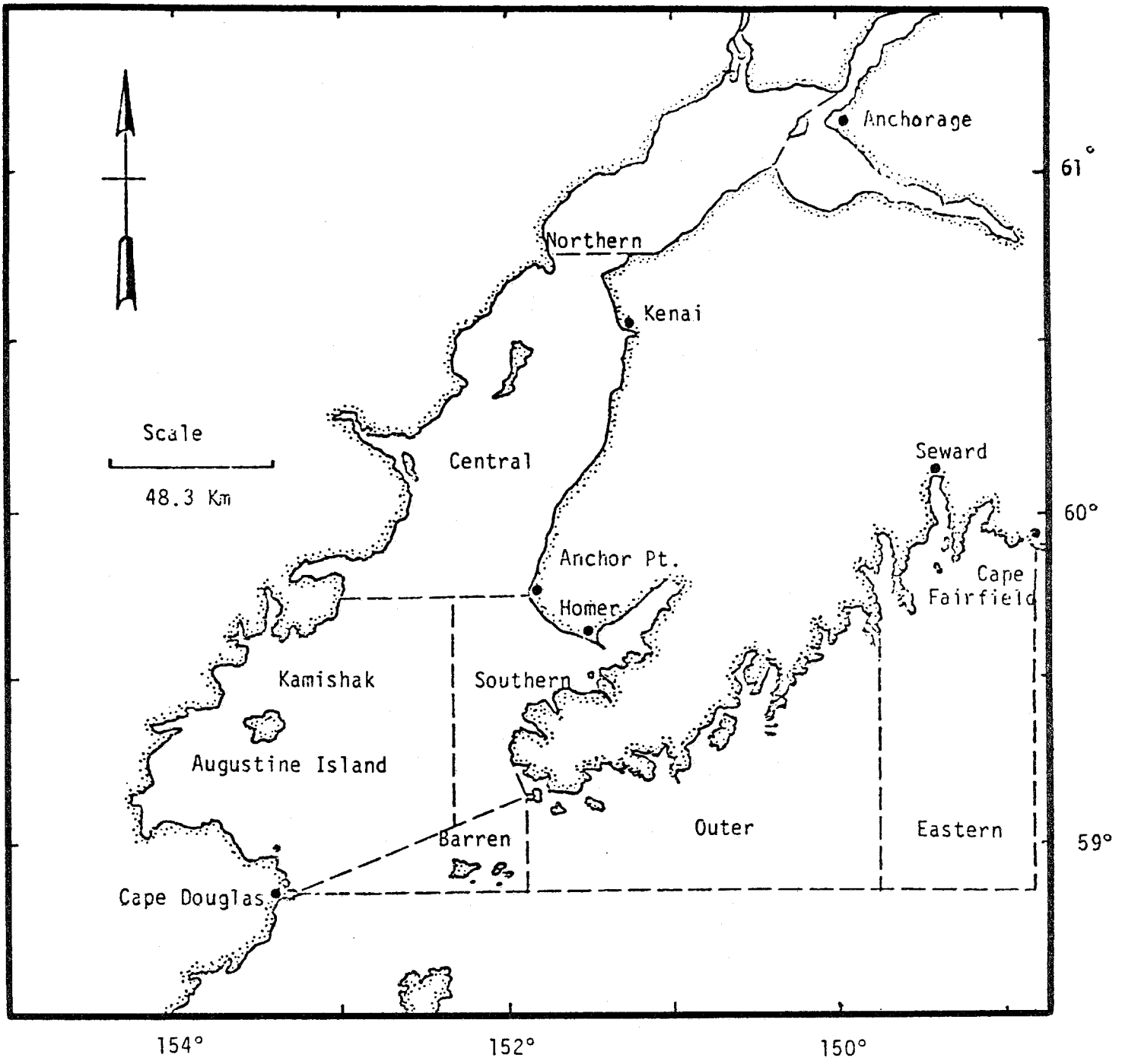

Figure 1. Cook Inlet area district location chart.

Bay District due primarily to lack of processing facilities in the Seldovia area as a result of earthquake damage in 1964. From the late 1960's through 1976 the seasonal total catch ranged from 1,134 to 2,177 t (2.5 to 4.8 million lb). In recent years, the harvests have been as low as 87.3 t (192,411 lb) total for all districts of Cook Inlet (Table 1) and have warranted district closures.

Tanner Crab

There are three geographically distinct Tanner crab fisheries in the Lower Cook Inlet area: (1) Southern District (Kachemak Bay); (2) Kamishak and Barren Islands Districts; and (3) the Outer and Eastern Districts (south of Seward).

During the initial years of the Tanner crab fishery, this species was harvested incidental to king crab during the open king crab season. As price and demand for Tanner crab increased in the early 1970's, fishermen began directing their efforts specifically towards this species. Table 2 lists Cook Inlet Tanner crab catches in pounds by district from the 1968-69 season through the 1983-84 season. The first significant catches of Tanner crab were taken from the Southern District during the 1968-69 fishing season and totaled 635 t (1.4 million lb). Fishing effort spread to other stocks of Cook Inlet Tanner crab and the largest catch occurred during the 1973-74 season when approximately 3,629 t (8 million lb) were harvested in all districts. Prior to the 1976-77 fishing season, there were no minimum size limitations on Tanner crab. Since that season, a 140 mm (5.5 in) carapace width minimum size limit has remained in effect.

There were no closed periods for Tanner crab fishing prior to 1973. Seasons have been shortened with summer and fall closures occurring in more recent years. An opening date of 1 December was in effect from 1974 to 1982. A 1 November opening date was established by regulation for 1983. Closing dates have varied through the years; some districts have remained open through the end of May.

In recent years, the majority of the Tanner crab fishing fleet has started the season in the Southern District. The larger vessels have moved later in the season to the more remote districts such as Kamishak, Outer, and Eastern Districts.

OBJECTIVES

The purpose of this project is to develop consistent and workable techniques for measuring stock abundance and condition of king and Tanner crab stocks throughout Lower Cook Inlet which will be utilized for managing the commercial king and Tanner crab fisheries on a sustained yield basis. The major objectives were as follows: (1) to develop relative abundance indices of king and Tanner crab stocks in the major production areas, and (2) to provide relatively accurate predictions of future population sizes. Secondary objectives were as follows: (1) to determine fishing mortality and migration through tagging studies, and (2) to examine the female king and Tanner crab in the index fishing for ovigerousness and relative size frequency.

Table 1. Cook Inlet king crab catches in pounds by fishing season by district, 1960-61 to present.

YEAR	SOUTHERN		KAMISHAK-BARREN	OUTER	TOTAL
	Aug-Jul		Aug-Mar	Aug-Mar	
1960-61	2,699,680		986,551	118,067	3,804,298
1961-62	1,619,642		3,642,500	368,909	5,631,051
1962-63	2,763,343		5,509,708	343,505	8,616,556
1963-64	1,960,426		4,915,303	59,352	6,935,081
1964-65	1,892,479		1,850,572	963	3,744,014
1965-66	1,948,012		1,684,346	14,491	3,646,849
1966-67	1,397,904		1,386,008	89,510	2,873,422
	Aug-Dec	Jan-Mar			
1967-68	764,783	352,614[1]	1,833,605	239,518	3,246,360
1968-69	638,066	112,840	1,711,296	87,302	2,549,504
1969-70	1,189,714	275,547	1,688,803	73,644	3,277,708
1970-71	1,225,741	314,277	2,115,991	9,468	3,665,477
1971-72	936,865	1,055,360	2,868,315	12,657	4,873,197
1972-73	838,964	552,060	2,756,023	1,966	4,149,013
1973-74	1,562,781	409,060	2,236,131	5,613	4,213,585
1974-75	1,156,433	660,079	2,965,310	2,035	4,783,857
1975-76	800,905	873,697	1,832,484	45,293	3,552,379
1976-77	764,182	271,134	3,103,895	16,384	4,155,595
	Aug-Nov	Dec-Mar			
1977-78	326,442	257,648	1,099,279	1,350	1,684,719
1978-79	566,435	97,953	480,261	1,753	1,146,402
1979-80	793,552	60,032	489,365	4,871	1,347,820
1980-81	408,497	100,173	1,635,922	8,022	2,152,584
1981-82[2]	144,423	39,476	1,371,821	4,143	1,559,863
1982-83	CLOSED	CLOSED	807,079	14,280[2]	822,359
1983-84	CLOSED	CLOSED	187,907	4,504[3]	192,411

[1] Includes 5,840 pounds caught in April 1968.

[2] August through October harvest only.

[3] 1 August to 26 August only.

Table 2. Cook Inlet Tanner crab catches in pounds by district 1968-1969 season through 1983-1984 season.

Year	Southern District	Kamishak/ Barren Is.	Outer/Eastern District	Total Catch
1968-69	1,388,282	12,398	816	1,401,496
1969-70	1,147,154	71,196	104,191	1,322,541
1970-71	1,046,803	541,212	3,000	1,591,015
1971-72	2,462,956	974,962	804,765	4,242,683
1972-73	2,935,662	3,361,023	1,266,937	7,563,622
1973-74	1,387,535	4,689,251	1,891,021	7,967,807
1974-75	967,762	3,150,462	656,660	4,774,884
1975-76	1,339,245	3,281,084	850,964	5,471,293
1976-77	2,009,633	1,765,926	824,520	4,600,079
1977-78	2,806,568	2,077,092	502,049	5,385,709
1978-79	2,323,420	2,713,339	694,728	5,731,487
1979-80	1,134,940	3,338,623	595,645	5,069,208
1980-81	1,047,680	1,757,331	463,201	3,268,212
1981-82	548,529	1,286,332	524,897	2,359,758
1982-83	584,908	1,693,794	682,919	2,961,621
1983-84	996,763	1,373,674	443,384	2,813,821

METHODS AND MATERIALS

Quantitative surveys of king and Tanner crab have been included in the Southern and Kamishak-Barren Islands Districts using pots since 1974 and 1975, respectively. The pots are 2.1 x 2.1 m (7' x 7') commercial king crab gear with a mesh size of 7.5 x 5.1 cm (3 in x 2 in) on the pot, and two 85.9 x 17.8 cm (35 in x 7 in) escape tunnels. Index fishing in the Southern District from 1974-1979 consisted of four pots per 1.8 km^2 (1 nm^2), every other square nautical mile, in areas of king crab abundance, and was conducted in June. In 1980 the sampling design was intensified to four pots spaced 0.4 km (1/4 mi) apart per 1.8 km^2 (1 nm^2) in areas of king crab abundance, and sampling was conducted in July. From 1981 to the present, sampling consisted of four pots every other square nautical mile (1.8 km), in July. In the Kamishak and Barren Islands area the sampling stations were 9.3 km^2 (5 nm^2) in size and five pots were fished in each sample station. Station distribution for the two areas of the survey was determined from systematic grid patterns. Pot soak times were as close to 24 hours as practical.

Index fishing in 1983 utilized the State of Alaska R/V PANDALUS. Fishing in the Southern District began on 28 June in the vicinity of Point Pogibshi, and the pots were moved in a northeasterly direction each day until the conclusion of the survey on 15 July near Bear Cove. A total of 60 stations was fished, ranging from 18 to 167 m (10-91 fm). Fishing in the Kamishak and Barren Islands area was conducted from 15-25 June. Direction of the pot strings in each sample station varied with tide and wind conditions. A total of 40 stations were fished, ranging from 29-187 m (16-102 fm).

King and Tanner crab caught in each pot were separated by sex and exoskeleton age. Subsampling was used in instances when the catch was large. Carapace length measurements were taken to the nearest millimeter using Vernier calipers. Exoskeleton age, fecundity, and egg condition were examined on female king and Tanner crab. Mature female Tanner crab without external eggs were dissected and the presence or absence of internal eggs or sperm determined.

During the course of the index fishing, individual data forms for each sex and species were used for recording the catches from individual pots. Data was edited and keypunched for data storage and analysis in the University of Alaska computer system.

Legal sized king crab were tagged with isthmus ring tags in 1983 and released near their capture points.

Legal size male Tanner crabs were tagged with carapace dart tags in October, prior to the 1 November opening date in the Southern District. Female king crab were inspected for ovigerousness and condition during September and October 1983.

RESULTS AND DISCUSSION

King Crab - Male

A description of the fishery and results of the assessment studies conducted in 1983 on male king crab are given below.

1983-84 King Crab Fishery:

The Southern District did not open to commercial or subsistence fishing for king crab because of very low average catches of legal male crab during the July 1983 index program (0.5 crab per pot).

The remaining districts of lower Cook Inlet opened 1 August 1983 for commercial fishing. A total of 17 vessels started the season in the Kamishak-Barren Islands Districts and landed a total of approximately 85 t (187,907 lb) through 26 August when the season was closed by emergency order. Legal male catch per pot declined from 3.0 at the beginning of the fishery to 1.4 crab, with an average of 2.6. In the Outer-Eastern District only 2 t (4,504 lb) were landed.

The price per pound for the Cook Inlet crab was high at $4.00. The total ex-vessel value of king crab was approximately $769,644.

Southern District:

The 1983 average catch of legal male king crab per pot was 0.5, 23% greater than the 1982 record low catch of 0.4 crabs per pot, but 75% less than the previous 9-year average of 2.1 (Table 3). The greatest catch of legal males per pot by index station was 9.8, and occurred northwest of Seldovia Bay (Figure 2). During the 1981 survey, stations in this vicinity had average catches as high as 29 crabs per pot (Davis 1982). Due to the apparent lack of legal male king crab in the Southern District, the commercial season was not opened during the 1983-84 season and the personal-use fishery was also closed.

Pre-recruit size crab, defined as age class group "one" comprised the greatest percentage (33.5) of the male population samples in 1982 and 1983 (Table 4). Because the overall abundance of the population is low, the strength of this pre-recruit class may not be very great. The mean carapace length in 1983 was 126.1 mm (Figure 3), about the same as the mean length observed in 1982 (124.8 mm) and over the previous 9 years (mean = 125.9 mm). No cohort of great abundance is expected to be emerging in the population sampled, although steady recruitment is anticipated.

During the 1983 index survey 146 legal male king crabs were tagged and released near their capture points. No tags were returned during 1983 because of the closure of the commercial fishery.

No significant linear correlation was found ($r^2 = 0.30$) between the average number of legal male king crab captured per pot in the index survey and the commercial harvest of crab following the index survey for the years 1974-1980. Presently, the index survey for king crab is not used to generate

Table 3. Total catches of king crab from Southern District during index cruises, 1974-1983.

Year	Month	Pots Pulled	Sublegal Males	Legal Males	Index catch per pot for Legal Males	Average Wt (lbs.)	Commercial Harvest (No.)
1974[1]	June	240	494	275	1.2	7.5	242,202
1975	June	260	552	573	2.2	8.3	201,759
1976	June	227	996	206	0.9	8.2	126,258
1977	June	260	9,771	286	1.1	7.1	82,266
1978	June	237	5,500	808	3.4	6.6	100,665
1979	June	255	2,909	609	2.4	6.8	125,527
1980[2]	July	367	10,035	1,947	5.3	6.8	74,804
1981	July	238	2,310	519	2.2	7.1	25,901
1982	July	222	608	95	0.4		CLOSED
1983	July	230	447	123	0.5		CLOSED

[1] Sample stations were selected randomly in 1974, number of pots pulled is not comparable to years 1975 to present when stations were selected systematically.

[2] Sample stations were increased in areas containing legal size king crab, 1980 index catch per pot is not comparable to previous year's values.

