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THE RED KING CRAB, PARALITHODES CAMTSCHATICA (TILESIUS) IN NORTON SOUND, ALASKA: HISTORY OF BIOLOGICAL RESEARCH AND RESOURCE UTILIZATION THROUGH 1982

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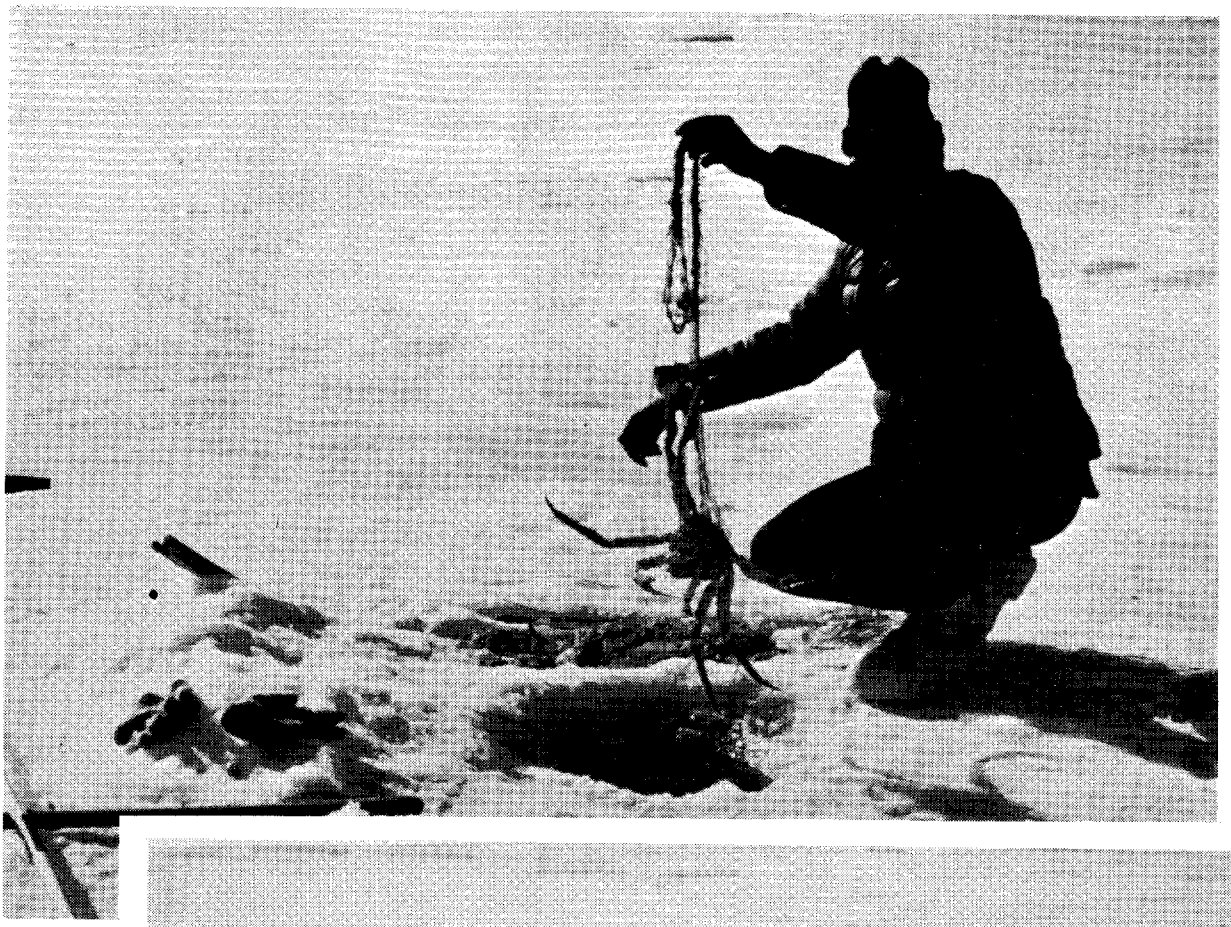

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INTRODUCTION

A domestic commercial fishery for red king crabs *(Paralithodes camtschatica)* has been conducted in the S.E. Bering Sea since 1947. The youthful American fishing fleet grew steadily and by 1973 American fishermen expanded west to begin harvesting blue king crabs *(P. platypus)* seaward from the nearby Pribilof Islands. As the more southerly fisheries became fully developed fishermen ventured even further north. Blue king crab stocks adjacent to St. Matthew and St. Lawrence Islands and red king crab of Norton Sound came under commercial exploitation for the first time in 1977 (Figure 1).

Norton Sound red king crab stocks may well be the extreme northernmost population that will support a commercial fishery. Exploratory commercial efforts north of Norton Sound, in the vicinity of Diomede Islands, Kotzebue Sound, and off Point Hope revealed relatively few red king crabs inhabiting this locality. The harsh environment of the Chukchi Sea and Arctic Ocean very probably is marginal crab habitat quite different from environments of the highly productive southern fisheries of Kodiak and Southeastern Being Sea (Figure 1). Fishery resources that inhabit the fringes of their range commonly are less productive and more fragile.

For its size Norton Sound does not produce a large tonnage of crabs, 1,315 mt (2.9 million lb) is maximum harvest for any 1 year. In comparison, the Northeastern Bering Sea in the 5 year period 1977-1981 produced approximately 17 times more tonnage of crabs per 3.4 km^2 (nmi^2) than Norton Sound. The smaller crabs of Norton Sound frequently are more costly to harvest and bring a lower price per pound to fishermen.

The purpose of this report is to describe the development, research, and management of the Norton Sound red king crab fishery and to compile under one cover the information that has been collected to date by involved state and federal agencies.

Initial limited research began in 1948 and continued in 1949, then approximately 27 years passed before any further research was undertaken. During four of the next 6 years, 1976-1981, fairly intense sampling of the red king crab population occurred.

The Norton Sound king crab fishery has specieal importance in Alaska because of the necessity to insure that the newly developed commercial fishery will not adversely impact the long established subsistence fishery. The emotional impact on the local populace upon seeing commercial utilization of crab stocks off their shores by large modern crab vessels with home ports from as far away as Seattle has been considerable.

DESCRIPTION OF NORTON SOUND

Norton Sound is an eastward extension of the northern Bering Sea, comprising approximately 37,780 km^2 (11,000 nmi^2) east of St. Lawrence Island and southeast of Bering Strait (Figure 2). The 1982 State of Alaska Shellfish Regulations

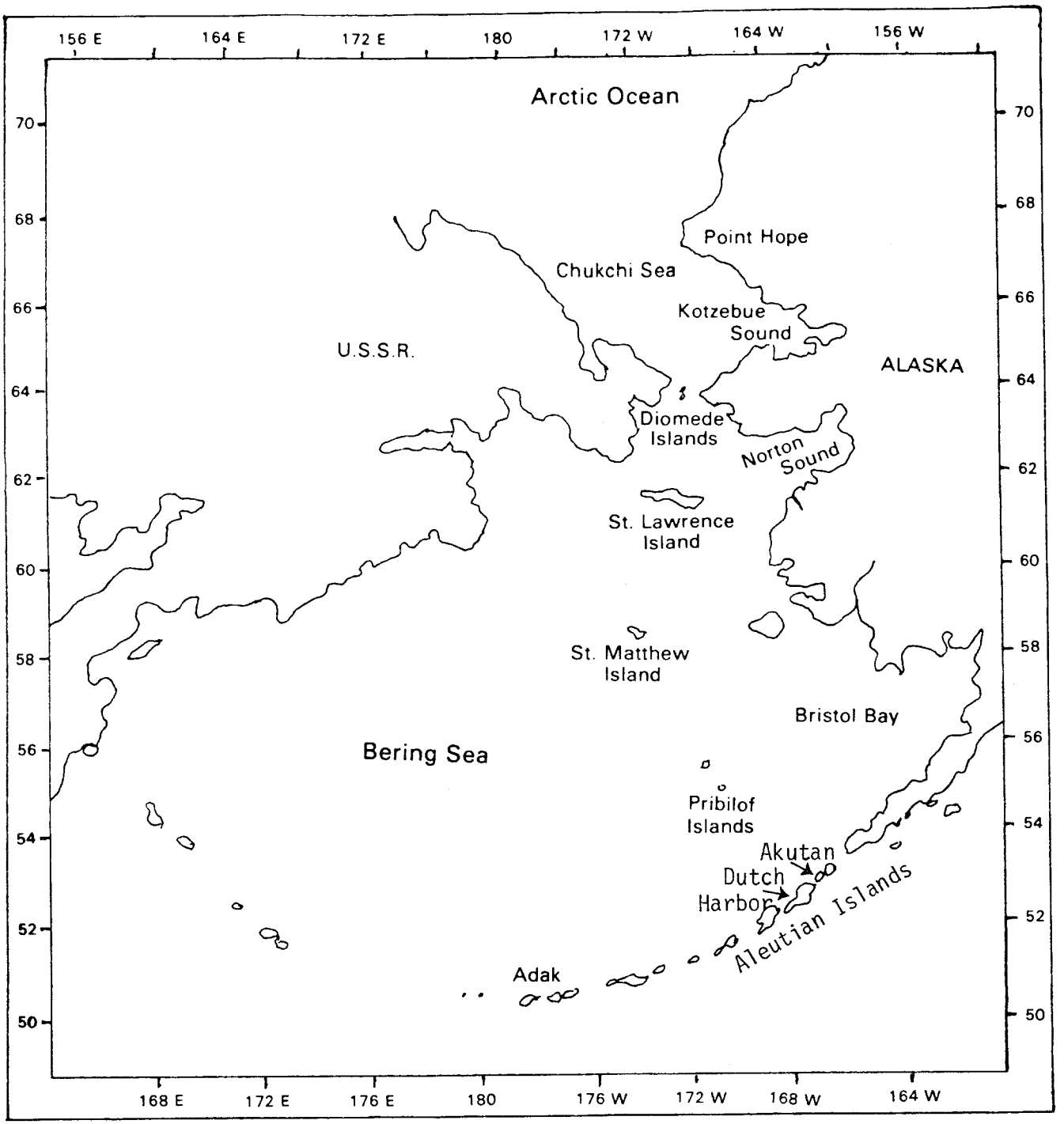

Figure 1. Geographical location of Norton Sound relative to the Bering and Chukchi Seas, and to the North American and Asian continents.