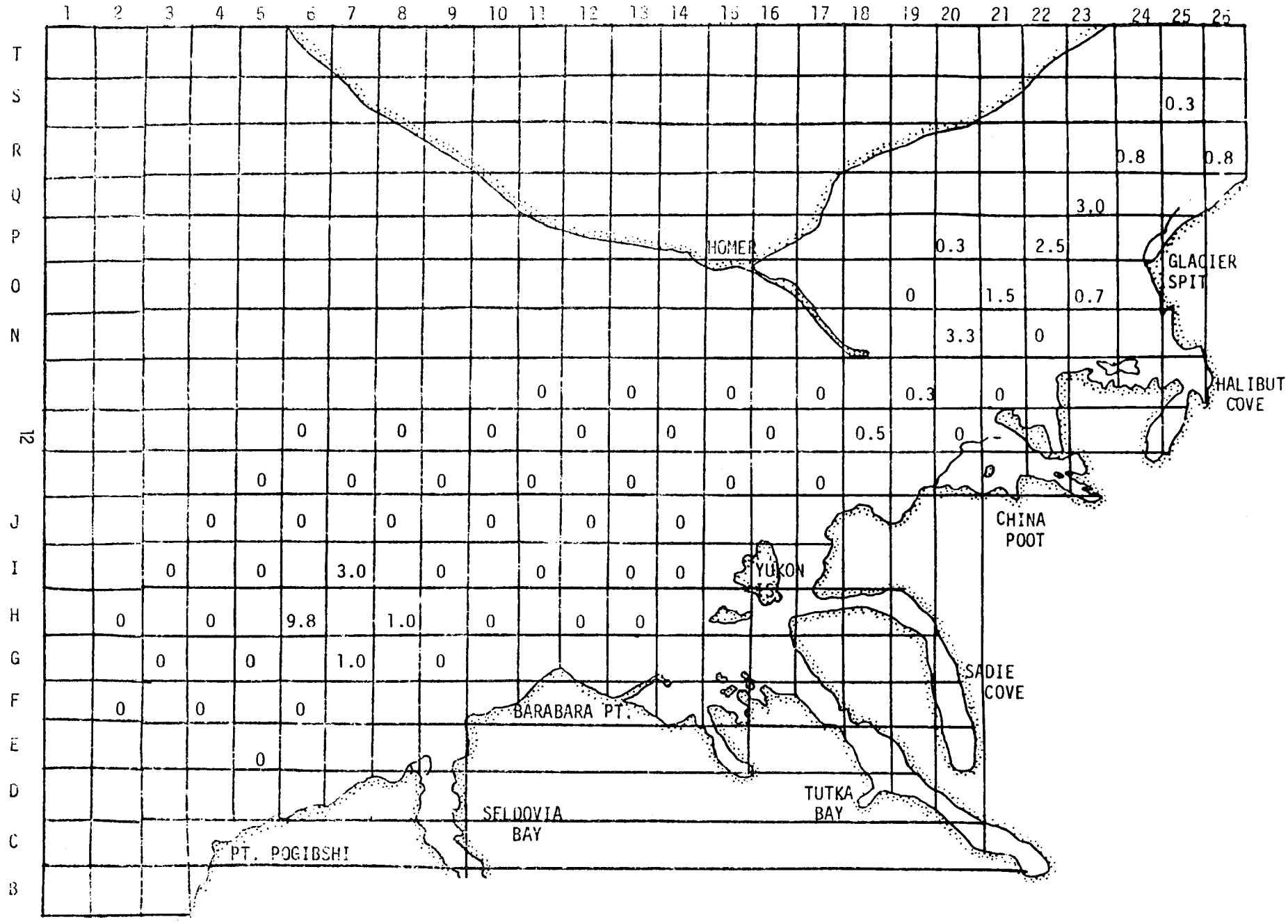

Figure 2. Average catch per pot of legal size male king crab captured during index fishing 28 June - 15 July 1983, (7' x 7' pots, two 2-qt. bait containers of herring, 24-hour soak).

Table 4. Percentage of male king crab by size class groups captured in Southern District during index pot cruises, 1974-1983.

Class[1] (carapace length)	1974 n=769	1975 n=1,125	1976 n=1,202	1977 n=10,053	1978 n=6,308	1979 n=3,518	1980 n=11,982	1981 n=2,649	1982 n=703	1983 n=570
FOURS	0.7	7.5	3.7	9.0	1.5	3.9	2.5	2.1	7.0	6.7
THREES	16.2	4.8	45.7	36.8	15.7	16.4	26.7	19.3	11.0	21.4
TWOS	29.2	13.4	23.1	35.5	37.1	32.1	28.8	30.8	32.7	16.8
ONES	18.0	23.0	8.8	15.9	32.9	28.7	25.8	28.2	35.8	33.5
RECRUITS	18.1	15.2	6.6	1.9	11.7	15.2	14.2	15.8	9.5	14.2
POST-RECRUITS	17.8	36.1	12.1	0.9	1.1	3.7	2.0	3.8	4.0	7.4

[1] FOURS (- 90 mm, 4 or more years from legal)
THREES (91-108 mm, 3 years from legal)
TWOS (109-126 mm, 2 years from legal)
ONES (127-144 mm, 1 year from legal)
RECRUITS (145-163 mm, enter commercial fishery)
POST-RECRUITS (all old shell males - 145 mm plus new shell males - 164 mm)

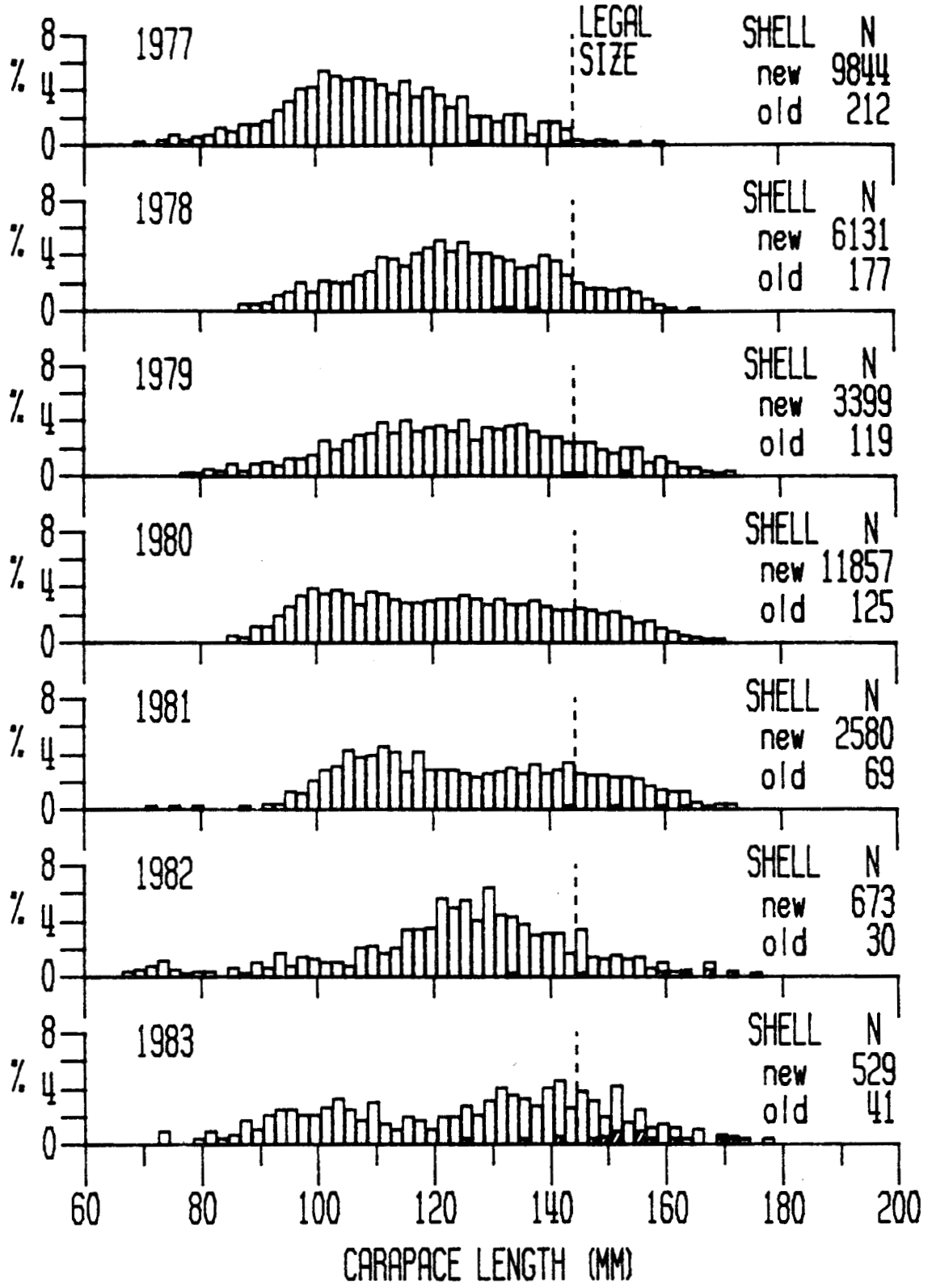

Figure 3. Carapace length frequency by percent in 2 mm increments of male king crab captured in index pots in the Southern District, 1977-1983. (Old shell are slashed lines).

commercial harvest forecasts in the Southern District. The lack of correlation between the index survey and commercial harvest may be due to inaccurate survey population trend estimates, changes in population movement, or great variance in exploitation rate between years. If tag returns are used as an estimate of exploitation rate, the mean from 1975-1981 is 38.7 (s = 10.5), ranging from 24 to 54%. No significant linear correlation ($r^2 = 0.10$) was found between the average number of legal male crab per pot in the index survey and the population estimate prior to harvest as generated from Peterson mark-recapture experiments in the Southern District for the years 1974-1981. This indicates either a problem in the design of the survey and/or mark-recapture experiments.

The average number of pre-recruits per pot determined from the index survey in year "x" showed no significant linear correlation to the average legal males per pot in the index survey ($r^2 = 0.10$) or total commercial harvest ($r^2 = 0.05$) in year "x + 1". Thus, the index survey will not yield a direct forecast of legal males based on pre-recruits.

The catch per unit effort (CPUE) of male king crab by age class was examined to determine the size at which crab are fully recruited into the survey, and to examine survival of a cohort over time (Table 5). The CPUE of the pre-recruit two class is greater than the CPUE of pre-recruit ones 60% of the time, indicating that in the Southern District pre-recruit two size crab are recruited into the survey the majority of the sample years. The exception to this occurs following a huge pre-recruit three year (1977 and 1980). The 1977 pre-recruit three year class carried through to recruitment, but the 1980 class did not. Large declines in numbers of pre-recruits generally correspond to years of high exploitation rate based on tag returns.

The mean survival rate of pre-recruit one male king crab to recruit crab was calculated by dividing the recruit CPUE by the pre-recruit one CPUE the previous year, yielding a mean of 61.8% (s = 52.7) from 1975 to 1983. The survival rate of pre-recruit ones in the Southern and Kamishak Districts appeared to regularly fluctuate over time (Figure 4). Factors affecting survival rates in the two districts appear to be asynchronous, causing a "lag time" of about 1 year between the peaks and valleys of survival rate fluctuations. Assuming constant population growth, fluctuations in survival may result from cyclical environmental events which influence crab populations. If population growth is cyclical, i.e., skip molting occurs on a regular basis, then the periodic lack of recruitment to legal size may be responsible for the apparent fluctuations in survival.

Kamishak District:

The 1983 average catch of legal male king crab per pot was 0.8 crab, about one-fifth the 1982 average catch of 4.2 crab per pot, and was the lowest on record (Table 6). The greatest catch of legal males per pot by index station was 10.0 and occurred west of Augustine Island (Figure 5). Due to the low abundance of crab in the commercial fishery, the 1983 season was closed early by emergency order after a harvest of 85 t (188,000 lb).

Table 5. Catch per unit effort by size class group of male king crab captured during index pot cruises in the Southern District, 1974-1983.

	CPUE by Age Class[1]					
Year	PR_4	PR_3	PR_2	PR_1	R	Post R
1974	0.02	0.53	0.94	0.58	0.58	0.57
1975	0.32	0.21	0.58	1.00	0.65	1.56
1976	0.19	2.42	1.23	0.47	0.35	0.54
1977	3.48	14.23	13.73	6.15	0.73	0.35
1978	0.40	4.18	9.87	8.76	3.11	0.29
1979	0.54	2.26	4.43	3.96	2.10	0.51
1980	0.82	8.72	9.40	8.42	4.63	0.65
1981	0.24	2.15	3.42	3.14	1.76	0.42
1982	0.22	0.35	1.04	1.14	0.30	0.13
1983	0.17	0.53	0.42	0.83	0.35	0.18

[1] PR_4 (- 90 mm, 4 or more years from legal)

PR_3 (91 - 108 mm, 3 years from legal)

PR_2 (109 - 126 mm, 2 years from legal)

PR_1 (127 - 144 mm, 1 year from legal)

R (145 - 163 mm, enter commercial fishery)

Post R (all old shell males 145+ mm, and new shell males 164+ mm).

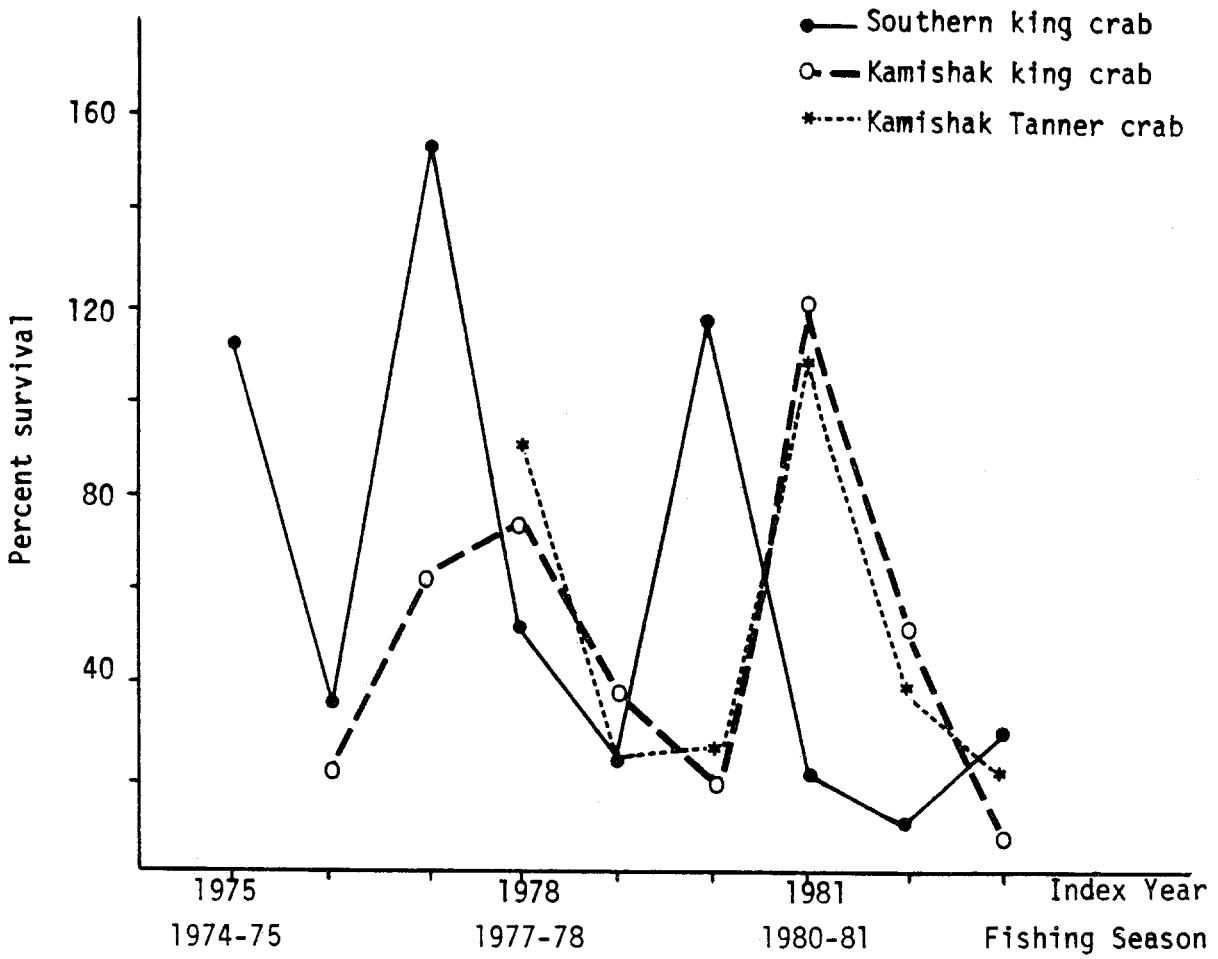

Figure 4. Percent survival of pre-recruit one male king and Tanner crab to recruit size in the index by year for two Cook Inlet commercial fishing districts.

Table 6. Total catches of king crab from Kamishak District during index cruises, 1975-1983.

Year	Dates From	Dates To	Pots Pulled	Sublegal Males	Legal Males	Pot[1] Index	Average wt.(lbs)	Commercial Harvest (No.)
1975	2 Jun	11 Jun	96	1,529	2,593	27.0	7.5	241,817
1976	29 Jun	23 Jul	159	1,304	767	4.8	8.0	348,496
1977	8 Jul	23 Jul	199	4,326	698	3.5	8.3	116,838
1978	29 Jul	20 Jul	224	7,776	880	3.9	7.2	66,371
1979	8 Jul	27 Jul	261	7,782	880	3.4	6.8	72,690
1980	6 Jun	16 Jun	171	1,098	602	3.5	6.7	214,220
1981	23 Jun	7 Jul	173	1,191	1,202	7.0	7.1	187,004
1982	24 Jun	4 Jul	70	504	296	4.2	7.2	111,572
1983	28 Jun	15 Jul	192	250	150	0.8	7.0	26,844

[1] Average catch per pot of legal male king crab.

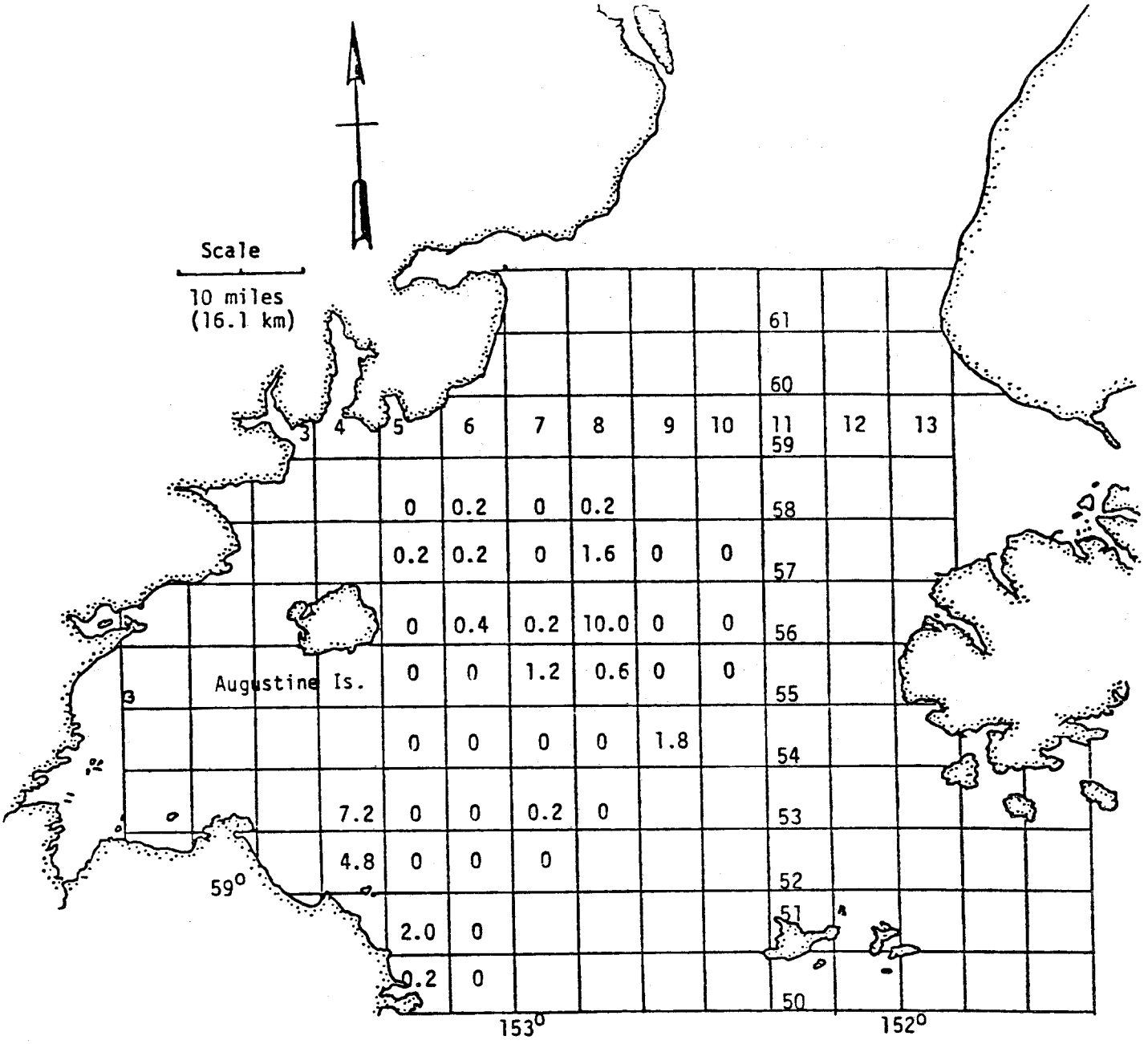

Figure 5. Average catch per pot of legal sized male king crab captured during index fishing, 15-25 June 1983 (7' x 7' pots, two 2-qt bait containers with herring, 5 pots per station).

Pre-recruit size crab, defined as age class group "one" comprised the greatest percentage (46.0) of the male population sampled (Table 7). Because the overall population is low, the strength of this pre-recruit class may not be very great. The mean carapace length in 1983 was 141.3 mm, 2.6% greater than the mean length observed in 1982 (137.7 mm), and 8.3% greater than the previous 8-year average of 130.5 mm (Figure 6). The increase in mean length indicates a lack of appearance of juveniles. A large cohort of pre-recruit crab first observed in 1976 grew to support a strong fishery in 1980 and 1981, but the lack of juveniles to sustain the pre-recruit and recruit age classes resulted in fishery closures in 1983. The population in Kamishak District is expected to continue declining.

During the 1983 index survey, 141 legal male king crabs were tagged and released near their capture points, and 37 (26.2%) tabs were returned from the commercial fishery (Table 8). Tagging of legal male king crab has been conducted during index surveys to the Kamishak District yearly since 1975, with tag return information applied to the Peterson mark-recapture equations. The number of legal king crab estimated to be available to the Kamishak commercial fishery in 1983 was only 99,807 crab (Table 9). The population estimates generally follow the trend of the commercial catch statistics. The largest estimated legal population of 18.6 million lb (8.4 thousand t) of crab ± 2.9 million lb (1.3 thousand t) occurred in 1975, and has erratically declined to the record estimated low of only 702,643 lb (319 t) crab in 1983.

No significant linear relationship was found between the average number of legal male king crab captured per pot in the index survey and the commercial harvest of crab following the index survey. Data from 1975 to 1982 (data after 1982 was excluded because of fishery closures), yielded an r^2 of 10.12. Similar to the Southern District, the index survey for king crab at present is not used to generate commercial harvest forecasts in the Kamishak District. Using the mean rate of actual tag returns as the exploitation rate estimate, fluctuations in exploitation rate can be examined. The mean from 1975-1983 was 26.6% with a low variance of 8.05. Variance in exploitation rate may not be sufficient to explain the lack of correlation between the surveys and commercial harvest.

A significant linear correlation ($r^2 = 0.88$) existed between the average number of legal male king crab per pot in the index survey and the population estimate prior to harvest as generated from Peterson mark-recapture experiments in the Kamishak District for the years 1975-1983 (Figure 7). Thus, the index survey in Kamishak generated a population abundance estimate as correlated with prior years' mark-recapture experiments.

Similar to the Southern District, the percentage of pre-recruits in the population and average number per pot determined from the index survey in year "x" showed no significant linear correlation ($r^2 = 0.09$ and 0.55, respectively) to the average legal male per pot in year "x + 1" for the years 1975-1983. The index survey is not presently used to generate a direct forecast of recruits based on pre-recruits from a previous year.

The CPUE of male king crab by age class was examined to determine the size at which crab are recruited in the Kamishak survey (Table 10). Since the same gear was used, results were similar to that in the Southern District. The

Table 7. Percentage of male king crab by size class group captured in Kamishak Bay during index cruises, 1975-1983.

Class[1] (carpace length)	1975 n=3546	1976 n=2069	1977 n=5024	1978 n=8657	1979 n=8662	1980 n=1700	1981 n=2393	1982 n=800	1983 n=400
FOURS	7.3	17.6	7.7	5.0	7.0	2.2	0.6	0.5	0.5
THREES	8.1	16.1	43.8	18.8	16.6	6.9	13.6	4.4	4.3
TWOS	8.2	12.3	24.0	39.6	24.5	19.8	11.4	27.4	11.8
ONES	17.2	16.9	10.6	26.4	39.1	36.5	24.2	30.8	46.0
RECRUITS	10.1	11.4	5.5	5.3	10.6	22.9	31.4	15.5	15.3
POST-RECRUIT	49.2	25.7	8.4	4.9	2.2	12.5	18.8	21.5	22.3

[1] FOURS (-90 mm, 4 or more years from legal)

THREES (91-108 mm, 3 years from legal)

TWOS (109-126 mm, 2 years from legal)

ONES (127-144 mm, 1 year from legal)

RECRUITS (145-163 mm, enter commercial fishery)

POST-RECRUITS (all old shell males - 145 mm plus new shell males - 164 mm)

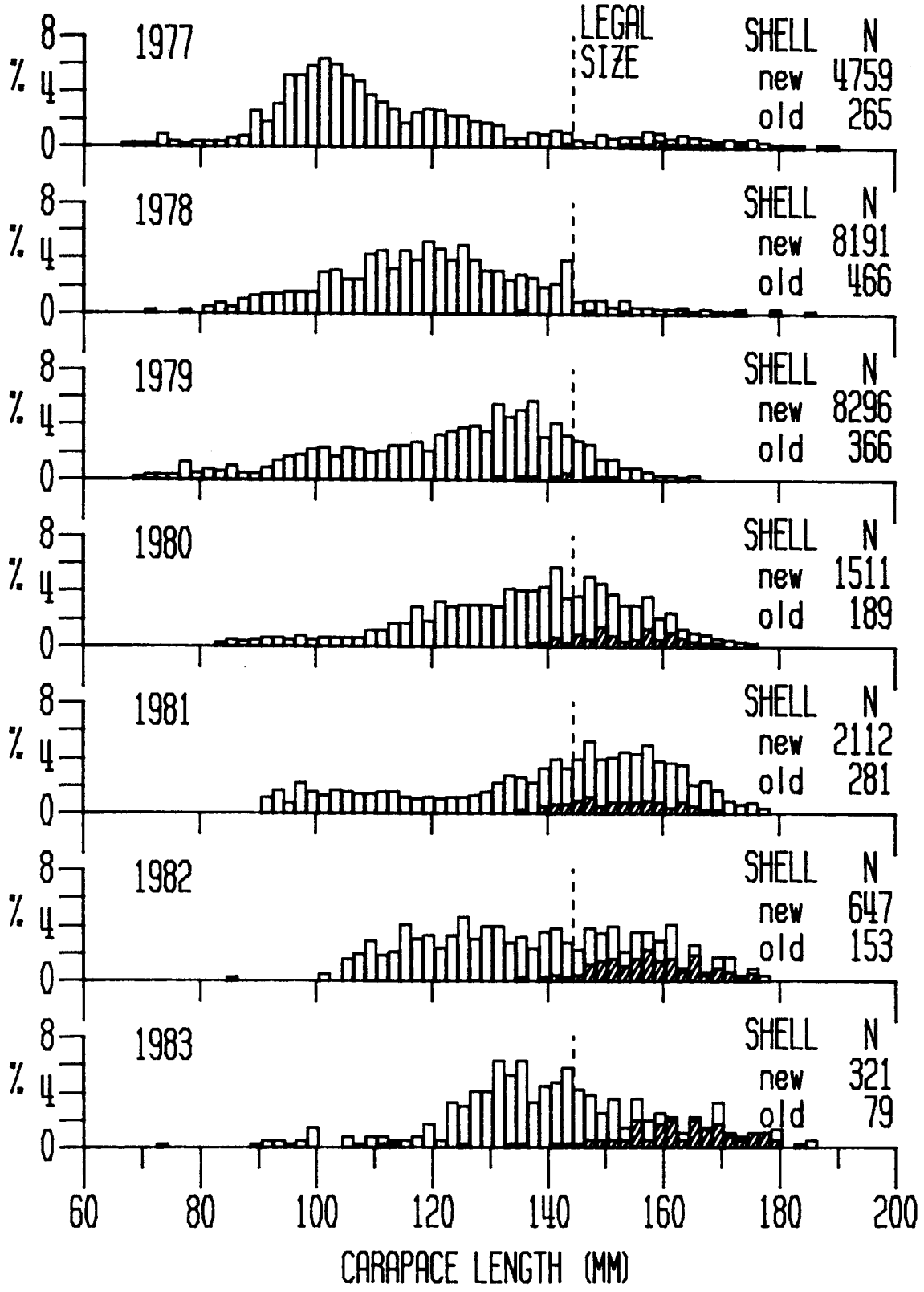

Figure 6. Carapace length frequency by percent in 2 mm increments of male king crab captured in index pots in Kamishak District, 1977-1983 (old shell are slashed lines).

Table 8. Actual king crab tag returns by size class and month in the Kamishak District during August to October 1983.

	Recruits		Post-Recruits					
	Less than 163 mm new shell		Less than 163 mm old shell 164-179 mm shell		164-179 mm old shell Greater than 180 mm all		Total	
Month	No. Released	No. Returned	No. Released	No. Returned	No. Released	No. Returned	No. Released	No. Returned
July	61		44		36		141	
Aug-Oct		16(26.2%)		13(29.5%)		8(22.2%)		37(26.2%)

Table 9. Population estimates of legal king crab from mark-recapture experiments in Kamishak District, 1975-1983.

Year	M	R	C	N(crab)	N(lbs.)	95% C.I. Million lbs.	Avg. Wt.
1975	1,469	152	241,817	2,323,349	18,586,792	15.7 - 21.5	8.0
1976[1]	2,207	808	348,496	951,149	7,609,192	7.1 - 8.1	8.0
1977[1]	835	186	116,838	522,339	4,335,414	3.7 - 5.0	8.3
1978	799	187	66,371	282,434	2,027,876	1.7 - 2.3	7.2
1979	881	283	72,690	225,752	1,512,538	1.3 - 1.7	6.7
1980	600	161	214,220	794,733	5,404,184	4.6 - 6.2	6.8
1981	990	268	187,004	688,929	4,960,289	4.4 - 5.6	7.2
1982[1]	349	121	111,572	320,086	2,304,623	1.9 - 2.7	7.2
1983	141	37	26,708	99,807	702,643	0.7 - 0.7	7.0

M = Number marked
R = Number of marks recaptured (August through December)
C = Number of crab captured (August through December)
N = $[(M + 1)(C+1)]/(r + 1)$ = Numbers of legal crab at start of season
N (lb) = Average weight od crab x N
Ave. wt. = Based on dockside sampling of commercial harvest

[1] The number of legal males tagged is greater than the number of legal males in the survey because: in 1976 some stations were surveyed twice to increase the number of tags released, and Kodiak staff tagged males south of the survey area; in 1977, commercial pots were fished with research pots and legal males from commercial pots were tagged, but not included in survey results; in 1982, some stations were fished repeatedly to increase the number of tags released.