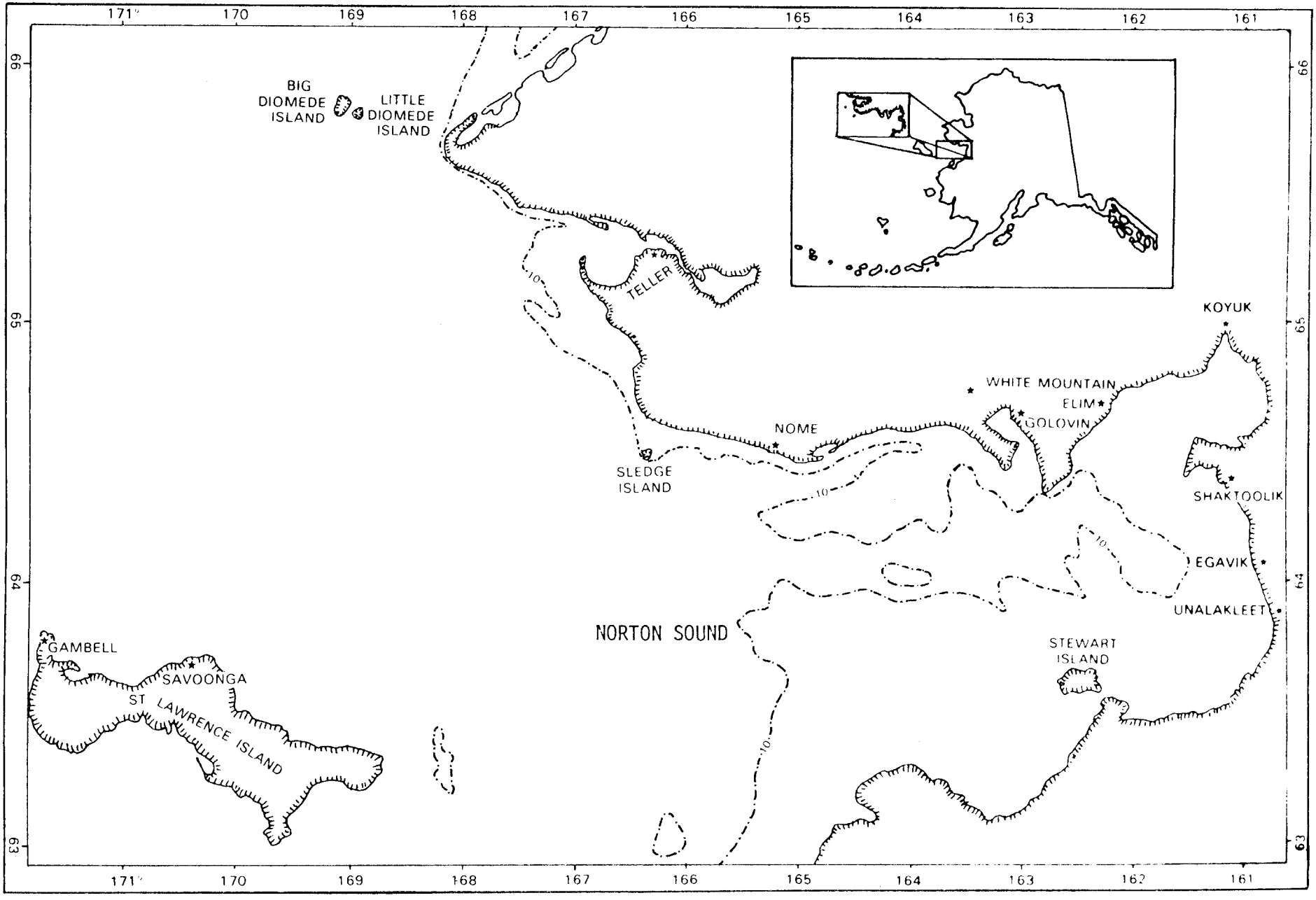

Figure 2. Norton Sound, Alaska, adjacent islands and coastal communities. The 10 fm contour is shown.

describe the Norton Sound section as all waters east of 168° W. long., and north of the latitude of Cape Romanzof (61° 49' N. lat.) and south of the latitude of Cape Prince of Wales (65° 36' N. lat.).

Several small communities are situated along the Norton Sound Coast, the largest of which is the city of Nome.

Norton Sound is located entirely upon the Alaskan continental shelf which partially accounts for the uniform shallowness of the area. A depth of 50 m is exceeded only in Bering Strait, while in the remainder of Norton Sound, depths of 10-35 m are most common. Isobaths closely parallel the coastline (Wolotira et al. 1977).

Bottom composition nearshore consists of small rocks and gravel and changes to mud and sand and eventually to grey mud and sand in the deepest offshore areas (Alverson and Wilimovsky 1966). Extensive silt depositories occurs off the mouth of the Yukon River.

Current patterns within Norton Sound, Northern Bering Sea, and Chukchi Sea are fairly uniform from surface to bottom and flow in a northerly direction paralleling the depth contours (Fleming and Haggarty 1966). Winter ice cover persists in Norton Sound for as many as 7 months and extensive ice scouring occurs in the nearshore areas. Because of the current patterns and shallow bottom depths, summer water temperature become relatively warm. Nearshore temperatures at all depths reach 15°C (Fleming and Haggarty 1966). Bottom temperatures drop from 15°C nearshore to 0-2°C at the western extremes of Norton Sound north of St. Lawrence Island (Wolotira et al. 1977).

Yukon River discharge, especially from May to August has a great influence upon conditions in Norton Sound. Salinity readings are commonly less than 31 parts per thousand (0/00) adjacent to the Alaska coastline (Wolotira et al. 1977).

HISTORY OF COMMERCIAL FISHING

Commercial fishing in Norton Sound began in 1977 and was initially designated by the Alaska Board of Fisheries as an exploratory fishery. Annual commercial harvests have continued since 1977 with a total cumulative summer harvest through 1981 of 3,677 mt (8,107,030 lb--2,563,340 crabs) and a combined summer-winter harvest of 3,689 mt (8,132,939 lb) of crabs through 1981 (Tables 1 and 2). The 1982 commercial season occurred during the final drafting of this manuscript and the authors decided to present only preliminary summary data for this year. The small 1982 catch of 103 mt (228,921 lb) brought the total cumulative harvest to 3,781 mt (8,335,951 lb) through 1982 and is shown later in the report in Table 5.

The Norton Sound commercial red king crab fishery differs significantly from other Alaskan king crab fisheries. Harvest must occur in the summer earlier than the other king crab fisheries, prior to sea ice formation. As a result, the majority of commercial harvests have occurred in July and August. Another difference is the small size of Norton Sound crabs, hence, the smallest legal size limit in Alaska is in effect, 12.1 cm (4.75 in). The Norton Sound fishery

Table 1. Commercial harvest of red king crabs from Norton Sound, Alaska (summer fishery only).

Year	Landings	Different Vessels	Crabs Processed		Crabs Wasted		Total Harvest		Total Pots	Average Crabs/Pot	Average Weight	Approximate Ex-vessel price[6]
			Number	Pounds	Number	Pounds	Number	Pounds				
1977[1]	13	7	116,162	305,639	79,715	212,148	195,877	517,787	5,457	36	2.7	0.75
1978[2]	54	8	656,887	1,996,936	33,523	95,025	690,410	2,091,961	10,817	64	3.0	0.95
1979[3]	76	34	819,115	2,503,998	151,847	427,674	970,962	2,931,672	34,773	28	3.0	0.75
1980[4]	50	9	329,778	1,186,596	-0-	-0-	329,778	1,186,596	11,199	29	3.6	0.75
1981[5]	108	36	376,228	1,378,702	85	312	376,313	1,379,014	33,745	11	3.7	0.85
ALL	301		2,298,170	7,371,871	265,170	735,159	2,563,340	8,107,030	95,991	27	3.2	----

[1] Fishery in 1977 occurred during July and August.

[2] Fishery in 1978 occurred during August and September.

[3] Fishery in 1979 occurred during last half of July.

[4] Fishery in 1980 occurred during last half of July.

[5] Fishery in 1981 occurred July 15 - August 22.

[6] Prices commonly are lower at the beginning of the season and higher later on.

Table 2. Summary of historic commercial catch and recent subsistence harvests of male red king crab, Norton Sound, Alaska.

Commercial harvest (lb)				Subsistence harvest[1]	
Summer fishery		Winter fishery			
Dates of fishing	Harvest	Jan 1 Apr 30	Total	Winter[4]	lb
7/1/77 - 7/31/77[2]	517,787	0	517,787	1976-1977	Unknown
7/26/78 - 8/16/78	2,091,961	25,193	2,117,154	1977-1978	48,408
7/15/79 - 7/31/79	2,931,672	641	2,932,313	1978-1979	582
7/15/80 - 7/31/80	1,186,596	75	1,186,671	1979-1980	554
7/15/81 - 8/22/81[3]	1,379,014	0	1,379,014	1980-1981	1,332
Totals	8,107,030	25,909	8,132,939	Jan-May	50,876

[1] In 1978 a new regulation was adopted requiring a permit for taking of subsistence king crab. Catch data is available for Nome fishery only.

[2] A total of 7,770 km² (300 sq mi) of the best fishing grounds were closed after 23 days of fishing.

[3] A coastal area larger than 10,490 km² (4,000 sq mi) was closed to fishing in 1981 and the main fishing grounds that were open, were closed 29 July 1981 leaving only the low production areas open through 22 August 1981.

[4] Subsistence harvest occurs in December, January, February, March, April, and May. (Most of the harvest recently has occurred during the last half of the winter months/early spring.)

is also the newest and northernmost Alaskan red king crab fishery. The nearest onshore processing facilities are located in Dutch Harbor and Akutan in the Aleutian Islands (Figure 1), about 1,296 km (700 nmi) to the south. The catch is currently processed entirely by floating factoryships and catcher vessels operating during the season in the Norton Sound area. During the first 3 years of the fishery much of the catch was transported alive to Dutch Harbor because the only floating processor present in 1977 and 1978 was the ALL ALASKAN. Two were present in 1979, the MOKUHANA and PAVLOF. A list of the floating factoryships, catch processors, and catcher vessels involved each year in the fishery is presented in Appendix Table 1. As a result of transporting crabs long distances to Dutch Harbor coupled with inability to deal with low salinities and warm water temperatures, deadloss waste in the Norton Sound fishery was high the initial 3 years the industry pioneered the fishery. Waste from deadloss reached 41% of the total harvest in 1977. By 1979 deadloss was down to 15% and almost no deadloss occurred in 1980 and 1981 (Table 1).