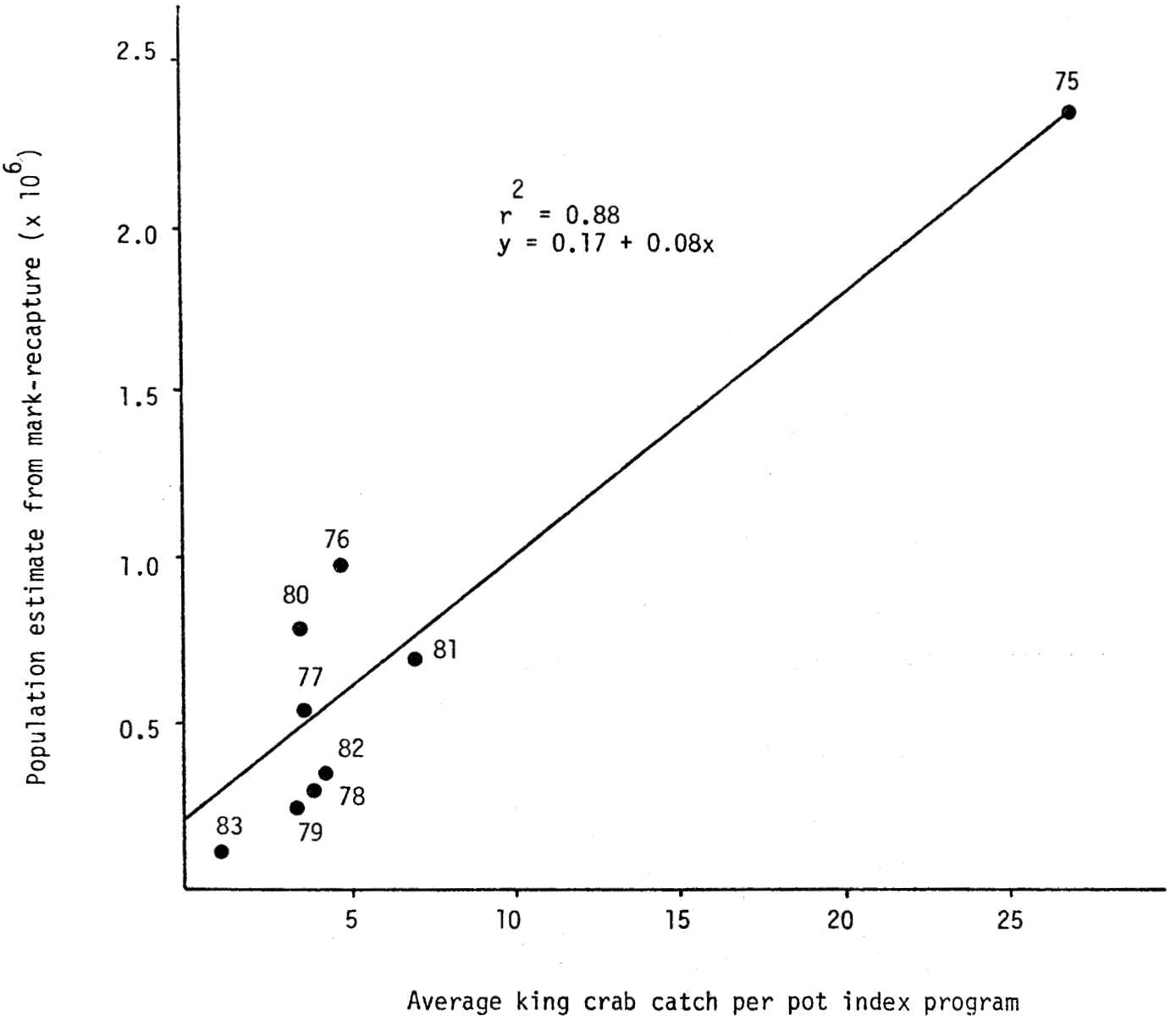

Figure 7. Linear correlation between the average legal male king crab catch per index pot and population abundance estimates from mark-recapture experiments in the Kamishak District of Cook Inlet.

Table 10. Catch per unit effort by size class group of male king crab captured during index pot cruises in the Kamishak District, 1975-1983.

	CPUE by age class[1]					
Year	PR_4	PR_3	PR_2	PR_1	R	Post R
1975	2.7	3.0	3.0	6.3	3.7	18.2
1976	2.3	2.1	1.6	2.2	1.5	3.3
1977	1.9	11.1	6.1	2.7	1.4	2.1
1978	1.9	7.3	15.3	10.2	2.0	1.9
1979	2.3	5.5	8.1	13.0	3.5	0.7
1980	0.2	0.6	2.0	3.6	2.3	1.2
1981	0.1	1.9	1.6	3.4	4.3	2.6
1982	0.1	0.5	3.1	3.5	1.8	2.5
1983	0	0.1	0.2	1.0	0.3	0.5

[1] PR_4 (- 90 mm)

PR_3 (91-108 mm)

PR_2 (109-126 mm)

PR_1 (127-144 mm)

R (145-163 mm, enter commercial fishery)

POST R (all old shell males 145+ mm, and new shell males 164+ mm)

CPUE of the pre-recruit two class is greater than the pre-recruit one class 50% of the time. The mean survival of pre-recruit male king crab to recruit crab was 49.3% (s = 36.4) from 1976-1983.

Survival as measured by the index of pre-recruit ones to the recruit age in both districts was correlated to a measure of fishing intensity for all of Lower Cook Inlet to determine if survival could be related to handling mortality. No correlation was found using the number of commercial pot lifts (from fish tickets). A fair correlation existed (r^2 = 0.59) between the commercial CPUE as determined from dockside interviews and percentage survival of pre-recruits to recruits (Figure 8). As the CPUE increases, percentage survival increased. Perhaps the percentage of survival of pre-recruits to recruits in the index can be used as a forecast of CPUE in the commercial fishery.

King Crab - Female

A description of assessment studies conducted in 1983 for female king crab follows below.

Southern District:

A total of 696 female king crab was captured during the 1983 index survey for an average catch per pot of 3.0. This is 64.7% less than the 1982 average catch per pot of 8.5 and one-fifth of the previous 9-year average of 15.4 females per pot.

The majority (56.6%) of the female crab had egg clutches of 1-39% ovigerity; only 2.4% of the females had full egg clutches in July (Table 11). This is a substantial decrease from previous years in percentage of females bearing full egg clutches and warrants careful monitoring. During September and October 1983, a total of 33 females was checked for ovigerousness and indications of greater egg mortality were observed (Table 12). A total of 42.9% of the female king crabs examined in October were barren with matted setae. Many of the remaining crabs had relatively small egg clutches. The numbers of king crab larvae available for release in the Southern District in the spring of 1984 will be seriously reduced. It was hypothesized that a parasite was contributing to egg mortality, so a sampling regime was initiated to obtain egg clutch specimens on a periodic basis. These specimens were sent to Dan Wickham at the University of California for analysis. Results from this analysis will be published in a separate report. Alternative hypotheses for the increasing egg mortality include a mean percentage increase of senescent females in the population.

The mean carapace length of a female king crab captured during the 1983 index was 121.4 mm, the largest mean length observed since inception of the index, and 7.6% greater than the previous 8-year average of 112.8 mm (Figure 9).

Kamishak District:

A total of 407 female king crab was captured during the 1983 survey for an average catch per pot of 2.1. This is less than half the 1982 average catch

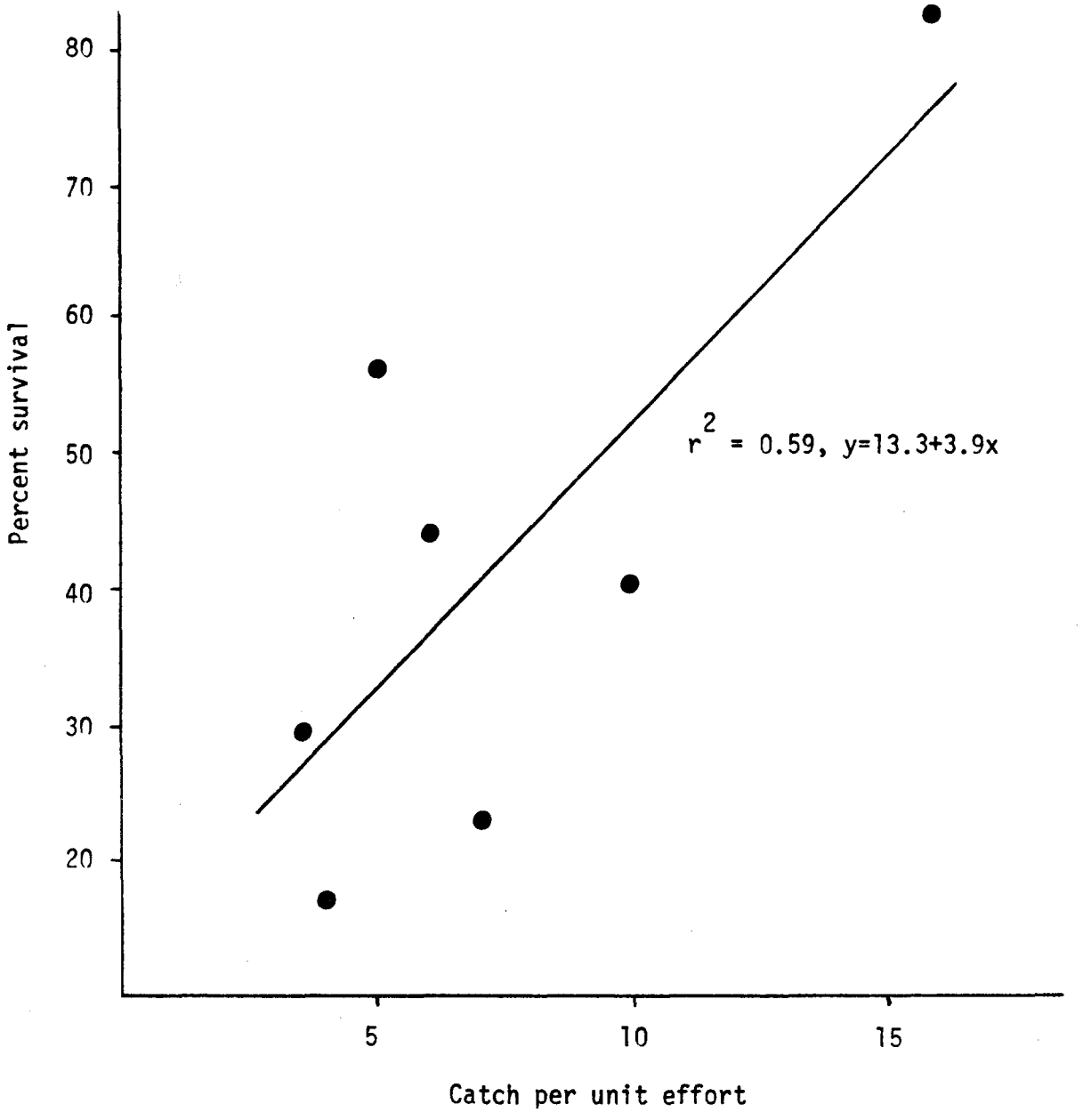

Figure 8. Linear regression of CPUE in the Lower Cook Inlet king crab fishery from dockside interviews, and percent survival of pre-recruit one male king crab to recruits in the Southern and Kamishak District index cruises.

Table 11. Percentage of relative egg abundance observed on female king crab during index cruises (June or July) 1977 to 1983 from the Southern District of Cook Inlet.

Category	1977	1978	1979	1980	1981	1982	1983
Juvenile	31.3	17.6	13.6	17.7	7.6	5.8	15.1
Barren[1]	0.0	0.2	0.4	0.2	0.2	0.0	1.6
Dropped Eggs[2]	0.6	0.7	3.1	0.4	1.2	0.5	1.3
1-39% ovigerity	0.5	1.2	0.2	2.6	6.0	1.2	56.6
40-89% ovigerity	3.0	10.0	13.4	12.5	33.5	15.5	23.0
90-100% ovigerity	64.6	70.3	69.3	66.6	51.5	77.0	2.4
Total	12,075	2,944	2,555	14,856	2,711	1,889	696

[1] Crab is in a new shell condition. Pleopods are not matted, indicating no eggs were present.

[2] Crab is in an old shell condition. Pleopods are matted indicating eggs were present but were dropped either due to maturity or disease. If dropped due to maturity, crab will molt, mate, and extrude eggs in near future.

Table 12. Observations on percentage of relative egg abundance in female king crab from the Southern District of Cook Inlet at periodic intervals over several years.

Category	November 1981	November 1982		September 1983[4]	October 1983[5]
Juvenile	7.6	2.8	---	0	0
Barren[1]	2.7	30.3	9.5	0	0
Dropped Eggs[2]	---	---	27.0	0	42.9
1-39% OVigerity	8.6		25.9	84.2	50.0
40-89% Ovigerity	30.8	66.9[3]	32.9	15.8	7.1
90-100% Ovigerity	50.3		4.7	0	0
Total	1,102	783 (sample)	85 (sub-sample)	19	14

[1] Pleopods are not matted, indicating no eggs were present.

[2] Pleopods are matted, indicating eggs were present but were dropped, perhaps due to disease.

[3] All females with eggs were grouped together. Subsample analysis by Kodiak staff.

[4] 4 miles north of Homer Spit, 33 fms.

[5] Outer Kachemak Bay, 40-60 fms.

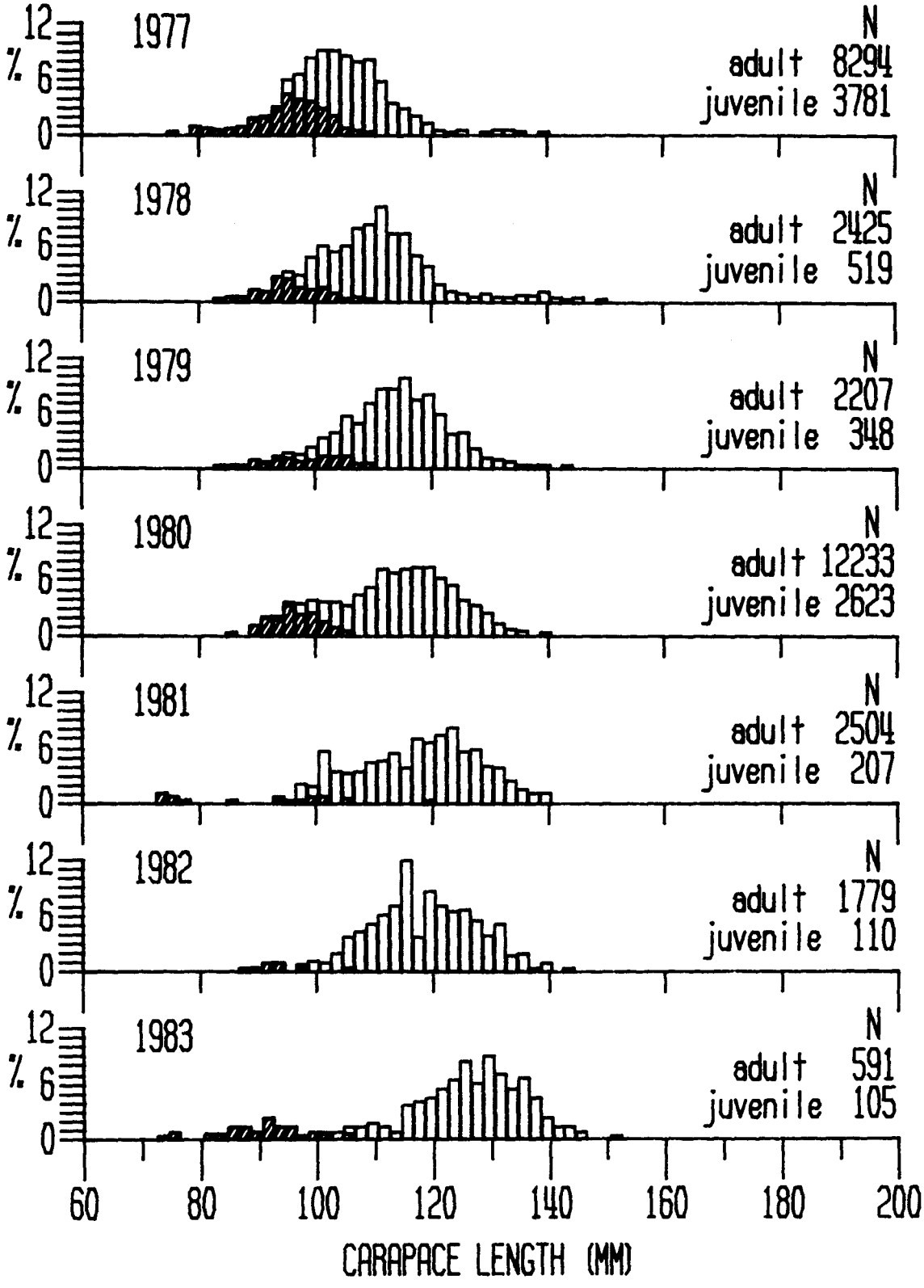

Figure 9. Carapace length frequency by percent in 2 mm increments of female king crabs captured during index cruises to Southern District, 1977-1983 (juvenile are slashed lines).

per pot of 5.1 and one-ninth of the previous 8-year average of 18.4 females per pot.