One of the most unique characteristics of the fishery is that Norton Sound king crabs spend their entire lives in shallow water, less than 36 m (20 fm) because of the absence of deeper water into which crabs could migrate. Large volumes of fresh water are discharged into Norton Sound by the Yukon River, one of North America's largest rivers. Resulting ice cover, therefore, provides a substrate through which coastal residents may fish for king crabs during winter months.

Attempts by Nome residents to fish commercially through the ice during winter months using dog sleds, snowmobiles, and even helicopters has met with limited success. The largest through-the-ice commercial fishery only landed 11.4 mt (25,193 lb) in 1978 (Table 2).

Fishery regulations of the State of Alaska require fishermen to report the location of their fishing to the buyer who in turn is required to record catch location on fish tickets at the time the crabs are purchased. In actual practice this system frequently fails and inaccurate fishing locations are recorded. One way to improve accuracy of data is to station trained biologists or technicians aboard processing vessels to interview the captains of fishing vessels when crabs are unloaded for processing. Harvest data collected in 1977 are most accurate for crabs delivered to the ALL ALASKAN, and less accurate for those deliveries made to shore plants in the Dutch Harbor area.

Commercial Fishery Catch Statistics

Catch statistics for each of the first 4 years have limitations because of three factors; lack of available staff, inexperienced staff, and lack of a standard plan of data collection and analysis. In 1981, for the first time the Alaska Department of Fish and Game (ADF&G) hired and trained a large staff to monitor the Norton Sound commercial fishery (Appendix Table 2).

The statistical area chart used by fishermen for catch reporting is shown in Figure 3. Statistical areas directly off the coast of Nome are reduced to 1,339 km^2 (390 nmi^2) to obtain more precise catch data. Commercial fishing in these areas must be closely monitored because of the possible impact on subsistence catches. Seaward statistical areas are twice as large in size, 2,679 km^2 (780 nmi^2).

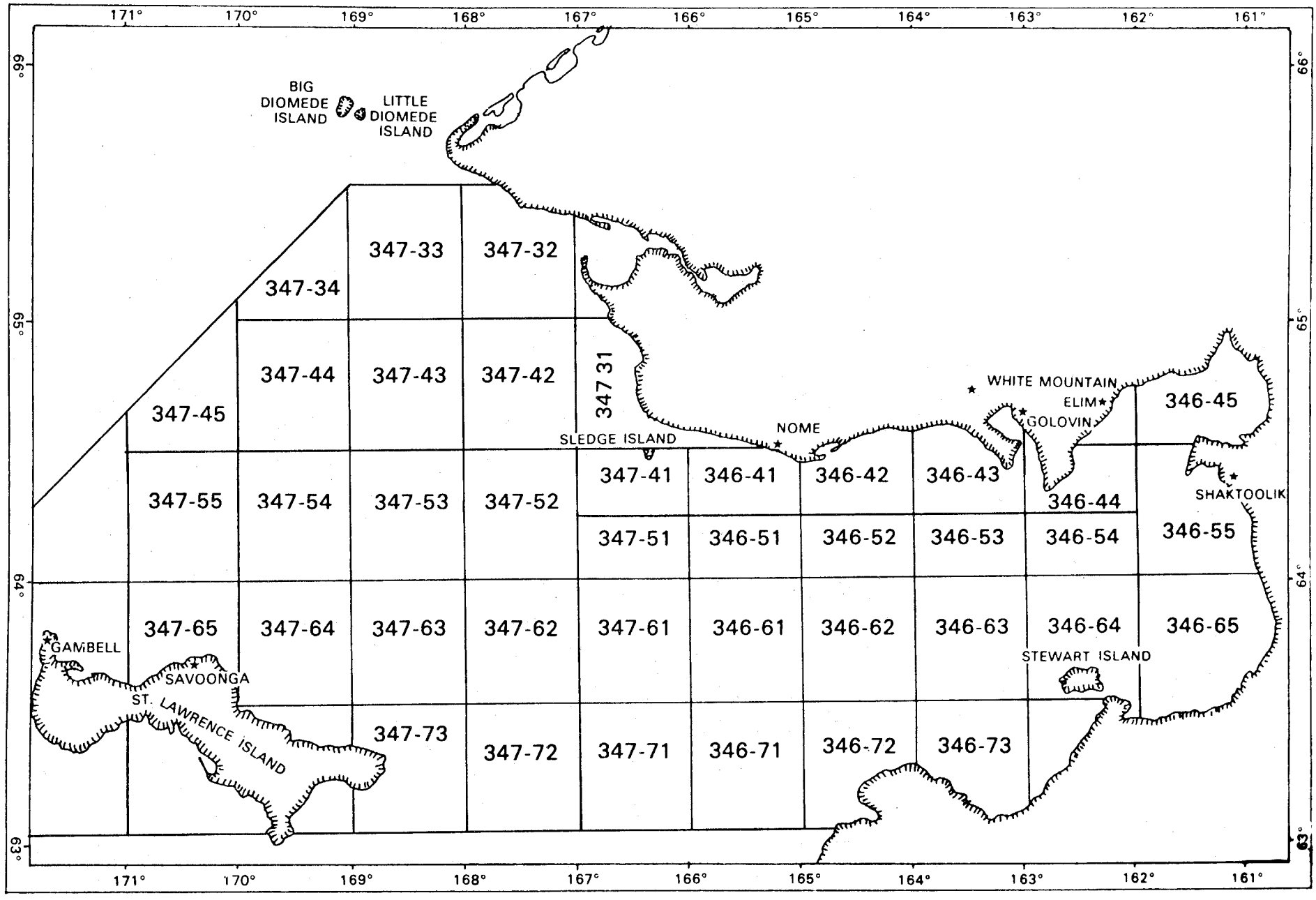

Figure 3. Statistical area chart of Norton Sound and adjacent waters, 1977-1981.

The most productive statistical area was 347-61 with an accumulative catch of 620 mt (1.4 million lb), followed by area 347-51 with 568 mt (1.3 million lb), and area 347-41 with 565 mt (1.2 million lb) of crab (Table 3 and Figures 3 and 4). Seventy-two percent of the total historic commercial catch of 2,676 mt (5.9 million lb) derived from six statistical areas comprising only 33% of Norton Sound. Fishery statistics for all statistical areas and years are presented in Appendix Tables 3-7.

Size of Crabs in the Commercial Catch

The size structure of a legal male population is often obtain by measuring crabs in commercial landings. The size of king crabs captured by the commercial fishery gradually increased since 1977 (Figure 5). The average weight of crabs increased from 1,225 to 1,678 g (2.7 to 3.7 lb) and recruit size crabs, which were abundant in the catch in 1977, decreased in abundance in subsequent years. The apparent abundance of recruit size crabs in the 1977 commercial catch would have been greater than indicated in Figure 5, had the size limit not been larger 127 mm (5 in) than that of recent years, 1978-1981, 121 mm (4.75 in). Relatively few recruits existed in 1979, 1980, and 1981.

Size data from the commercial fishery indicate that one or two strong year classes entered the fishery, peaking in 1977 and that these year classes supported the bulk of the fishery through 1981. Additional evidence of this dependence upon a single cohort resulted from decreasing average catch per effort from 64 to 11 crabs per pot from 1978 to 1981 (Table 1).

Size of male crabs 11 years before the commercial fishery began were available from 525 measurements of subsistence catches taken during two winters, January through April 1966 and 1967 (Figure 6; Appendix A, Document #1). Average length in 1966 and 1967 was 106 and 102 mm, respectively. The average crab size was similar to those in the commercial fishery 11 years later in 1977. Size of males captured during research surveys in 1976, 1979, 1980, and 1981 complements that of commercial catch samples and is presented later in the section entitled, Population Size Structure.

Carapace Length at Which Males Become Legal Size

Carapace length is the standard measure used for biological purposes. Biologists determine what the minimum commercial length of crabs should be for harvest by studying their growth, sexual maturity, natural mortality, and other important factors. The legal commercial size is determined by selecting the width which best corresponds to the desired length, hence it is necessary to study the relationship between carapace length and width. Commercial fishermen determine crab legal size by measuring the carapace width outside lateral spines.

Of 907 crabs measured within the size interval 95-111 mm carapace length during 1980 and 1981 surveys, the smallest carapace length of any legal crab, 121 mm (4.75 in) carapace width or larger and the largest length of any sublegal crab, was 100 and 106 mm, respectively (Appendix Tables 8 and 9). Carapace length of juveniles and adults, therefore, only overlapped one another within a 7 mm range. Greater than 50% of the crabs reached minimum legal size, i.e., have a carapace width of 121 mm (4.75 in) outside the spines, by the time they attained a carapace length of from 102 to 104 mm. The 1981 data is believed to be a little more

Table 3. Annual commercial harvests of red king crabs from Norton Sound, Alaska by statistical areas for years 1977-1981 (summer fishery only -- catch in pounds -- edited fish ticket data).

Statistical Subarea	1977	1978	1979	1980	1981	Total all years
346-41	306,302	90,187	288,869	918	3,098	689,374
346-42	80,969					80,969
346-44	38,995					38,995
346-51			138,011	121,147	253,387	512,545
346-52			155,972		1,319	157,291
346-53				12,398	61,823	74,221
346-54	31,572			4,830	399	36,801
346-61			323,518	72,735	395,662	791,915
346-62					4,716	4,716
346-64	40,020					40,020
346-65	7,893					7,893
346-71			161,699		15,174	176,873
347-31			146,029			146,029
347-32					36	36
347-41	12,036	515,778	534,938	183,581		1,246,333
347-42		3,811	12,309	-0-	373	16,493
347-51		179,212	486,947	205,400	381,510	1,253,069
347-52		667,130	33,856	274	92,026	793,286
347-61		353,016	505,050	367,446	141,513	1,367,025
347-62		51,304	81,798	6,762	18,734	158,598
347-63			1,860			1,860
347-71		162,795	60,816	84,874	9,167	317,652
347-72		13,238		126,231		139,469
347-81		55,490			77	55,567
GRAND TOTALS	517,787	2,091,961	2,931,672	1,186,596	1,379,014	8,107,030