The majority (51.4%) of the female crab had egg clutches of 40-80% ovigerity compared to the previous year when 68.1% of the females had full egg clutches (Table 13). The decrease in percentage of females bearing full egg clutches in the Kamishak District is similar to the decrease in ovigerousness observed in females in the Southern District and warrants careful monitoring. The numbers of king crab larvae available for release in the spring of 1984 will be reduced.

The mean carapace length of female king crab captured during the 1983 index program was 121.4 mm, the largest on record (Figure 10). The percentage of juvenile females found were the lowest on record and indicates the population will continue to decline.

Tanner Crab - Male

Descriptions of the fishery and assessment studies conducted in 1983 on male Tanner crab are presented below.

1983-84 Tanner Crab Fishery:

The Tanner crab season opened 1 November 1983 in all districts of lower Cook Inlet with a total of 65 vessels participating.

The Southern District harvest totaled approximately 452 t (996,763 lb) which was achieved in 10 days, at which time the fishery was closed. The actual harvest was 10.8% greater than the predicted harvest. The commercial catch per unit of effort was 20.5 legal males per pot as compared to 12.9 legal males per pot in the 1982-83 season. Fishing effort in the Kamishak-Barren Islands District reached 15 vessels by December 1983. The season remained open until the end of May 1984. The harvest totaled 621 t (1.37 million lb) of Tanner crab from the two districts. Fishing in the Outer-Eastern Districts also continued through the end of May 1984. The peak effort occurred in December and the total reported catch was 201 t (443,384 lb).

The ex-vessel price of Tanner crab through the course of the 1983-84 season ranged from $1.10 to $1.55 per pound with the majority of the product purchased at $1.23 per pound. The ex-vessel value of the total Cook Inlet Tanner crab catch of 1,270 t (2.8 million lb) was approximately 3.46 million dollars.

Southern District:

The 1983 average catch of legal male Tanner crab per pot was 22.1, 35.6% greater than the 1982 catch per pot of 16.3, but similar to the previous 9-year average of 22.5 legal males per pot (Table 14). The greatest catch of legal males per pot by index station was 69.0, and occurred north of Tutka Bay (Figure 11).

Table 13. Percentage of relative egg abundance observed on female king crab captured during index cruises in Kamishak District, 1977-1983.

Category	1977	1978	1979	1980	1981	1982	1983
Juvenile	30.1	18.6	26.8	5.4	17.7	6.2	1.7
Barren[1]	0	T	0.1	0.5	0	0	0.5
Dropped eggs[2]	0.1	0.4	0.6	1.9	0.2	0.3	1.0
1-39% ovigerity	1.2	0.6	1.7	2.3	2.2	0.8	5.9
40-80% ovigerity	4.5	8.7	16.6	17.4	40.6	24.6	51.4
90-100%	64.1	71.7	54.1	72.5	39.3	68.1	39.6
TOTAL	7,488	8,164	6,123	930	1,337	357	407

[1] Crab is in a new shell condition. Pleopods are not matted, indicating no eggs were present.

[2] Crab is in an old shell condition. Pleopods are matted, indicating eggs were present but were dropped either due to maturity or disease. If dropped due to maturity, crab will molt, mate, and extrude eggs in near future.

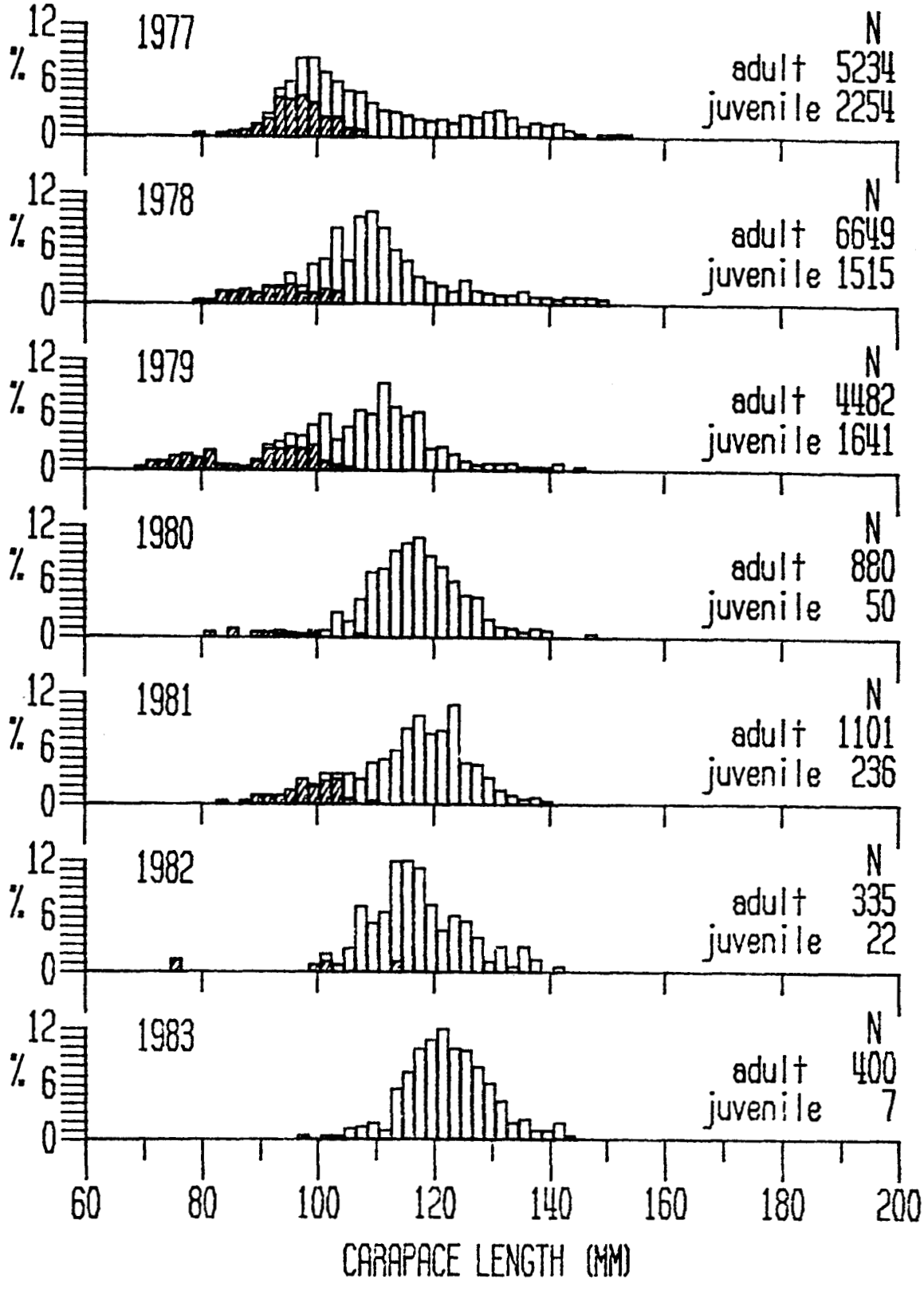

Figure 10. Carapace length frequency by percent in 2 mm increments of female king crabs captured during index cruises to Kamishak District, 1977-1983 (juveniles are slashed lines).

Table 14. Total catch of legal sized Tanner crab and average number of legal males per pot during index fishing, and the commercial harvest in numbers and pounds of crabs in the Southern District during 1974-1983.

Year	Pots Pulled	Total Legal Males	Average Legal Males per Pot	Average Weight (lb)	Commercial Harvest (lb)	Commercial Harvest (no.)
1974	240	3,889	16.2	2.9	967,762	339,565
1975	260	5,093	19.6	2.7	1,339,245	505,375
1976	227	5,014	22.1	2.8	2,016,501	722,760
1977	260	10,352	39.8	2.7	2,765,243	1,043,488
1978	237	8,508	35.9	2.6	2,323,420	880,083
1979	255	3,721	14.6	2.6	1,134,940	436,515
1980	219[1]	4,525	20.7	2.8	1,047,680	380,975
1981	238	4,012	16.9	2.5	548,579	219,411
1982	222	3,628	16.3	2.5	584,908	236,805
1983	230	5,087	22.1	2.5	996,763	397,116

[1] Number of pots pulled includes only stations previously sampled prior to 1980, 367 pots pulled 9,680 legal crab captured on all stations.

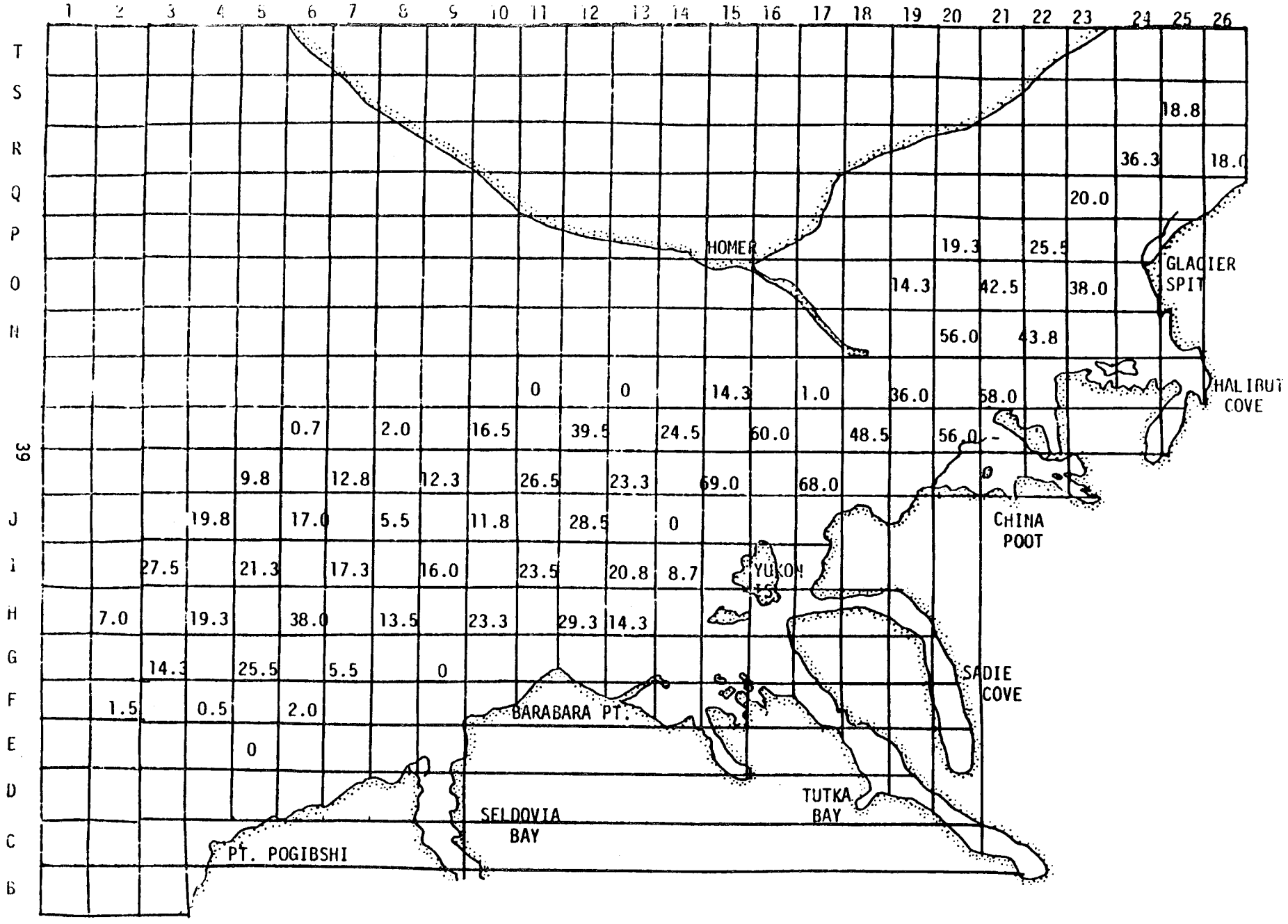

Figure 11. Average catch per pot of legal size male Tanner crab captured during index fishing 28 June - 15 July 1983 (7' x 7' pots, two 2-qt. bait containers of herring, 24-hour soak).

Recently molted recruit crab comprised the greatest percentage (54.9) of the male population sampled in 1983, similar to previous years (Table 15). The mean carapace width in 1983 was 142.8 mm, 3.5% greater than in 1982, but 1.8% less than the previous 7-year average of 145.4 mm (Figure 12).

During October 1983, 399 legal male Tanner crabs were tagged and 34.3% of the tags were recovered from the commercial fishery, which opened 1 November (Table 16). The percentage tags recovered is greatest when tagging occurs just prior to the fishery opening; during the first 2 years of tagging, crabs were marked in early summer and returns were low (5.3-8.3%). Since 1976, Tanner males have been marked in October or November when the carapace condition has been much harder. Tag recoveries since 1976 have ranged from 29.0 to 54.8% actual tag returns with no correction factors for unreported tags. When the tag return information is applied to the Peterson mark-recapture estimate formula, population estimates of legal Tanner crab at the start of the commercial fishery can be estimated. The 1983 legal population prior to harvest was estimated to be 1.15 million crab (Table 17). The legal population appears to have peaked in 1977 and subsequently declined.

A significant linear correlation exists between the average number of legal male Tanner crab captured per pot in the index survey and the commercial harvest of crab following the index survey (Figure 13) because the survey results are used to set the harvest guidelines. During 1976-1979 management of the harvest was based on a 48.0% tag return. The legal male catch per pot in the survey correlated well ($r^2 = 0.94$) with the number of legal males harvested. During 1980 -1983 the mean tag return decreased to 40.0%, and anticipating that fishermen would not comply with tag return requests, management estimated total tag return. The fishery was managed in a more conservative manner because of decreased legal males per pot in the survey and estimated tag returns. The decreased abundance of crab and percentage of tag returns resulted in a new relationship between the average legal Tanner male crab catch per pot in the survey and harvest of crab ($r^2 = 0.96$).

When the 1983 index survey value of 22.1 legal crabs per pot is correlated with numbers of crab harvested, using the most recent regression line, the estimated commercial harvest of 1983 in the Southern District is 360,000 crab or 408 t (900,000 lb) with an approximate 40% harvest rate.

A fair relationship ($r^2 = 0.62$) exists between the average number of legal male Tanner crab captured per pot in the index program and the population abundance estimate generated from Peterson mark-recapture experiments.

The percentage and average number of pre-recruits per pot (recently molted and old shell) determined from the index survey in year "x" showed no significant linear correlation to the recruit male per pot in the index program in year "x + 1". Thus, the index survey presently does not yield a direct forecast of recruits based on pre-recruits from a previous year. This could be the result of inaccurate shell aging. The fact that the CPUE of recruits was consistently greater than the CPUE of pre-recruits (Table 18) indicated that pre-recruit ones may not be fully recruited into the Southern District survey. Lack of sublegal male recruitment into the survey may be due to the gear used but more probably because of inappropriate survey design to cover

Table 15. Percentage of male Tanner crab by size class group captured in Southern District during index cruises, 1977-1983.

Carapace Width group (mm)	1977		1978		1979		1980		1981		1982		1983	
	RM	O + VO	RM	O + VO	RM	O + VO	RM	O + VO	RM	O + VO	RM	O + VO	RM	O + VO
51 - 87	0.1	0	0	0	0.2	0	0.2	0	0.4	0	0.1	0	0	0
88 - 114	3.1	2.1	1.9	2.0	1.8	2.4	3.0	1.0	7.4	2.1	7.8	3.1	2.5	2.7
115 - 139	21.3	5.5	14.7	8.3	14.4	15.4	11.3	7.2	26.1	7.5	29.5	10.3	23.4	9.4
140 - 165	51.7	2.3	54.5	3.0	48.0	7.9	43.3	7.7	43.3	2.8	40.4	3.1	54.9	3.0
166 - 215	13.6	0.3	15.2	0.3	8.6	1.4	24.6	1.8	10.0	0.4	5.3	0.4	3.6	0.4
Total Catch	15,235		11,662		5,650		12,520		7,100		7,377		8,217	

RM - Recently Molted - soft exoskeleton, no scratching or epifauna, spines sharp.

O + VO - Oldshell - carapace hard and brownish, scrathces present, epifauna may be present, spines worn.