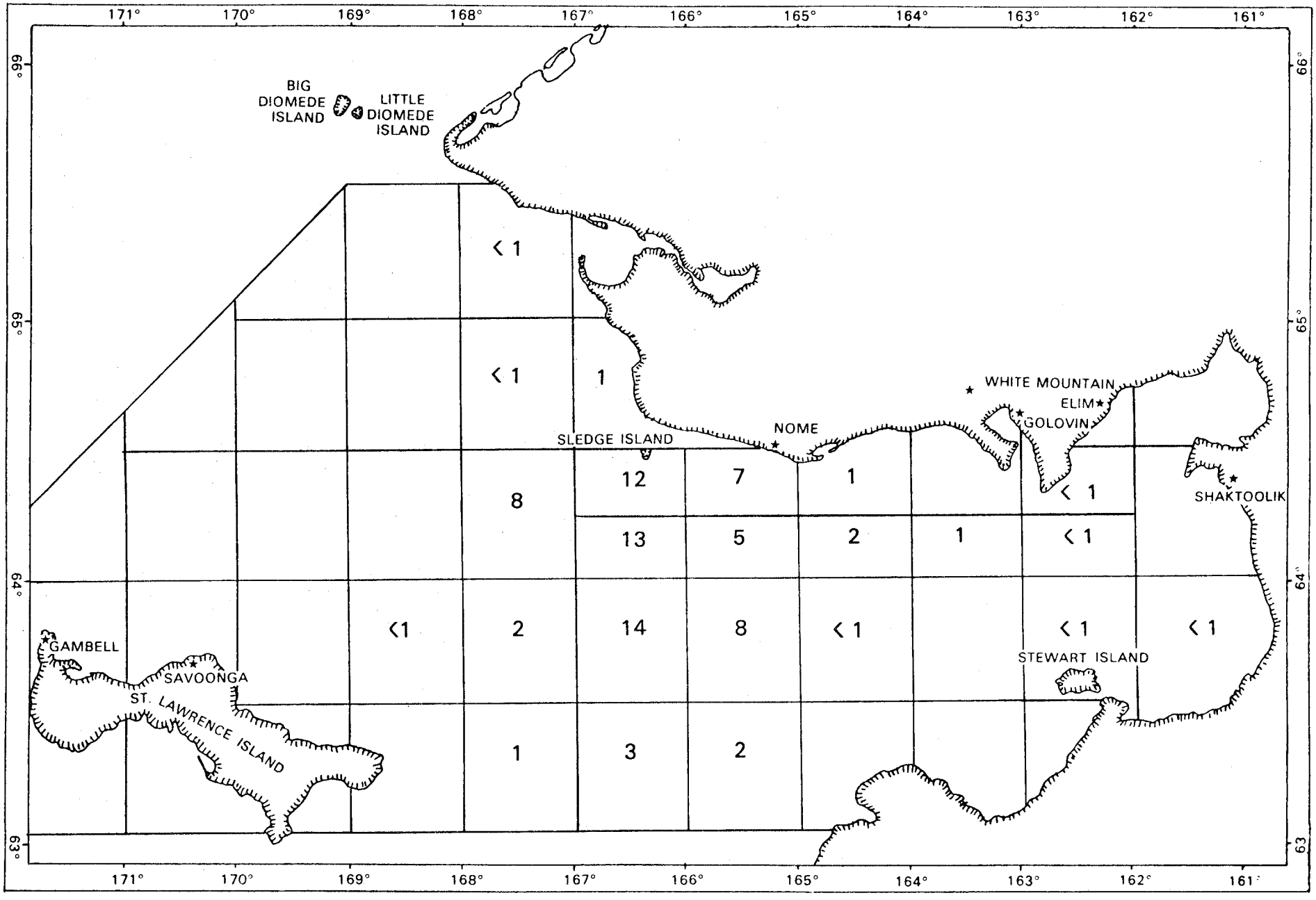

Figure 4. Total commercial catch of red male king crabs in hundreds of thousands of pounds in each statistical area, Norton Sound, Alaska, 1977-1981.

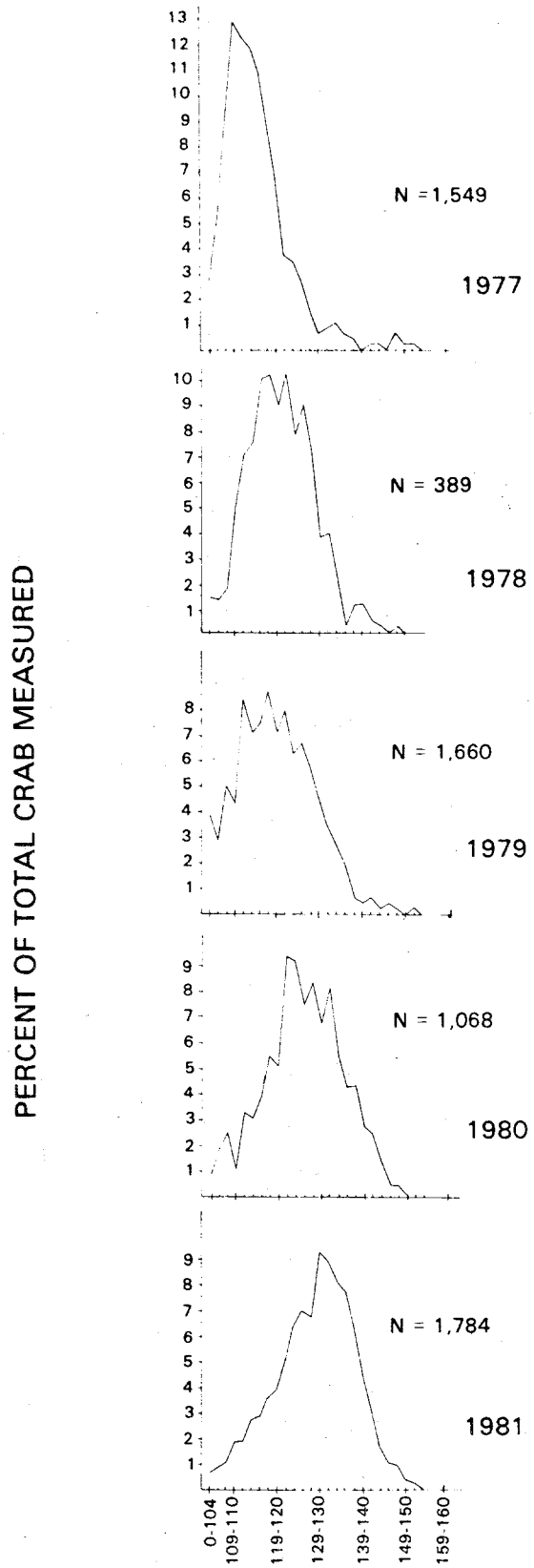

Figure 5. Size of male red king crabs in the commercial catch for the first five years (1977-1981) of commercial fishing, Norton Sound, Alaska.

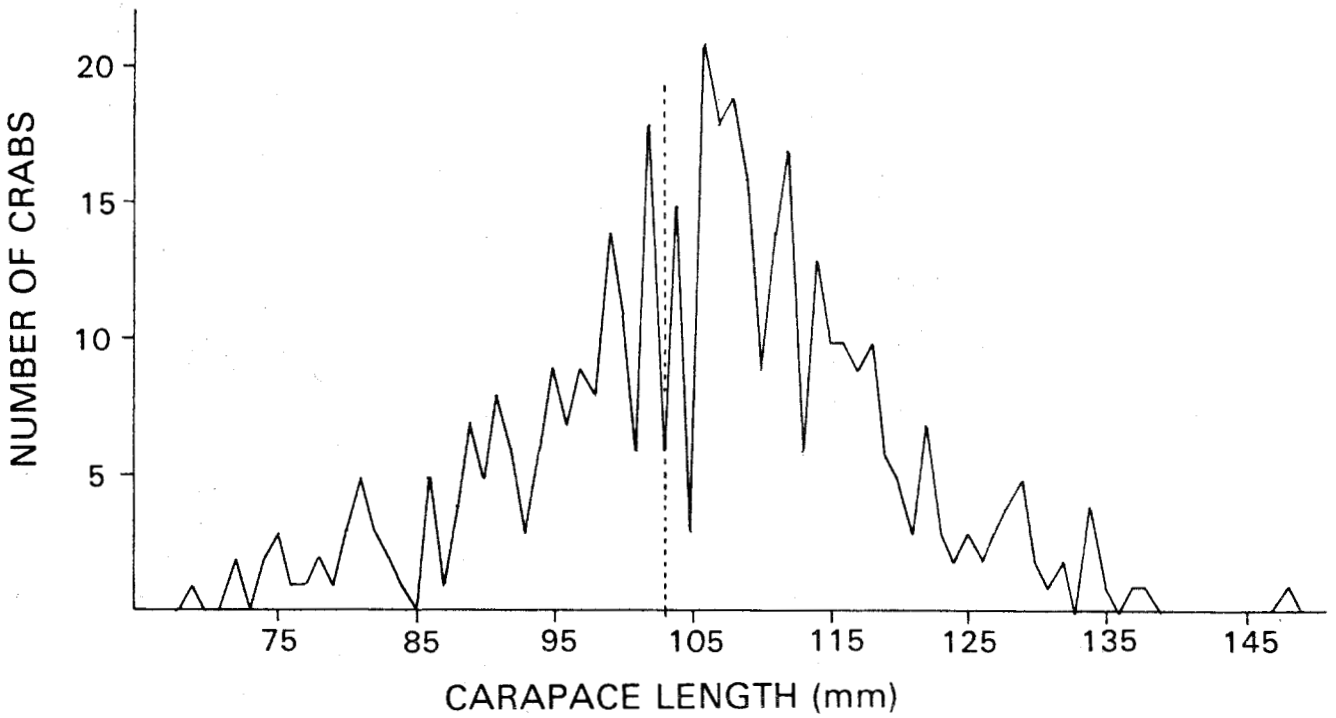

Figure 6. Size of male red king crabs captured through the ice by subsistence fishermen near Nome during two winters, 28 January-8 April 1966 and 1967. Dotted line represents current minimum legal size.

precise than that collected in 1980 because of more careful measurement and that the best estimate of the carapace length at which 50% of the crabs were of legal size lies between 103 and 104 mm (Figure 7).

Regulations

Regulations pertaining to the fishery are evaluated annually by governmental agencies, regulatory bodies (Alaska Board of Fisheries), and other interested parties, and published in a shellfish regulations booklet. Sections of the 1981 shellfish regulations pertaining to the Norton Sound fishery include selected Alaska Statutes (pp. 3-12), Alaska Board of Fisheries policy statement (p. 13), statewide regulations for the king crab fishery (pp. 46-56), statistical area Q regulations (pp. 68-70), and general provisions (pp. 99-108). Other useful references include emergency regulations, emergency orders, announcements, and news releases issued by the Board of Fisheries and ADF&G. Since many of these documents become very difficult to obtain with the passing of years, those for the Norton Sound 1977-1981 fishery have all been located and stored in the ADF&G Kodiak and Nome offices to make them readily accessible. Included are statewide regulations, statistical area Q regulations, emergency orders, and emergency regulations.