Very Old Shell - carapace hard, dark brown to blackish, scratches present, epifauna present, spines very worn.

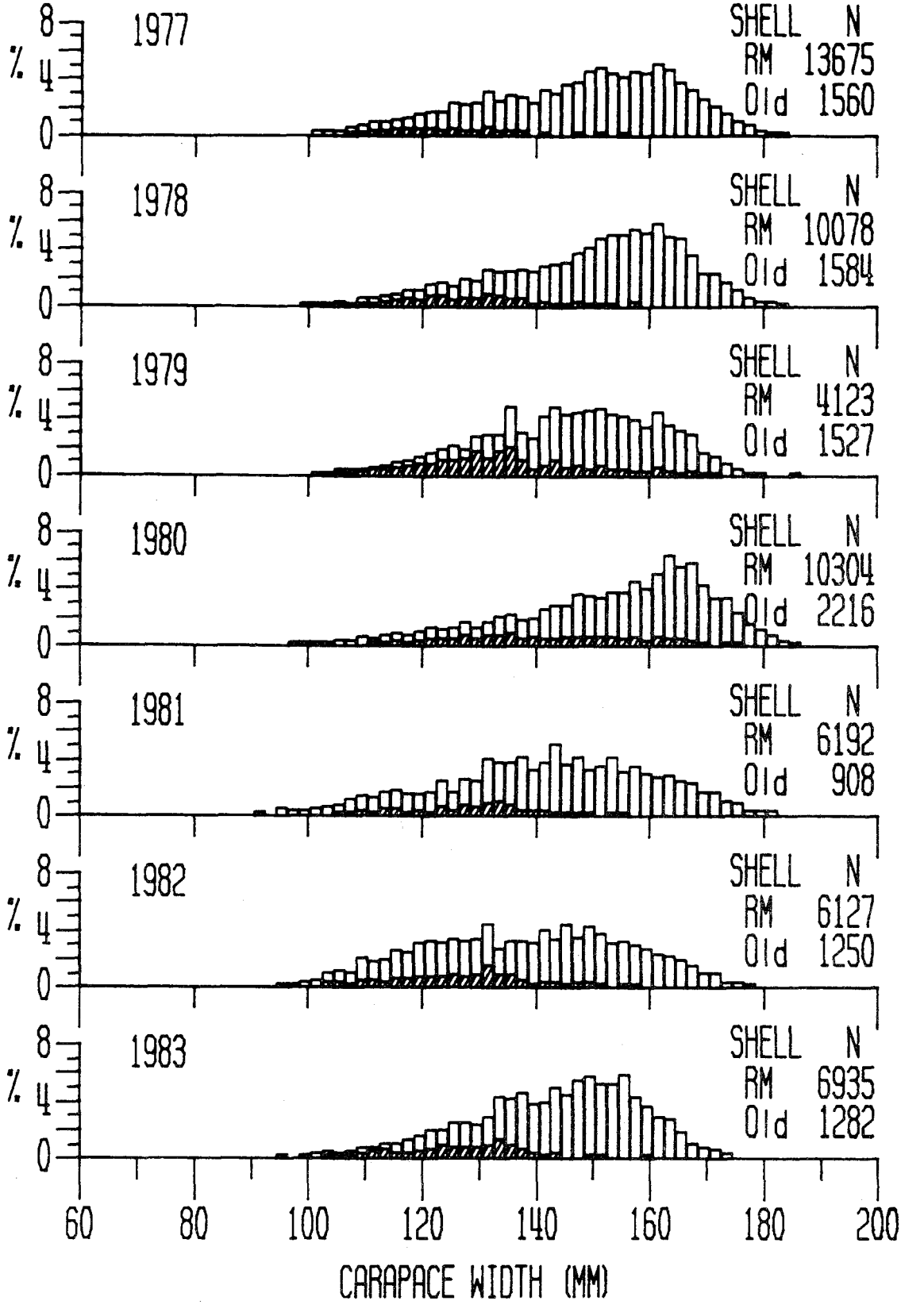

Figure 12. Carapace width frequency by percent in 2 mm increments of male Tanner crabs captured during index cruises to Southern District, 1977-1983 (old shell are slashed lines and RM is Recently Molted).

Table 16. Summary of tagging experiments of legal male Tanner crab in Southern District, 1974-1983 (carapace dart tags only).

Year	Tagging dates	No. tagged	Recovered[1]	% Recovered
1974	Jun 13-19	2,289	122	5.3
1975	May 23-31	1,500	124	8.3
1976	Nov 22-30	1,000	548	54.8
1977	Nov 12-14	497	225	45.3
1978	Nov 16-22	438	235	53.7
1979	Nov 12-30	362	105	29.0
1980	Nov 18-24	442	216	48.9
1981	Nov 06-18	500	216	43.2
1982	Nov 10-17	500	172	34.4
1983	Oct. 6-10	399	138	34.3

[1] Number recovered from season directly following tagging. Actual returns, no corrections for unreported tags.

Table 17. Population estimates of legal Tanner crab in the Southern District of Lower Cook Inlet, based on Peterson mark-recapture experiments.

Year	M	R	Catch (lbs)	C (crab)	N (crab)[1]	N (lbs.)[1]	95% C.I.[2] Million lbs.	Average Weight (lbs.)
1976	1,000	548	2,016,501	722,760	1,317,821	3,689,899	3.4 - 4.0	2.8
1977	497	225	2,765,243	1,043,488	2,299,370	6,093,329	5.3 - 6.9	2.65
1978	438	235	2,323,420	876,762	1,630,928	4,321,959	3.8 - 4.9	2.65
1979	362	105	1,134,940	436,515	1,494,861	3,886,640	3.2 - 4.6	2.60
1980	442	216	1,047,680	380,975	777,753	2,138,820	1.9 - 2.4	2.75
1981	500	216	548,579	219,411	506,569	1,266,422	1.1 - 1.4	2.50
1982	500	172	584,908	236,805	685,779	1,693,875	1.4 - 1.9	2.47
1983	399	138	996,763	397,116	1,151,064	2,889,171	2.5 - 3.3	2.51

M = Number marked

R = Number of marks recaptured

C = Number crab captured

$N = \frac{(M + 1)(C + 1)}{(R + 1)}$ = numbers of legal crab at start of season[1]

N (lbs.) = Average weight of crab x N.

[1] See Ricker (1975; p. 78, eq. 3.7). Total number and pounds of legal male crab available at the start of the respective years, December fishery season.

[2] Variance $N = \frac{N^2 (C-R)}{(C+1)(R+2)}$

95% CI = $N \pm 1.96\sqrt{VN}$

95% CI N (lbs.) = Average Weight of Crab x 95% CI N

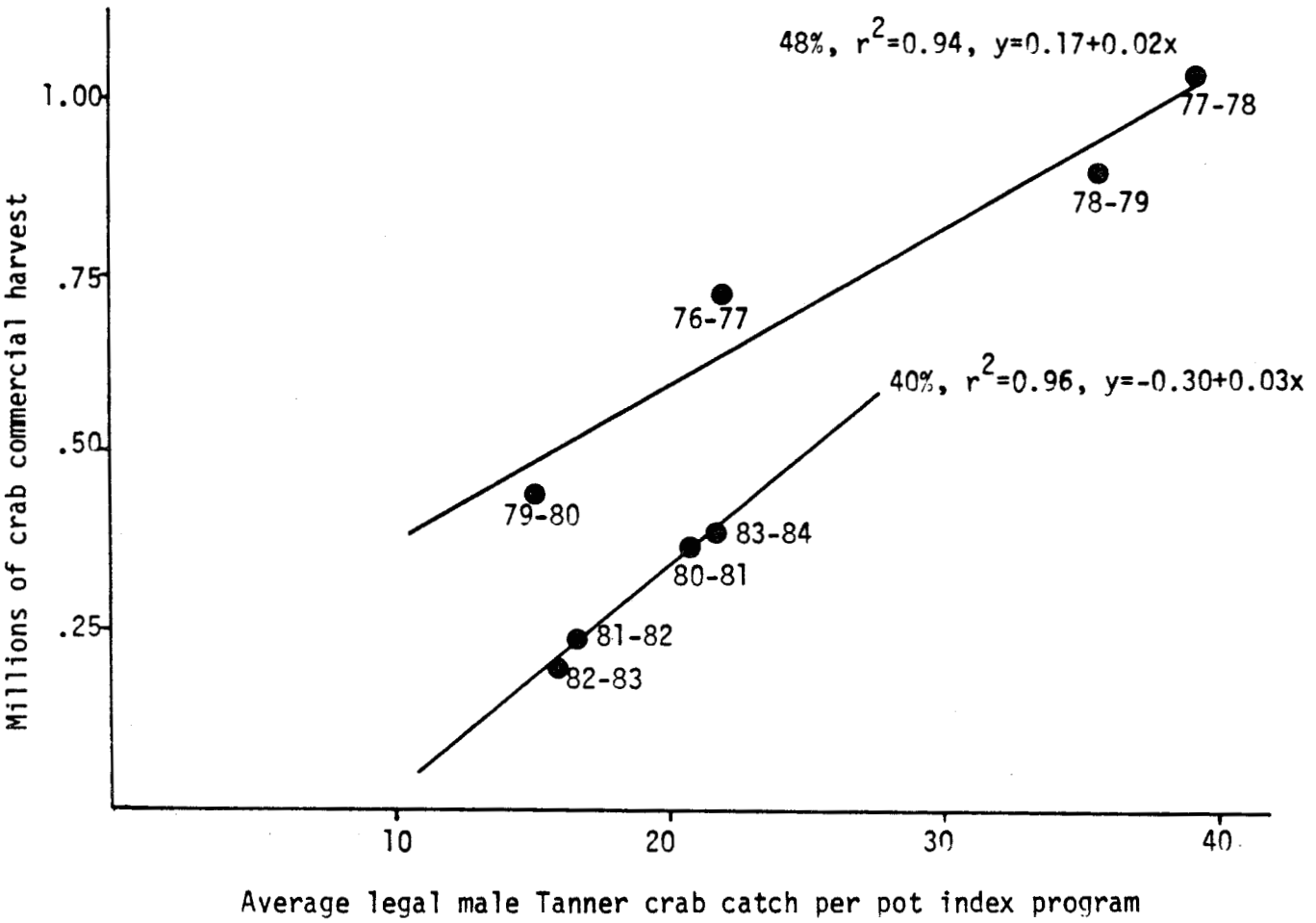

Figure 13. Linear regressions of legal male Tanner crab catch per index pot and commercial harvest in numbers of crab by year for different exploitation rates in the Southern District of Cook Inlet.

Table 18. Catch per unit effort by size class group of male Tanner crab captured during index pot cruises in the Southern District, 1977-1983.

	CPUE by size class[1] and shell condition[2]									
	PR_3		PR_2		PR_1		R		Post-R	
Year	New	Old	New	Old	New	Old	New	Old	New	Old
1977	0.1	0	1.8	1.2	12.5	3.2	30.3	1.4	8.0	0.2
1978	0	0	0.9	1.0	7.2	4.1	26.8	1.5	7.5	0.2
1979	T	0	0.4	0.5	3.2	3.4	10.6	1.7	1.9	0.3
1980	0.1	0	1.0	0.3	3.9	2.5	14.8	2.6	8.4	0.5
1981	0.1	0	2.2	0.6	7.8	2.2	12.9	0.8	3.0	0.1
1982	T	0	2.6	1.0	9.8	3.4	13.4	1.0	1.8	0.2
1983	0	0	0.9	1.0	8.4	3.4	19.6	1.1	1.3	0.1

[1] PR_3 (51-87 mm)

PR_2 (88-114 mm)

PR_1 (115-139 mm)

R (140-165 mm)

Post R (166-215 mm)

[2] New shell is recently molted and old shell includes "very old".

pre-recruit habitat area. It has been reported (J. Hilsinger 1985, personal communication) that small Tanner crab may congregate in areas not inhabited by larger crab.

The mean survival rate for new molt pre-recruit crab to recruit size could not be calculated because the CPUE of pre-recruit Tanner crab was less than that for recruits.

Kamishak District:

The 1983 average catch of legal male Tanner crab per pot was 1.9, 44% less than the average catch in 1982 of 3.4, and about one-sixth of the previous 8-year average of 10.9 legal males per pot (Table 19). The greatest catch of legal males per pot by index station was 12.4, and occurred northeast of Augustine Island (Figure 14). This is about one-sixth of the greatest catch of legal males per pot (69.0) observed during the 1983 Southern District index, implying that male Tanner crab in Kamishak tended to be more dispersed and/or less abundant than male Tanner crab in Kachemak Bay during the summer months of June/July, or that male crab occurred outside the survey area.

Recently molted pre-recruit crab, similar to previous years, comprised the greatest percentage (29.8) of the male population sampled in 1983 (Table 20). The low percentage of legal male crab (10.2%) in the Kamishak index survey contrasts markedly with the proportion of the male population which was legal to harvest in the Southern District index (61.9%). The mean carapace width in 1983 was 122.1 mm, 1.6% less than the 1982 mean of 124.1 and 2.9% less than the previous 6-year average of 125.7 mm (Figure 15). A substantial portion of pre-recruit Tanner crab did not molt in 1979 and 1980. It appeared that in the Kamishak District large numbers of pre-recruit Tanner crab did not emerge into the fishery en masse because of skip molting.

No Tanner crab males are tagged in the Kamishak District because poor weather conditions prevent research vessel operations in Kamishak in October.

A linear correlation existed ($r^2 = 0.76$) between the average number of legal male Tanner crab captured per pot in the index program and the commercial harvest of crab following the index survey (Figure 16). When the 1983 index value of 1.9 legal crabs per pot was correlated with numbers of crab harvested, the estimated commercial harvest for 1983 in the Kamishak District was about 610,000 crab or 617 t (1.36 million lb) with an assumed 40% harvest rate. Because Tanner crab are not tagged in Kamishak, no exploitation rate based on rate of tag return can be estimated.

The percentage and average number of pre-recruits per pot determined from the index survey in year "x" showed no significant linear correlation ($r^2 = 0.00$ and 0.33, respectively) to the average legal male or recruit male per pot in the index survey in year "x + 1". Thus, the index survey presently does not yield a direct forecast of recruits based on pre-recruits from the previous year.

Unlike the Southern District survey, the CPUE of new molting pre-recruit one male Tanner crab in the Kamishak District survey indicated that this age class

Table 19. Total catch of legal sized Tanner crab and average number of legal males per pot during index fishing, and the commercial harvest in numbers and pounds of crab in the Kamishak District during 1975-1983.