Size Limit:

The minimum legal size was initially set at 127 mm (5 in) in 1977. The following year (1978) the limit was lowered 6 mm (0.25 in) to 121 mm (4.75 in) and has remained at that size to the present time (Table 4).

Harvest Guideline:

Harvest guidelines for the summer and winter commercial fishery were first adopted in 1978. Guidelines for the summer fishery ranged from a low of zero to 454 mt (0-1 million lb) in 1980 to a high of 907 to 2,268 mt (2-5 million lb) in 1981 (Table 4). The guideline for the winter fishery has remained the same ever since it was adopted in 1978: 68 to 227 mt (150 thousand to 500 thousand lb).

Fishing Season:

On 7 June 1977 the first commercial summer season of 7 June-15 July (Table 4) was established by emergency regulation, but was extended until 31 July 1977. Emergency order 4-S-13-77 was needed to extend the original season beyond 15 July.

From 1978 to the time of this report the published summer season was 15 July through 3 September. The season for the winter commercial fishery since 1978 has always remained 1 January through 30 April.

Closed Areas:

A portion of the available fishing ground was first closed to fishing in 1977, the first year of commercial harvest. Emergency order 4-S-13-77 closed the area offshore Nome in 1977 to prevent overfishing and to disperse the effort to adjacent

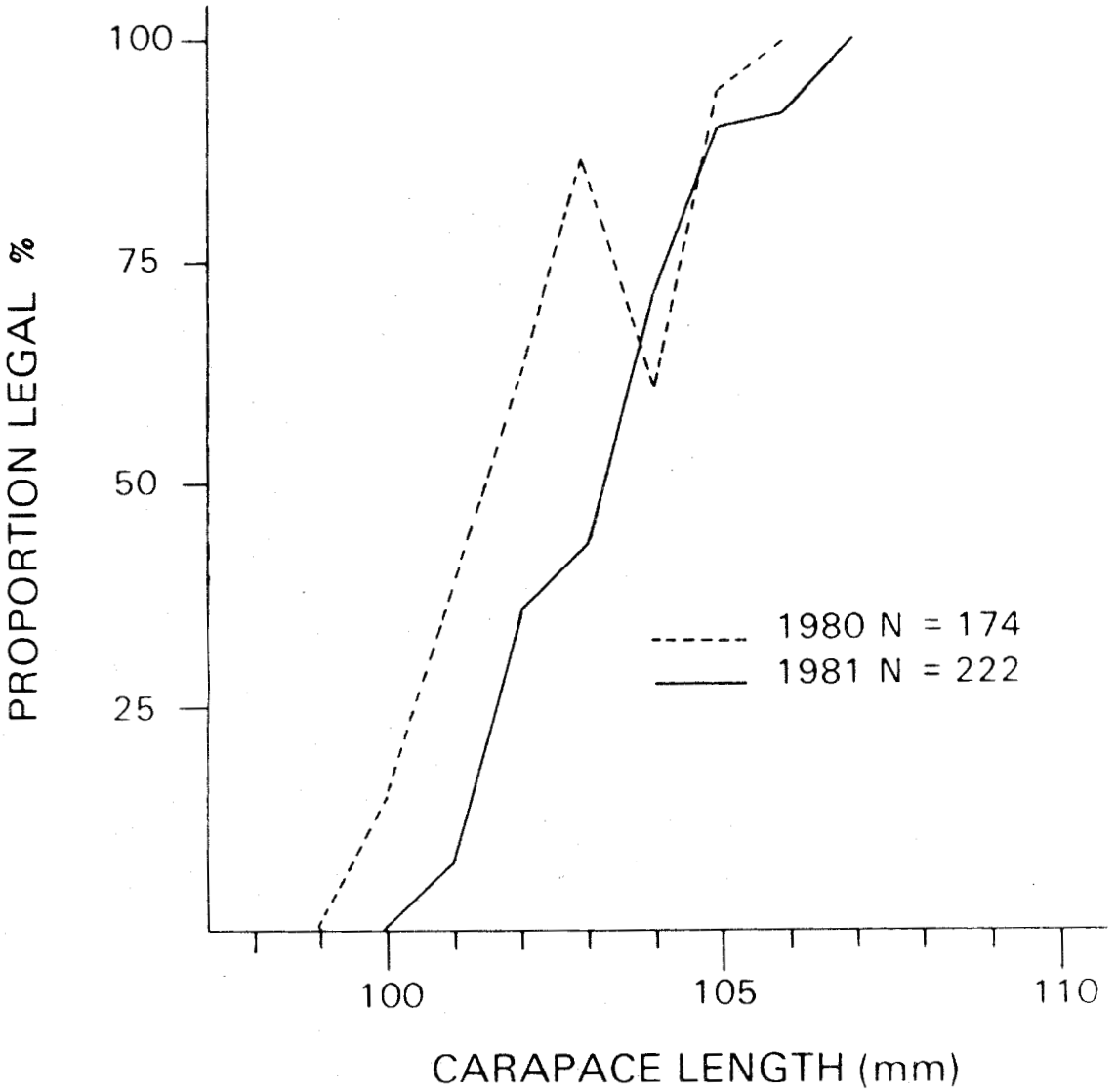

Figure 7. Carapace length conversion to male red king crabs legal size, Norton Sound, Alaska. Legal size is defined as a carapace width of 4-3/4 inches (121 mm) or greater.

Table 4. Summary of the more important red king crab commercial fishing regulations, Norton Sound, Alaska, 1977-1981.

Fishing Year	Size limit[1] (inches)	Harvest guideline (million pounds)	Season		Closed areas	Emergency[5]	
			Open	Close		Regulations	Orders
1977	5	None	June 7	July 15	None	6/7/77[2]	4-S-13-77
1978	4-3/4	.35 to 1 .15 to .5	July 15 Jan. 1	Sept. 3 April 30	None None	1/23/78[3]	4-S-20-78
1979	4-3/4	2 to 3 .15 to .5	July 15 Jan. 1	Sept. 3 April 30	None None		4-S-15-79
1980	4-3/4	0 to 1 .15 to .5	July 15 Jan. 1	Sept. 3 April 30	None None		3-Z-11-80
1981	4-3/4	2 to 5 .15 to .5	July 15 Jan. 1	Sept. 3 April 30	Approximately 4,430 and 2,340 nmi^2 [4]		3-Z-17-81 3-Z-27-81

[1] Carapace width outside the spines.

[2] Emergency regulations adopted in order to provide for a Norton Sound summer commercial fishery.

[3] Emergency regulations adopted for winter 1 January - 30 April commercial fishery; 4-3/4 size limit, pots as legal gear, no pot specifications, waiver of various vessel registration and tank inspection requirements.

[4] See Appendix A, Document 40 and Figure 8.

[5] Emergency Order closures were enacted in 1977 and 1981, see Figure 8.

grounds (Figure 8). The All Alaska, Inc. and the Elizabeth F, Inc. filed an injunction against this State of Alaska emergency order in the Superior Court Third Judicial District at Kodiak. The ruling favored the plaintiffs in State of Alaska case number 77-17340 that the emergency order was invalid; however, the season was nearing an end and no more fishing occurred in the closed area despite the ruling that the closure was not legal. Table 4 indicates that no areas were closed in 1977 because of the judge's ruling when in fact a closure actually existed.

SUMMARY OF RESEARCH DATA - RESULTS AND DISCUSSION

Population Assessment Surveys

Seven research surveys were conducted in Norton Sound from 1948 through 1982 which have contributed biological data on the red king crab (Table 5). The first and second surveys occurred in September and June-July 1948 and 1949, respectively. Forty-one king crabs were captured in 25 tows during these two surveys (Table 5 and Figure 9). An interesting observation from these earliest surveys was the reported occurrence of blue king crab *(P. platypus)* near Sledge Island just seaward from Nome (Figure 2). Every one of the 11 crabs captured in 1948 and five of those in 1949 were recorded as *P. Platypus*. Blue king crabs in later years were always found west of Sledge Island in July. The next survey occurred 27 years later in September-October 1976 when the federal research vessel MILLER FREEMAN trawled extensively in Norton Sound (158 tows) completing Outer Continental Shelf Environmental Assessment Program (OCSEAP) baseline studies. During the 1976 survey 1,503 red king crabs were captured, of which 555 were legal size males, 106 mm or greater in length (Table 5).

Another Norton Sound survey occurred 3 years later in July and August of 1979, when the R/V MILLER FREEMAN completed 71 tows and captured 280 crabs of which 194 were legal size. The survey was unique in that most of the trawling on the productive grounds was conducted after the commercial season resulting in lower catches of legal males than would otherwise have been expected.

The 1976 and 1979 federal surveys subdivided Norton Sound into four major sections with systematic 0.5 hour trawl hauls made at stations within each. Subdivisions and density of stations within each section were based on location of potential oil lease sites, levels of impact for possible environmental alterations, and limited prior knowledge of the distribution of marine resources (Wolotira et al. 1977). Sampling within two of the four sections was planned at one station per 750 km^2 (218 nmi^2), and one station per 375 km^2 (109 nmi^2) within the remaining two.