Year	Pots Pulled	Total Legal Males	Average Legal males per pot	Average Weight lbs.	Commercial Harvest (lb.) (x 1,000)	Commercial Harvest (no.) (x 1,000)
1975	96	2,666	27.8	2.02	3,281	1,624
1976	159	1,537	7.7	2.30	1,776	772
1977	199	1,547	7.8	2.35	2,077	884
1978	224	3,309	14.8	2.25	2,713	1,206
1979	261	3,044	11.7	2.23	3,339	1,497
1980	171	1,470	8.6	2.20	1,757	799
1981	173	857	5.0	2.29	1,286	562
1982	70	238	3.4	2.29	1,694	740
1983	192	359	1.9	2.23	1,374	616

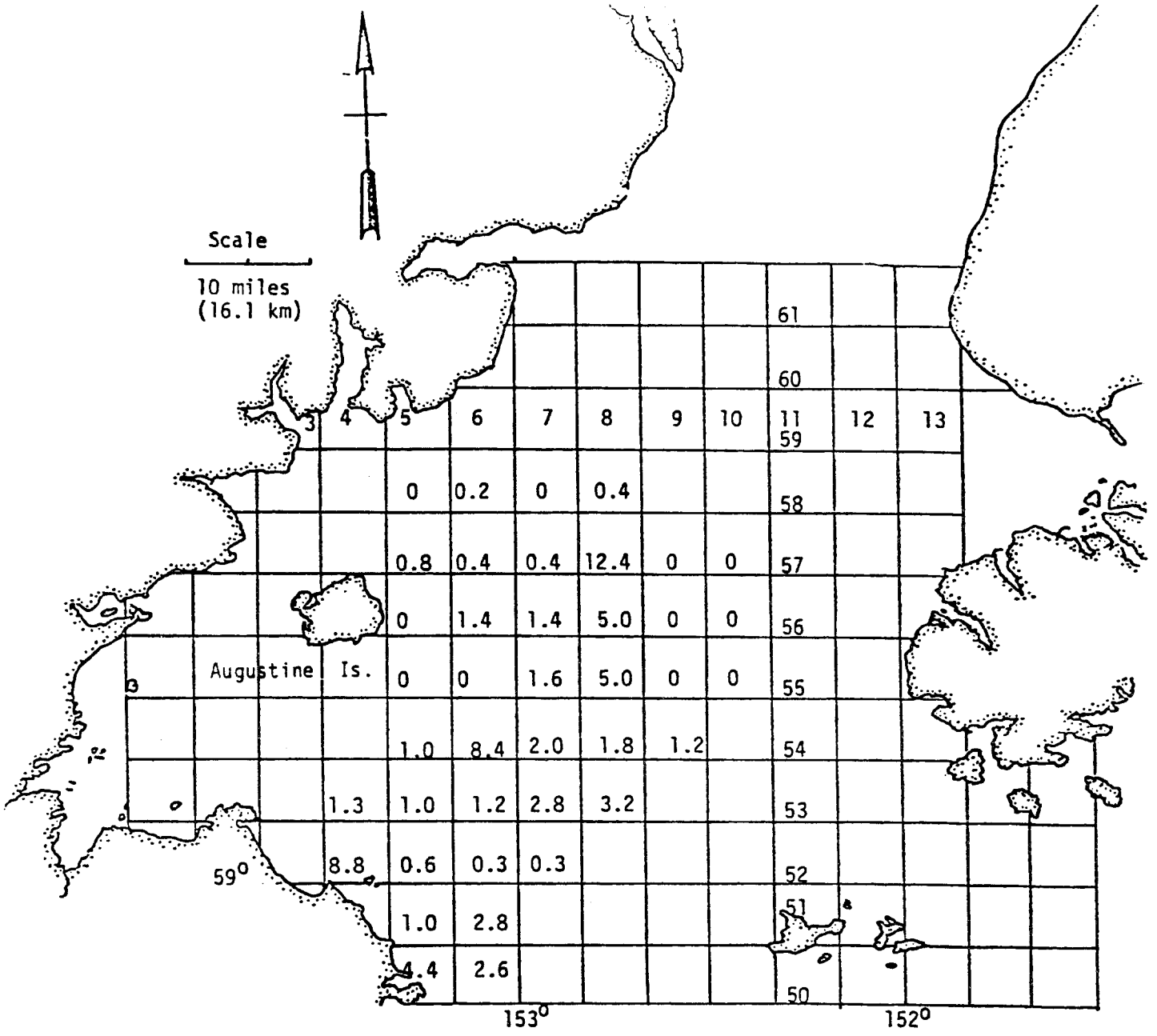

Figure 14. Average catch per pot of legal sized male Tanner crab captured during index fishing, 15-25 June 1983 (7' x 7' pots, two 2-qt. bait containers with herring, 5 pots per station).

Table 20. Percentage of male Tanner crab by carapace width (age class) group captured in the Kamishak District during index cruises, 1977-1983.

Carapace Width (mm)	1977		1978		1979		1980		1981		1982		1983	
	RM	0 + VO	RM	0 + VO	RM	0 + VO	RM	0 + VO	RM	0 + VO	RM	0 + VO	RM	0 + VO
51 - 87	0.5	0.5	0.1	0	0.2	0.1	0.4	0.1	0.2	0.2	0.1	0.1	0.4	0.1
88 - 114	22.6	13.4	9.9	11.4	3.4	13.9	5.1	10.7	14.0	13.1	15.3	13.3	13.8	14.6
115 - 139	23.4	22.8	40.3	18.9	16.8	37.6	7.1	57.2	31.1	38.4	34.7	18.5	29.8	31.2
140 - 165	10.1	6.4	12.7	6.3	19.3	8.0	4.5	14.4	9.7	3.1	16.8	1.0	8.2	1.9
166 - 215	0.1	0.4	0.1	0.1	0.6	0.1	0.2	0.1	0.2	0.0	0	0	0.1	0
Total Catch	9,100		17,235		10,870		7,657		6,595		1,336		3,519	

RM = Recently Molted - soft exoskeleton, no scratching or epifauna, spines sharp.

0 + VO = Oldshell - carapace hard and brownish, scratches present, epifauna may be present, spines worn.

Very Oldshell - carapace hard, dark brown to blackish, scratches present, epifauna present, spines very worn.

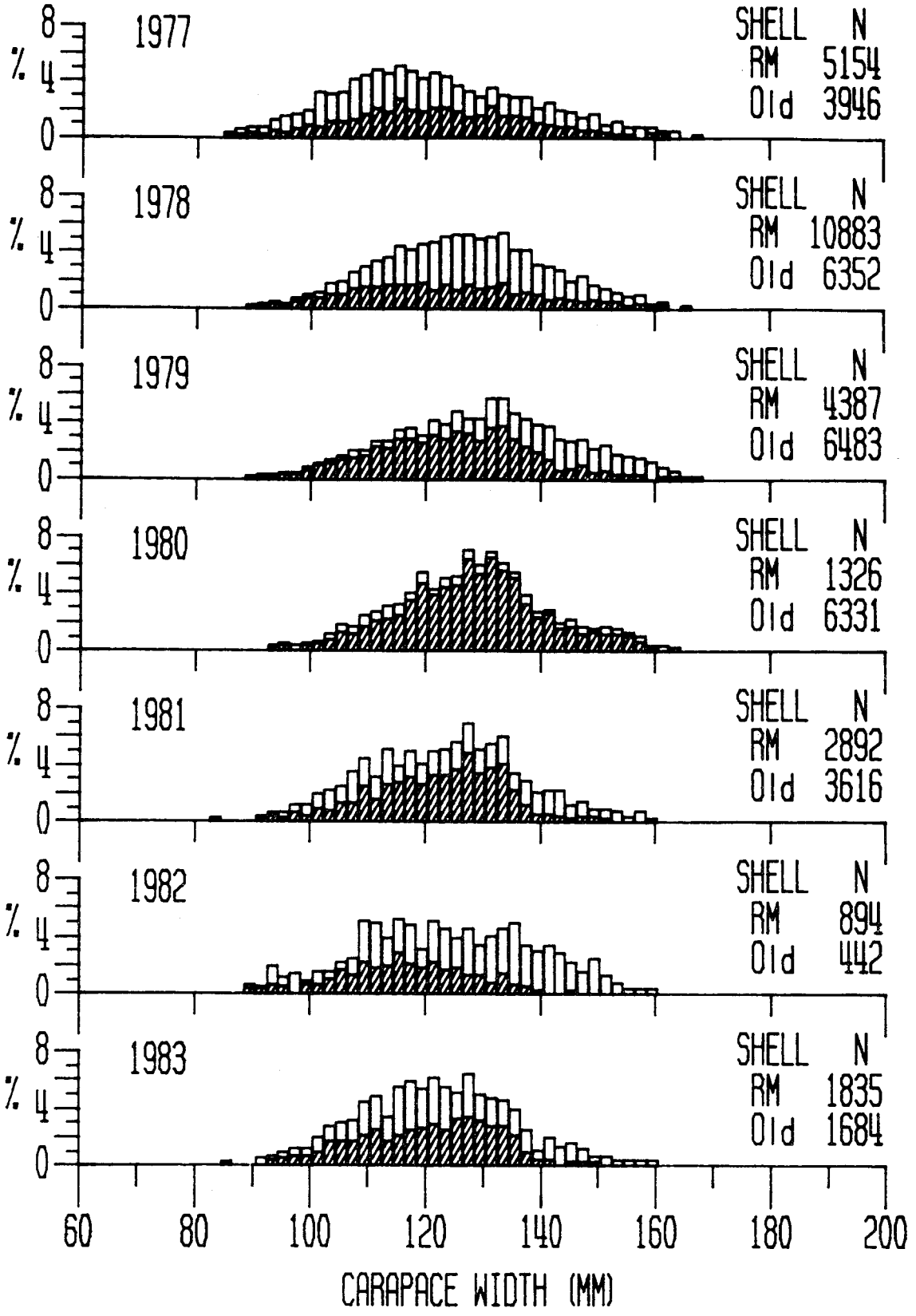

Figure 15. Carapace width frequency by percent in 2 mm increments for male Tanner crab captured during index cruises to Kamishak District, 1977-1983 (old shell are slashed lines and RM is recently molted).

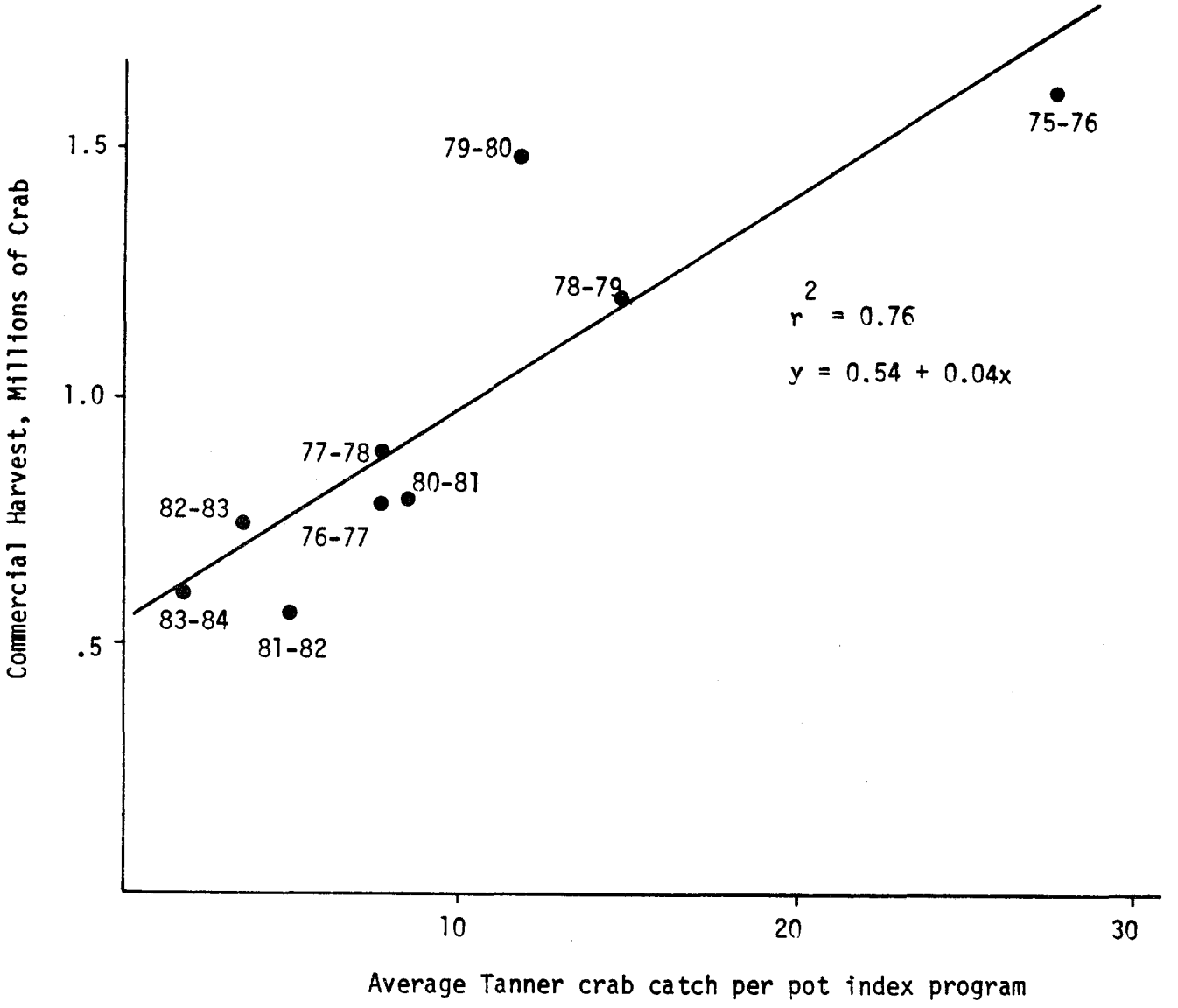

Figure 16. Relationship between legal male Tanner crab catch per index pot and population abundance indicators in the Kamishak District of Cook Inlet.

was fully recruited in the survey (Table 21). Since the same gear was used, it is probable that the Southern District survey area did not encompass areas of small Tanner crab habitation.

Mean survival rate of new molt pre-recruit crab from 1977-1983 was calulated to be 54.0% (s = 39.6), by dividing the recruit CPUE by the pre-recruit CPUE the previous year. Survival rates of pre-recruit Tanner crab to recruits in the Kamishak survey showed an identical cyclical nature as that found for king crab pre-recruit one survival rates in Kamishak. This suggests that both species are equally vulnerable to the factors affecting survival and/or growth of the pre-recruit age class.

Tanner Crab - Female

Descriptions of assessment studies conducted in 1983 follow below.

Southern District:

A total of 2,195 female Tanner crab was captured during the 1983 index survey for an average catch per pot of 9.5. This is 23% less than the 1982 average catch per pot of 12.4, but similar to the previous 8-year average of 9.4 females per pot.

The majority (80.0%) of the female crab had egg clutches of 90-100% ovigerity. This was an improvement in fecundity from the previous 3 years (Table 22). Only 1.6% of the females examined were barren (no external or internal eggs). The large percentage of full egg clutches indicated a strong larvae release in the spring of 1984, barring unforeseen egg mortality between the July index survey and time of hatching. No female crab were examined during the October 1983 male Tanner crab tagging study.

A total of 92.2% of the females examined was old shelled, with the remaining defined as having newly-molted shells. Of the females with 90-100% egg clutches, 94.2% were old shelled.

The mean carapace width of Tanner crab females captured during the 1983 index was 103.8 mm, similar to the previous 6 years (Figure 17).

Kamishak District:

A total of 358 female Tanner crab was captured during the 1983 index survey for an average catch per pot of 1.9. This is 3.8 times greater than the 1982 average catch of 0.5, but about one-third of the previous 6-year average of 5.2 females per pot. Similar to male Tanner crab, the 1983 average catch per pot of females in the Kamishak District was less than that in the Southern District.

The majority (49.7%) of the female crab had egg clutches of 90-100% ovigerity. This is a decrease in fecundity from the previous 2 years (Table 23). The percentage of barren females (5.3) was relatively high. Larvae release in the spring of 1984 should be moderate.

Table 21. Catch per unit effort by size class group of male Tanner crab captured during index pot cruises in the Kamishak District, 1977-1983.

	CPUE by size class[1] and shell condition[2]									
	PR_3		PR_2		PR_1		R		Post R	
Year	New	Old	New	Old	New	Old	New	Old	New	Old
1977	0.2	0.2	10.3	6.1	10.7	10.4	4.6	2.9	0.1	0.2
1978	0.1	T	7.6	8.8	31.0	14.5	9.8	4.9	0.1	0.1
1979	0.1	T	1.4	5.8	7.0	15.7	8.1	3.3	0.2	T
1980	0.2	0.1	2.3	4.8	3.2	25.6	2.0	6.4	0.1	0.1
1981	0.1	0.1	5.4	5.0	8.1	14.6	3.7	1.2	0.1	0
1982	T	T	2.9	2.6	6.6	3.5	3.2	0.2	0	0
1983	0.1	T	2.5	2.7	5.5	5.7	1.5	0.4	T	0

[1] PR_3 (51-87 mm)

PR_2 (88-114 mm)

PR_1 (115-139 mm)

R (140-165 mm)

Post R (166-215 mm)

[2] New shell is recently molted and old shell includes "very old".

Table 22. Summary of percentage relative egg abundance of female Tanner crab captured during index fishing in the Southern District, 1977-1983.