The ADF&G began conducting research surveys in 1980. Instead of trawling, king crab pots were fished with a standard of 10 per string (station), occasionally ranging from a low of 8 to a high of 13. Strings or stations were approximately 13 km (7 nmi) apart in the east-west direction and 7.4 km (4 nmi) apart in the north-south direction so that on the average one pot was set for every 13.7 km^2 (4 nmi^2). Stations were arranged in a stratified checkerboard pattern with a random start (Figure 10). Four different stations were fished each day initially

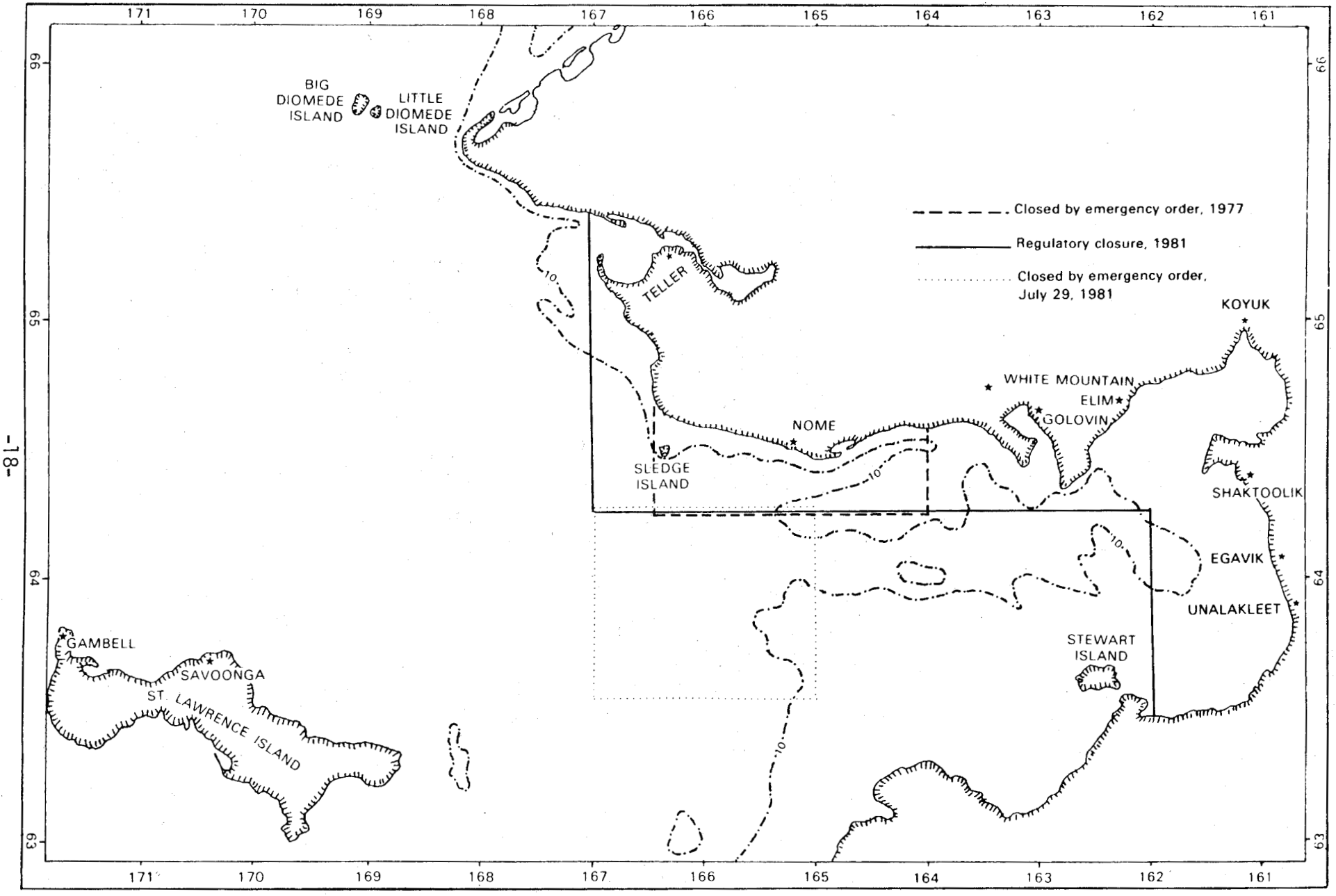

Figure 8. Chart of Norton Sound, Alaska showing the three area closures that have occurred since commercial fishing began in 1977.

Table 5. Catch of king crabs during each of the seven research surveys and initial population estimates prior to the commercial season, Norton Sound, Alaska.

King Crab Survey					Number of Crabs Captured[1]				Population Estimates Legal Males Prior to 7/15		Commercial Harvest		Within year Actual Tag Recovery (legal)
Date	Days	Agency	Vessel	Method	Sublegal Males	Legal Males	Females	Total	Number	Pounds	Pounds	Average Weight	(Percent)
1948													
9/14-9/18	3	F.W.S.	Washington	Trawling 8 tows	0	0	11	11	---	---	None	---	---
1949													
6/27-7/2	6	F.W.S.	Deep Sea	Trawling 17 tows	4	18	8	30	---	---	None	---	---
1976													
9/2-9/5 9/16-10/7	13	NMFS	Miller-Freeman	Trawling 158 tows	768	555[2]	180	1,503	3,119,800	8,111,480[3]	None	---	---
1977[4]	No	Survey	---	---	---	---	---	---	---	---	517,787	2.7	---
1978	No	Survey	---	---	---	---	---	---	---	---	2,091,961	3.0	---
1979													
7/26-8/5	11	NMFS	Miller-Freeman	Trawling 71 tows	46	194[5]	40	280	1,808,203[6]	5,443,395[7]	2,931,672	3.0	---
1980													
7/4-7/14	11	ADF&G	Altair	Pots 397	443[8]	3,290	158	3,891	3,941,176[6]	13,400,000	1,186,596	3.4[10]	7
1981													
6/28-7/14	17	ADF&G	Altair	Pots 718	4,097[8]	3,415	1,933	9,445	1,285,195[6]	4,755,221[11]	1,379,014	3.7	26
1982													
7/6-7/20	15	ADF&G	Aleutian #1	Pots 689	5,019	2,001	424	7,444	762,376	2,822,503[9]	228,921	3.6	7
Totals	--	--	--	--	10,377	9,473	2,754	22,604	--	--	8,335,951	--	--

-Continued-

[1] Data presented for the 1980, 1981, and 1982 pot surveys are standardized to a 24-hour soak.

[2] Legal males include all crabs 106 mm carapace length and greater.

Table 5. Catch of king crabs during each of the seven research surveys and initial population estimates prior to the commercial season, Norton Sound, Alaska (continued).

[3] Population estimate should be doubled if you accept the 44 day night tow comparisons $\bar{x}$ = approximately 2.6 lbs/crab.

[4] The ROYAL ATLANTIC on O.C.S. survey lifted 19 pots and captured 73 crabs, 22 June - 13 July 1977.

[5] Legal males include all crabs 105 mm carapace length and greater.

[6] Obtained by dividing pounds by the average weight.

[7] Commercial catch has been added to the initial population estimates because the survey occurred after the commercial fishery ended.

[8] Crabs with carapace widths less than 4-3/4 inches regardless of length.

[9] Presented to the Alaska Board of Fisheries at the spring Board meeting.

[10] Obtained from actual samples taken aboard BILLIKEN.

[11] Derived from Peterson mark-recovery estimates of 1981 data assuming 10% unreported tag recoveries.

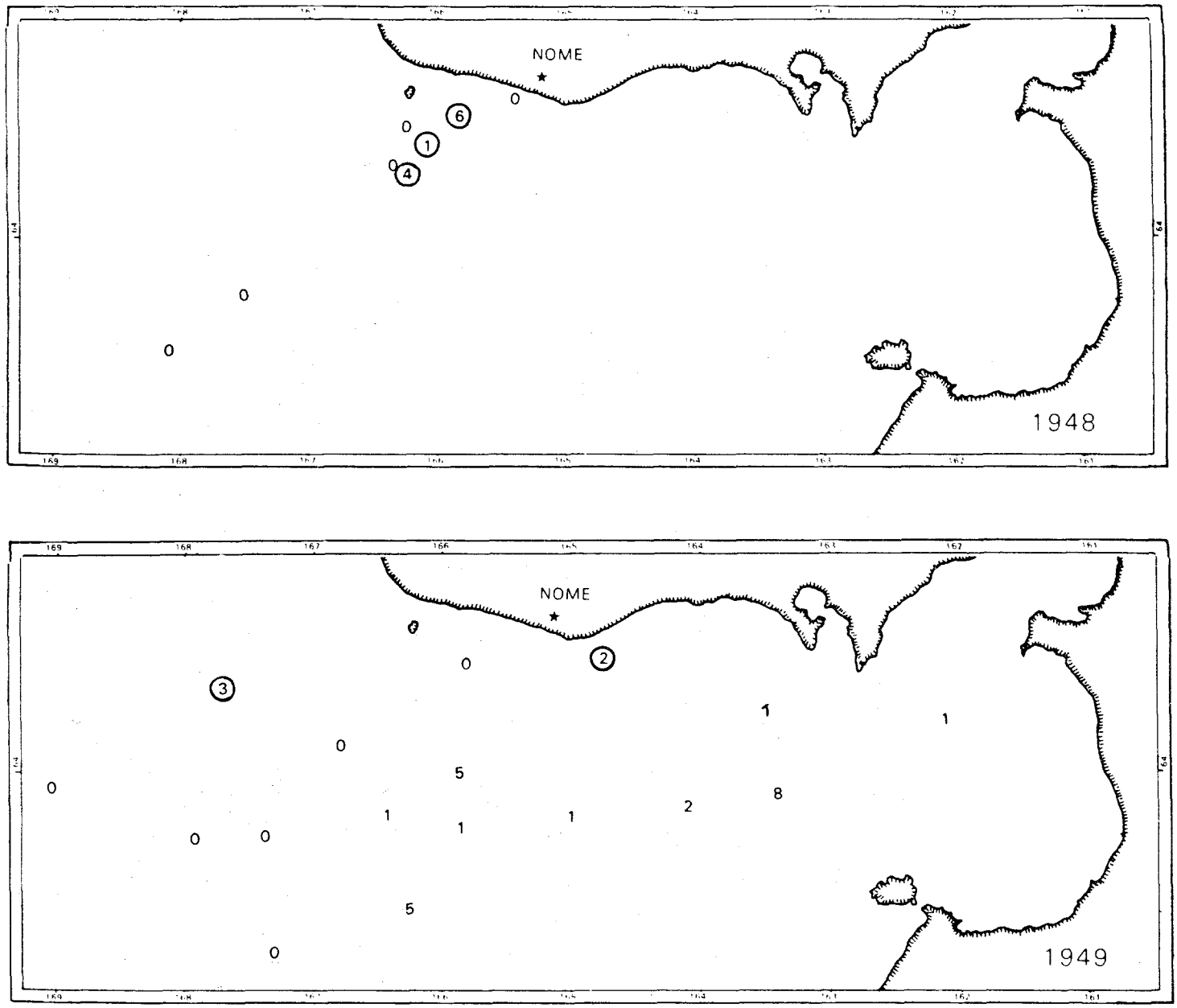

Figure 9. Distribution of male and female red and blue king crabs captured in Norton Sound during the September 1948 and June-July 1949 Fish and Wildlife Service trawl surveys. Note: all blue king crabs, *Paralithodes platypus* were females and are circled.