Old shell % in index	--	--	90.3	94.7	96.3	73.7	98.5	95.9	92.2
Sexual maturity	1975	1976	1977	1978	1979	1980	1981	1982	1983
Juvenile[1]	3.3	1.1	0.1	0.7	0.8	2.8	3.3	0.8	0.1
Barren[2]	2.0	0.8	2.6	0.7	0.3	2.3	3.2	1.5	1.6
Internal Eggs Present[3,4]	---	--	---	1.0	1.0	1.6	3.5	1.2	1.5
1-39% ovigerous No			4.0	4.5	1.0	3.3	3.7	7.0	3.6
40-89% ovigerous break			14.4	17.0	9.0	19.8	25.0	24.3	13.0
90-100% ovigerous down			78.9	75.9	87.9	70.1	60.7	65.3	80.0
TOTAL NUMBER CAPTURED	1,747	1,492	3,937	2,578	3,065	1,455	1,719	2,772	2,195

[1] Sexually immature.

[2] Sexually mature - no external or internal eggs - swimmerettes clean.

[3] External eggs absent.

[4] Females with no external eggs which were not examined for internal eggs, are not listed. Their percentage is the difference between 100% and the total group percentage listed by year.

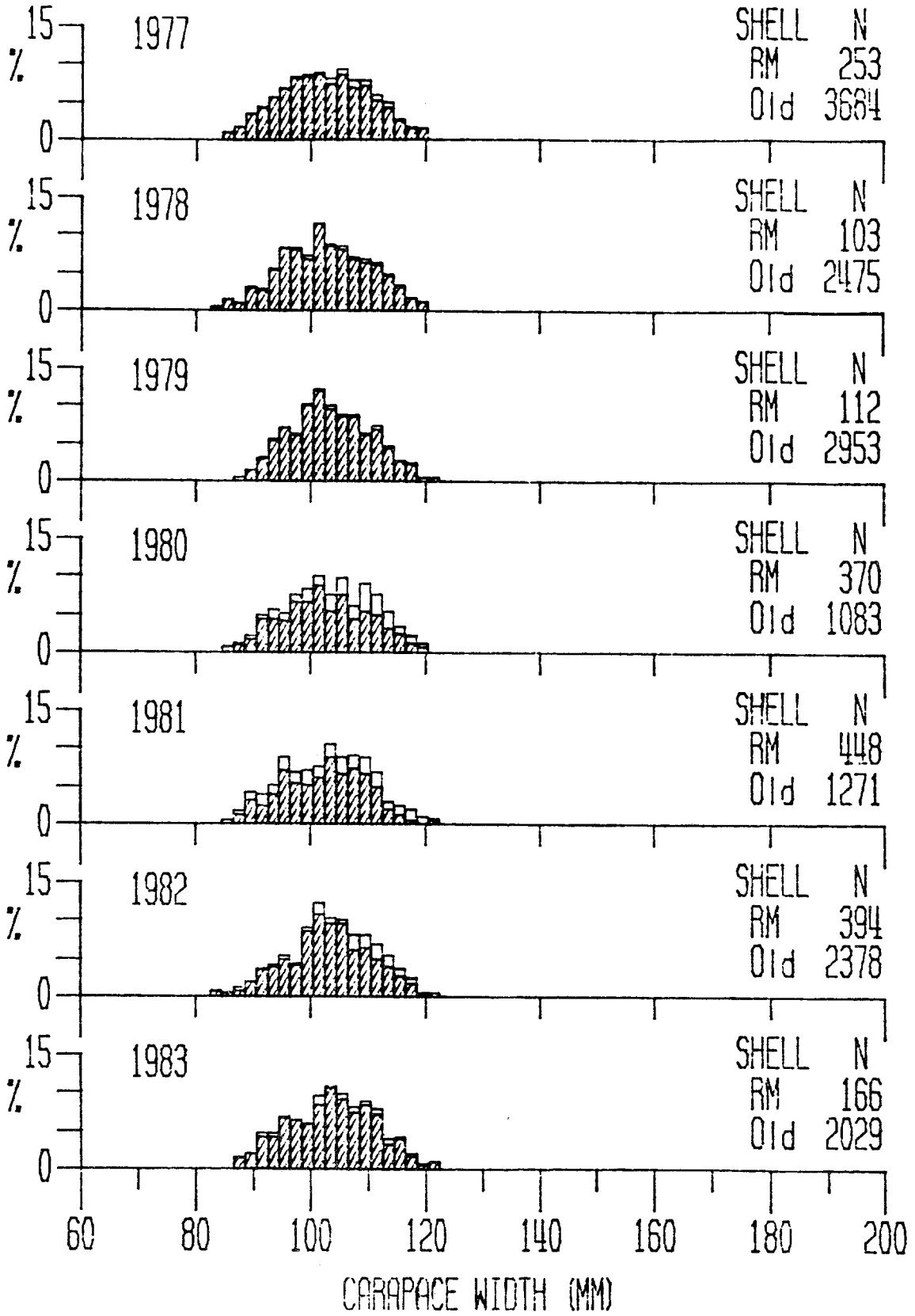

Figure 17. Carapace width frequency by percent in 2 mm increments of female Tanner crabs captured during index cruises to Southern District, 1977-1983 (old shell are slashed lines and RM is Recently Molted).

Table 23. Summary of percentage relative egg abundance of female Tanner crab captured during index fishing in the Kamishak District, 1977-1983.

Sexual maturity	1977	1978	1979	1980	1981	1982	1983
Juvenile[1]	0.9	1.3	1.8	0.8	0.9	2.7	0.6
Barren[2]	0.6	1.8	1.8	2.9	5.6	2.0	5.3
Internal Eggs present[3],[4]	0	1.6	2.9	1.3	0.5	0	5.3
1-39% ovigerous	5.5	7.4	8.5	17.2	5.5	13.5	9.5
40-89% ovigerous	38.7	26.3	20.8	35.0	21.0	18.9	29.6
90-100% ovigerous	54.3	61.6	64.2	42.8	66.5	62.2	49.7
TOTAL NUMBER CAPTURED	1,867	1,672	2,004	711	871	37	358

[1] Sexually immature.

[2] Sexually mature - no external or internal eggs - swimmerettes clean.

[3] External eggs absent.

[4] Females lacking external eggs which were not examined for internal eggs are not listed. Their percentage is the difference between 100 percent and the total group percentage listed by year.

A total of 85.2% of the female examined was old shelled, with the remaining defined as having newly-molted shells. Of the females with 90-100% egg clutches, 79.2% were old shelled.

The mean carapace width of Tanner crab females captured during the 1983 index was 94.4 mm, similar to the previous 6 years (Figure 18). The average female in Kamishak was 9% smaller than the average female in the Southern District in 1983.

SUBSISTENCE/PERSONAL USE HARVEST OF CRABS

The Sport Fish Division of the ADF&G conducted a creel census on all recreational species landed from Kachemak Bay during the period 15 May - 15 September 1978. This census involved interviews of recreational fishermen when they returned to the Homer Harbor and aerial surveys of the fishing grounds to estimte total effort. In 1978 the estimated number of angler days was 27,525, and estimated harvests were 8,330 king crab, 3,568 Dungeness crab, and 2,938 Tanner crab. These data have a ±30% confidence limit. No surveys were conducted in 1979 or 1980. Beginning in 1981, Sport Fish Division included shellfish in their creel census mail survey. For the Kachemak Bay area in 1983 the total estimated days fished was 17,096, and the estimated harvest was 409 king crab (season was closed), 14,130 Dungeness crab, and 3,053 Tanner crab (Mills 1984).

INCIDENTAL HALIBUT CATCH

Halibut incidentally caught in pots during the crab index surveys were counted and measured, yielding an average catch per pot of 0.60 in the Southern District (the highest on record) and 0.35 in the Kamishak District (Table 24). The mean length of halibut caught in pots in the Southern District was 766.8 mm (s = 168.0) and in Kamishak was 807.9 mm (s = 174.1). No direct correlation exists between the average halibut and legal male king crab catches per pot by district.

SUMMARY AND CONCLUSIONS

A low average legal male king crab catch per pot in the index and decreased ovigerity of king crab females were used to justify a fishery closure in the Southern District during 1983. These same biological conditions encountered during the index survey in Kamishak, plus low CPUE by the king crab fishery, justified an early closure in the Kamishak District during 1983. The average legal male catch per pot and percentage ovigerity in females indicates Southern District king crab are continuing to decline, although no abundance estimate can be generated from the index survey. The most recent population estimate from mark-recapture data in 1981 placed the Southern District legal king crab population at 75,000. Kamishak District king

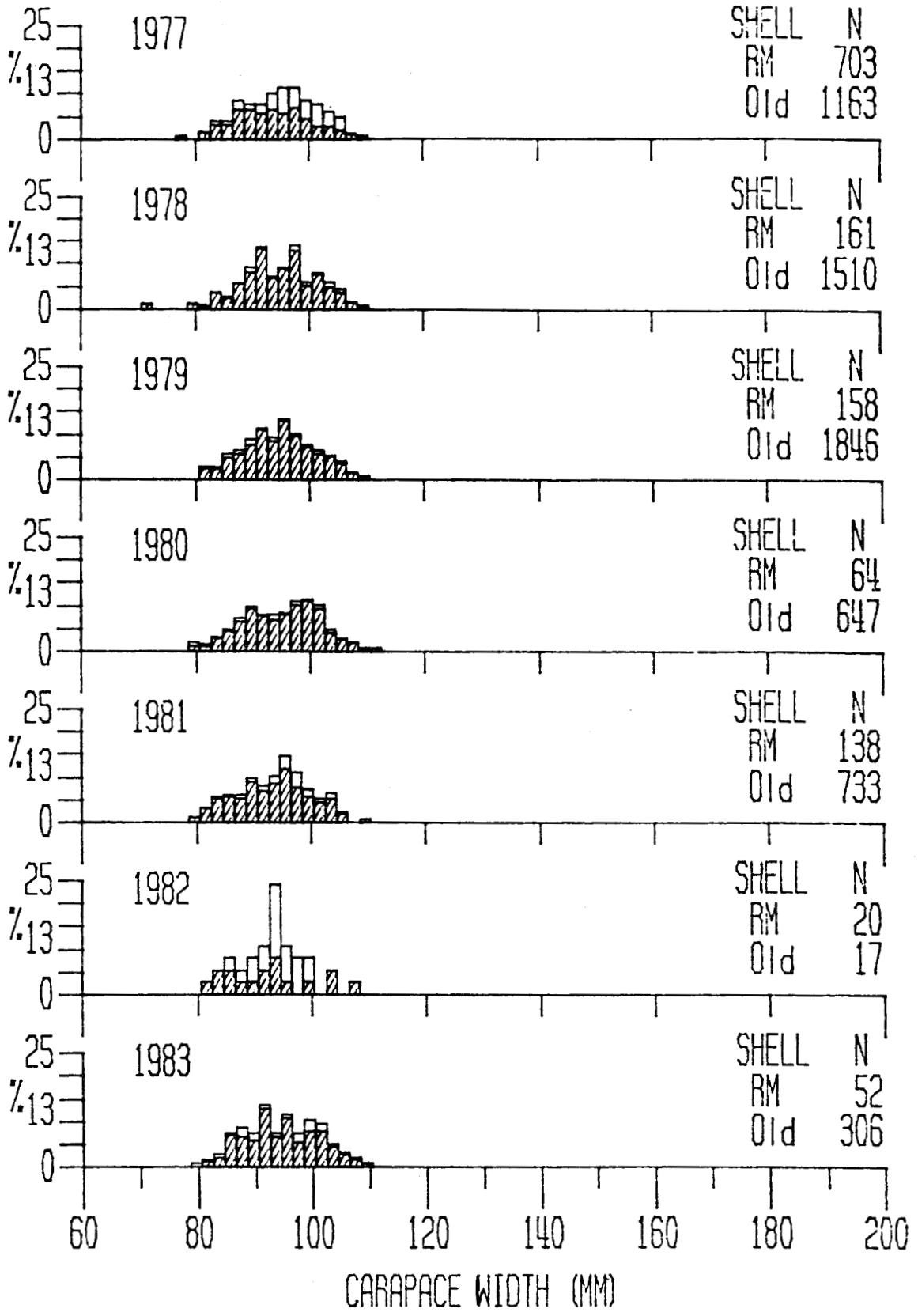

Figure 18. Carapace width frequency by percent in 2 mm increments of female Tanner crabs captured during index cruises in Kamishak District, 1977-1983 (old shell are slashed lines and RM is Recently Molted).

Table 24 . Incidental halibut catches in king crab pots during index cruises, Lower Cook Inlet, 1974 to present.

District	Year	No. Pots Pulled	Live Halibut[1]	Dead Halibut[1]	Total Halibut	Catch/Pot
Southern	1974	240	12	36	48	0.20
	1975	260	-	-	16	0.06
	1976	227	-	-	36	0.16
	1977	260	38	13	51	0.20
	1978	237	52	19	71	0.30
	1979	255	19	4	23	0.10
	1980	367	79	60	139	0.38
	1981	238	67	56	123	0.52
	1982	222	79	32	111	0.50
	1983	230	97	13	139	0.60
Kamishak	1975	96	-	-	34	0.35
	1976	159	115	22	137	0.86
	1977	277	211	50	261	0.94
	1978	209	72	72	144	0.69
	1979	261	92	38	130	0.50
	1980	171	30	27	57	0.33
	1981	173	60	59	119	0.69
	1982	70	42	26	68	0.97
	1983	192	57	9	68	0.35

[1] Condition of halibut not noted in all cases so total live and dead may sum up less than total halibut caught during index.

crab are similarly low in abundance. A population size estimate ranging between 100,000 and 250,000 king crab can be generated from the index survey and mark-recapture programs in Kamishak, although this estimate seems a little high based on initial CPUE data from the August 1983 fishery. No definitive explanation for declines in king crab abundance is available for Lower Cook Inlet. The cyclical fluctuations in pre-recruit survival between years is intriguing and warrants additional investigation.

Close correlations between Tanner crab average catch per pot in the index and commercial harvest allows the manager to predict harvest quotas prior to the season. Tanner crab abundance in the Southern District appeared average compared to the previous 9 years. Tanner crab abundance in Kamishak appeared lower than average and should be monitored.

Primary objectives of the index survey were to: (1) develop abundance estimates for Tanner and king crab and (2) provide predictions of future population sizes. The Tanner crab index survey achieves the first objective, but the king crab index survey in the Southern District does not. The king crab index survey in Kamishak may provide some estimate of abundance. The lack of relationship between the index survey, harvest, and Peterson population estimate in Southern District leaves the manager questioning which estimator is the most reliable indicator of king crab abundance. Stratification of the sampling regime to emphasize suspected prime king crab habitat, rather than random sampling, may yield closer correlations between index survey and harvest data. Another option may be the use of trawl gear to generate an area-swept population estimate, as is employed by the National Marine Fisheries Service in the Bering Sea (Reeves 1981). Initial trawling efforts in the Southern District for king crab in 1977 were moderately successful (Davis 1977), although in general, the substratum in Kachemak Bay is too varied to allow substantial trawling efforts, and damage to crab occurs in a trawl.

Predictions of population sizes are not readily discernable from analysis of age class data in both king and Tanner crab. Pre-recruit percentages and average catches per pot presently show no correlation to recruits the following year. This indicates possible inaccuracies in shell aging and also that probability of molting may vary between years. A model describing probability of molting is currently being formulated and will be applied to the data base.

Secondary objectives of the index survey were to: (1) determine fishing mortality and migration through tagging studies and (2) examine females for ovigerousness and size frequency. Tagging studies have provided the manager with some indications of fishing mortality in spite of low numbers of tag returns from the commercial fishing fleet. Migratory movement is not being defined by the index survey to a satisfactory level because of problems in tag recovery location information provided by the fleet and lack of current king crab fisheries. Lower Cook Inlet king crab migration studies conducted prior to the index survey occurred in 1961-63 (Powell 1963). Changes in distribution may have occurred over the past 2 decades, requiring an update in detailed migratory movement of king crab.

The program to examine female crab has been successful, although the relationship between incidence and size of egg clutches and legal male abundance is undefined in Cook Inlet.

ACKNOWLEDGMENTS

John Hilsinger, Chuck Meacham, and Al Kimker reviewed the report and offered helpful suggestions. Scott Kyle provided commercial fisheries data. Rance Morrison, Paul Budge, and Doug Loshbaugh conducted the sampling and tagging during the index cruises. Fred Jamson provided computer analysis of the data. The crew of the R/V PANDALUS, Paul Desjardin, Craig Forrest, and West Humbyrd operated the vessel and gear during the index surveys. Donna Coble and Ann Oberlitner typed the report.

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