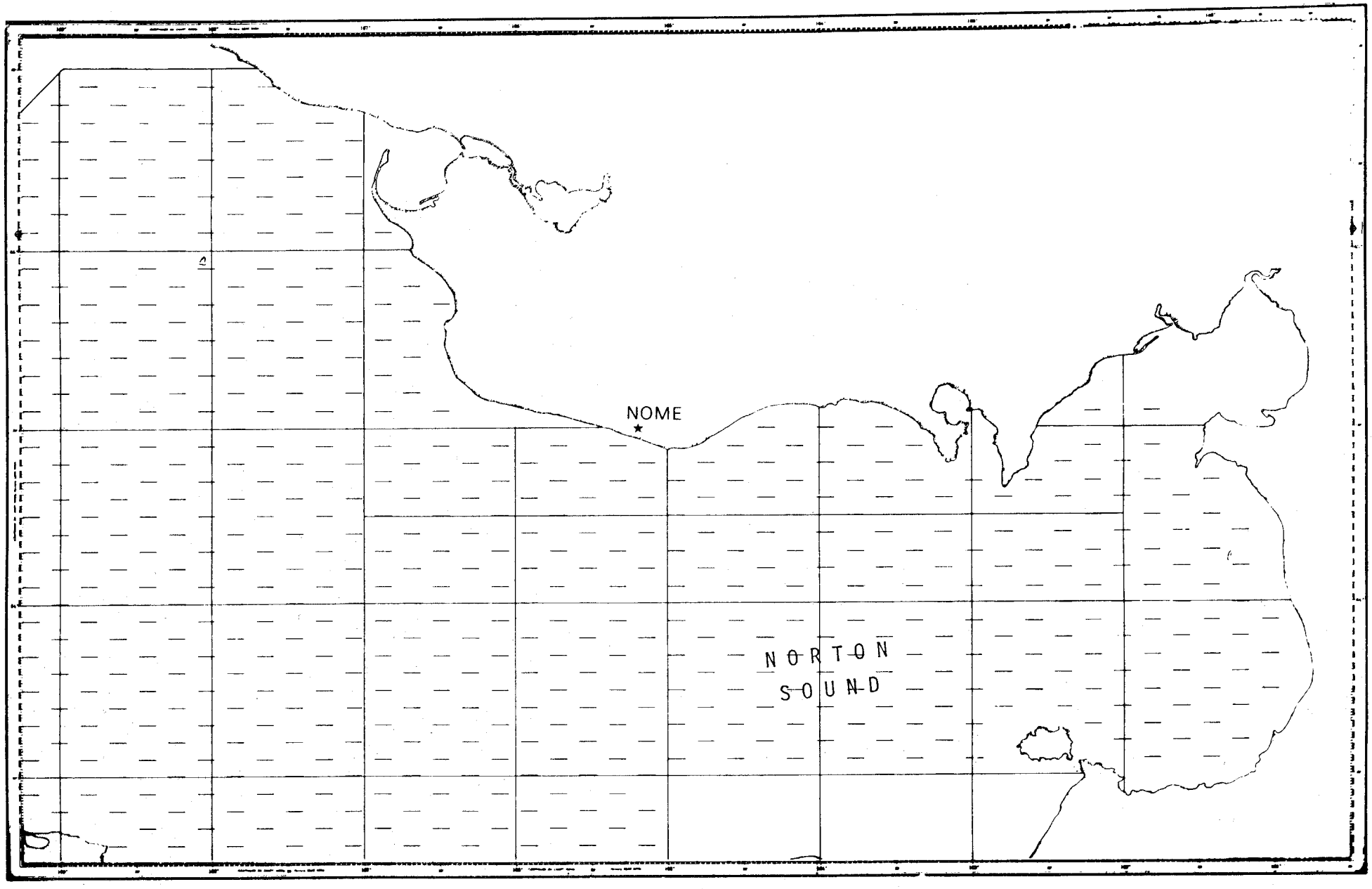

Figure 10. Systematic placement of all possible king crab research fishing stations for Norton Sound and adjacent waters, Alaska. Each horizontal line represents a possible pot fishing station.

then expanded to five stations per day in 1981. The only locality studied in 1980 was the commercially productive area south of Sledge Island and Nome.

ADF&G pot surveys of 1980 and 1981 were conducted within a relatively small portion of Norton Sound; namely that area which had supported the commercial fishery in past season, i.e., the vicinity south of Sledge Island and Nome, as well as in the eastward extension of the 18.3 m (10 fm) trench. In 1981 a larger area was surveyed because of increased funding and expansion of effort to five stations per day. The location of stations fished during the 1976-1981 surveys (excluding 1982) is shown in Figure 11. The 1982 ADF&G research survey, like the 1982 fishery, occurred during the final drafting of this report and the authors chose to present only summary preliminary data for this year (see Table 5).

Male Molting Season

A newly molted male is easy to identify by the clean, white, unscratched, relatively soft exoskeleton. The presence of newly molted males indicates that molting has occurred recently, i.e., within the last 3 months. Determining the length of the molting season and it's probable end is more complicated than merely observing that molting had occurred because it is difficult to determine if old shell crabs are going to molt. Normally the absence of soft, newshell crabs, but presence of recently molted individuals, would be interpreted as signaling the end of the molting season.

Male king crabs of legal size commonly skipmolt; i.e., fail to molt during the molting season. Skipmolting is more prevalent among larger older males, with small legal crabs and large sublegals commonly molting annually, and smaller younger animals molting more frequently (see section entitled Male Molting Frequency).

Visual observations of the exoskeletons of the 10,377 sublegal males and 9,473 legal males captured in Norton Sound surveys through 1982 were seasonally limited and, therefore, did not define the season of molting. Study animals were obtained from commercial and research vessels during approximately the same time period each of the past 5 years (1977-1981) from 28 June-7 October (Tables 2 and 5). Crabs were studied in the late fall only in September and October 1976, and in the spring once in May 1981.

Molting in Norton Sound king crab appeared to be more variable than in other areas of Alaska and the authors hypothesize that the reason is partly due to the lack of deep water in which crabs may take refuge. Consequently, crabs are subject to highly variable environmental conditions, e.g., light intensity, ice cover, shallow water, low salinity, sea water temperatures, and food availability.

The percentage of newshell legal males comprising the commercial catch in the 5 years (1977-1981), as determined from catch sampling, was 91, 98, 5, 96, and 74%, respectively (data are not tabulated in this report). In most areas of Alaska molting of legal males occurs in March and April and it is common for a portion of the population to skipmolt. Two conclusions may be drawn from the Norton Sound data: (1) molting occurred in five of the 6 years prior to July and very likely during April, May, and June, and (2) 1979 was an unusual year in that both the research and commercial catches indicated that the little molting that took place

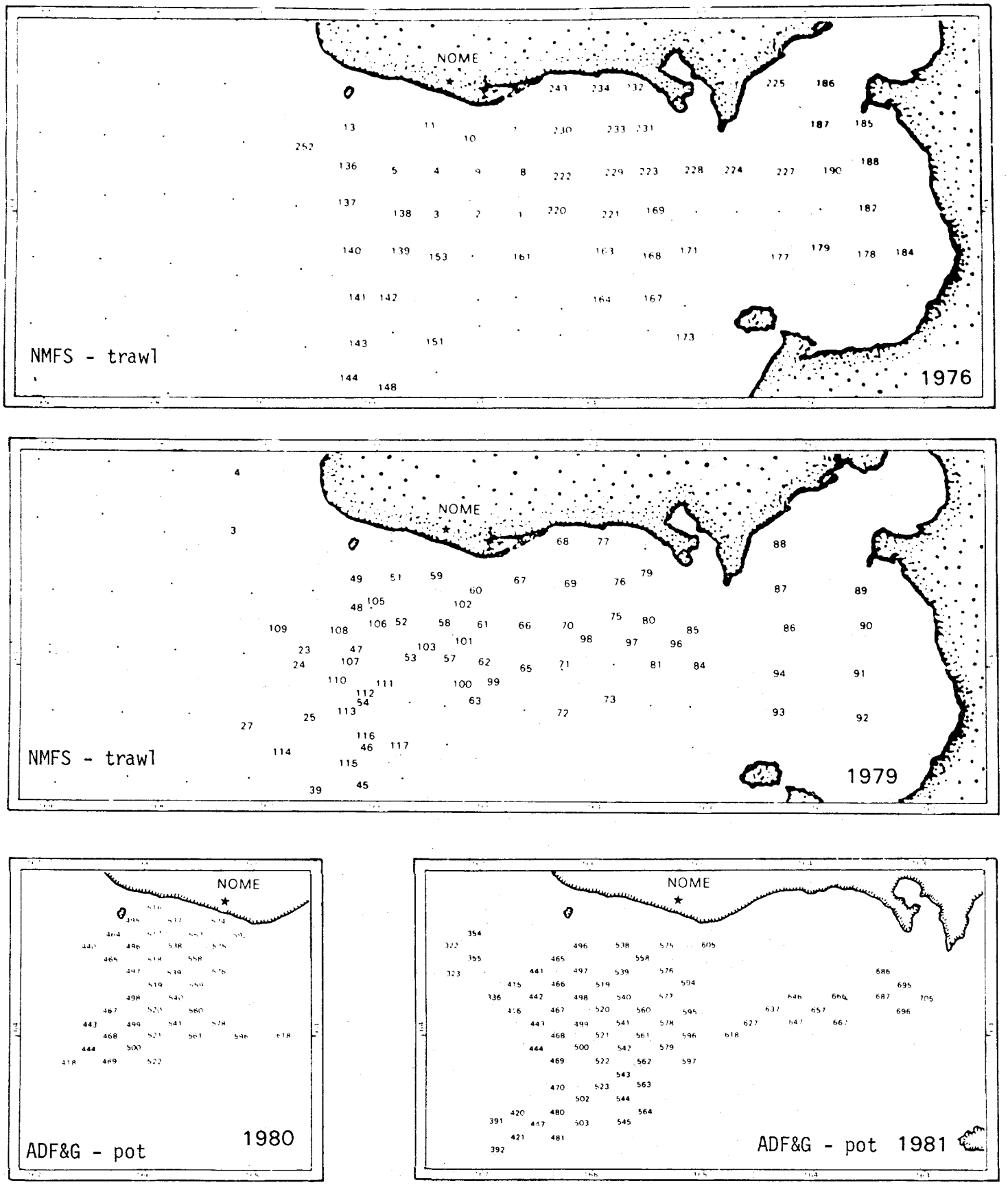

Figure 11. Actual number of each research station fished plotted on location for each survey year. Note: dots for 1976 and 1979 indicate stations that produced no red king crab.

occurred after July. Average weight in the commercial catch remained constant from 1978 to 1979 further substantiating that skipmolting was prevalent in 1979 and verifying that the recruitment was low. In late May 1981, all juvenile males and half of the legal males just offshore from Nome were observed to be in new-shell condition but not soft. These study crabs were caught in pots fished from a skiff by ADF&G Nome biologist Leonard Schwarz. Recently molted males have been reported as early as March by Schwarz but no data are presented (Schwarz 1980).

The molting season of small males may be different than that of legal males. Numerous small males were captured on 12 July 1981 at Station 657 (Figure 11, 1981) ranging from 60 to 79 mm carapace length; some had molted recently and some were ready to molt.

Male Molting Frequency

The ability to accurately determine exoskeletal age and the duration of the molting season are both important in studying molting frequency of various size crabs. We did not accumulate adequate qualitative and quantitative data until 1981 to determine the probable molting schedule. Molting data were derived primarily from two sources, from tag recapture studies and from examining exoskeletal age of crabs within a population.

Apparently sublegal and small legal males in Norton Sound molted at least annually with an increasing incidence of biennial molting as size and age increased. Triennial molting appeared to be uncommon.

Studying the growth or lack of growth of tagged crabs over one or more molting seasons provides a great deal of information about molting. Each of the 23 sublegal males tagged and released in 1980 with shell-of-the-year exoskeletons molted prior to recapture after 1 year. By comparison only 54% (33 crabs) of the 61 legal males tagged as shell-of-the-year crabs and free 1 year, molted. All of the eight males released in 1980 as skipmolt crabs and recaptured 1 year later had molted. This data indicated that small males molted annually until they were approximately legal size at which time increasingly greater proportions molted in alternate years with a greater probability of molting for skipmolt crabs than for shell-of-the-year crabs.

Without regard to shell age at release, of the 114 legal males tagged in 1978 and 1980, 58% (66 crabs) molted and grew, while 42% skipmolted (48 crabs) before recapture 1 year later. Skipmolting was more prevalent in 1979 when 91% (20 crabs) of 22 recoveries were skipmolts. By comparison, in 1981 only 30% (28 crabs) of the 92 recoveries had skipmolted after 1 year. Our statements about molting are accurate only if the molting season occurs prior to August; conversely, if molting is late and occurs after July then crabs we consider skipmolts conceivably may not be and our statements concerning molting would be in error.

Data on the exoskeletal age of Norton Sound males after the month of July were available for only 3 years (1976, 1979, and 1981). Only in 1979 did the data suggest that crabs might have been molting as late as August. The molting season is further discussed later in this report.

Studying tagged crabs free two or more years before recapture reduces chances of error because of possible late male molting. Of the 12 crabs tagged in 1978 and free 2 years before recapture, all had grown, 11 had molted once, and one molted twice (see Table 9 from the tag and recovery program section occurring later in this report). Of the 10 crabs tagged in 1978 and free 3 years before recapture, four molted once, six molted twice, and none had molted three times. Those that molted once were all recaptured as old shells. No recaptured tagged crabs are known to have skipmolted two successive times.

Grasping

The mating season is considered to begin when males start grasping female partners. Males grasp old shell females either prior to or during the egg hatching period and continue to hold them for up to 16 days before the females molt and mating can occur. Grasping pairs can be observed and studied through the use of SCUBA diving equipment.

Workers of the Golovin Bay Salmon Co-op reported observing 25 grasping pairs while recreational diving in Golovin Bay on 15 June 1977. Underwater SCUBA studies in Golovin Bay for 3 days (15-17 June 1982) by the senior author (Guy Powell) and diver Mark Silberstein (Moss Landing Laboratory-California) were inconclusive as no mating pairs or shed female exoskeletons were found. Frequently, grasping pairs are observed in pots and occasionally in trawls as gear is taken aboard vessels during routine fishing operations. On 29 June 1981 during the ADF&G June-July research charter, pot number eight in station 497 (Figure 11, 1981) was brought aboard from 20 m (11 fm) depth. This pot contained a male that was grasping the only old shell female (82 mm) caught during the survey. A final observation worthy of note was made by a young Eskimo man who told the senior author that he saw grasping pairs in shallow water in April near the village of Shaktoolik as he hunted seal in his skiff along the open ice leads.

Female Molting and Mating Season

Female crabs are mated immediately after molting, consequently, female molting coincides with the mating season which can be determined directly by the presence of grasping pairs or indirectly by egg development and exoskeletal condition of females. Mating occurred during April, May, and June in Norton Sound during the study period.

Female crabs are captured by commercial fishermen incidental to the catch of legal males but it is seldom that biologists have the opportunity to study them aboard commercial vessels. Some observations on Norton Sound females were made aboard commercial vessels in 1981. These observations mirrored data obtained from a research vessel 2 weeks earlier. Most of the Norton Sound females studied had been captured by research vessels.

The first five research vessels caught only 397 females, while the 1981 survey alone caught 1,933 females or 70% of those captured (Table 5). Eight ovigerous adult females were also captured in small pots fished from a skiff off Nome 28 May to 21 June 1981; however, the observers did not record the relative age of the eggs and exoskeletons.

During the trawl survey conducted in September and October 1976, 130 females (111 adults and 19 juveniles) of the 180 captured were examined with the result that 9% were reported as soft, 76% new, and 15% old shell (Wolotira et al. 1977). No determination of exoskeletal age was made between juveniles or adults and no comments were provided on egg development. We were unable to determine when molting and mating occurred from these data.

Mating of Norton Sound crabs in 1980 and 1981 occurred prior to July as determined by examining the 2,091 female crabs captured (1,665 adults and 426 juveniles). All adult females captured were recently molted and bore new uneyed eggs except for one old shell nonovigerous female whose eggs had hatched. Time of molting and mating cannot be calculated precisely by studying adult females that have already molted and mated, but estimates are possible. Considering that none of the newly ovulated eggs were eyed, ovulation had to have occurred within the past 4 months, otherwise, the black eyes of the embryo would have been visible through the egg shell (Marukawa 1933). The mating season appeared to have occurred during April, May, and June in 1980 and 1981 with peak female molting probably occurring in May. If mating had occurred as early as March, female exoskeletons probably would have been harder and more scratched than they were.

Younger females in Norton Sound are assumed to mate earlier than older individuals, similar to mating activities of young females in other areas of Alaska.

Through-the-ice king crab studies were initiated in Norton Sound in the winter of 1983. Seventeen adult females were captured from 11 February through 7 May. Of these, 24% of the females bore eyed eggs (two in March and one each in April and May). The rest of the females bore uneyed eggs (Appendix A, Document 43). The eyed eggs of the females captured 7 May began hatching a few hours after capture while being held in sea water in the Nome ADF&G office. Sixty percent of the females bore uneyed eggs and from their exoskeletal appearance we would say that mating and egg laying was occurring as early as March. Pubescent females mating for the first time are believed to molt and mate earliest in the season. Until egg cell division is examined it will not be possible to accurately determine time of mating merely by noting presence of eyed or uneyed eggs.

Egg Hatching

King crab eggs are fertilized externally as they are ovulated. Fertilized eggs are carried by the female for almost a year and cared for as they develop within the brood chamber formed between the abdomen and ventral body surface. Eggs usually hatch just before grasping occurs and prior to female molting, consequently the egg hatching period coincides with the early mating season. The most likely period of egg hatching in Norton Sound was March through June.

Egg Laying

Soon after the female molts, the male partner deposits spermatophore material throughout the setae encircling the two gonopores through which the eggs pass. Immediately thereafter the female lays her eggs which are fertilized as they pass through the spermatophore material. All activities in Norton Sound related to mating (grasping, female molting, sperm deposition, and ovulation) coincided during the same season, March through June.

Female Size at Sexual Maturity

The determination of whether a female is a juvenile or an adult is usually based upon the absence or presence of an external egg clutch. The few large nonovigerous females observed are exceptional and are considered unmated adults. Small nonovigerous unmated adults are also rare and are most often incorrectly classified as large juveniles.

The majority of Norton Sound adult females studied were captured in pots in June and July 1981 (398 juveniles and 1,535 adults). Fifty percent sexual maturity was attained at a carapace length of approximately 68 mm (Figure 12). The smallest adult observed was 60 mm and very few juveniles, if any, exceeded 79 mm. Three crabs larger than 79 mm (86, 90, 98 mm) are shown as juveniles but it is also possible that these crabs were unmated adults and were, therefore, nonovigerous.

Norton Sound female king crabs attained sexual maturity at a smaller size than the females of any other Alaskan red king crab population. The smallest mature adult females ever observed in other areas were 86 mm at Kodiak, 81 mm at Adak in the Aleutian Islands, and 76 mm in the Eastern Bering Sea compared to 60 mm in Norton Sound. Studies in the Kodiak area have shown that male crabs attained sexual maturity at least at the same size as females (Powell et al. 1972).

Egg Development - Size of Egg Clutches

A female must be attended by a male soon after she molts for successful mating. A male that has mated repeatedly becomes less capable of fertilizing eggs. The presence of adult females without eggs or with partial clutches may indicate the lack of suitable male crabs for reproduction, a condition that may be caused by intense commercial harvests.

The relative size of egg clutches is recorded from visual examination on all ADF&G crab research vessels. This procedure was inadequate to verify that in Norton Sound eggs were fertilized because cell development had progressed to a visual stage by mid-July. However, it was assumed that the majority of the eggs in clutches were fertilized, an assumption that may sometimes be erroneous. Eggs of king crabs in Norton Sound have never been found in the eyed stage during June or July. Eyed eggs wouldn't be expected to appear until the end of July if they are laid in late March, because approximately 4 months of development are required before eyes become visible to the naked eye. Development to the eyed stage may require additional time in Norton Sound if water temperatures are colder than in the Southern Bering Sea and Gulf of Alaska. Eyed eggs were observed in August, September, and October during the 1976 and 1979 surveys (Rob Wolotira, personal communication 4 June 1982). Eyed eggs were also observed in March and April 1982 on females captured through the ice offshore Nome.

Egg clutch size of 1,775 adult females was examined during three surveys, 1976-1981 (Table 6). The small sample of 40 females collected during the 1979 research survey was predominantly juveniles and is omitted. The only large sample of adults was obtained in 1981 when 86% (1,535 crabs) of the total female sample was examined. The proportion of the population with full clutches increased from 41% in 1976 to 83% in 1981. However, the small samples of 1976 and 1980 may not be representative of the adult population.

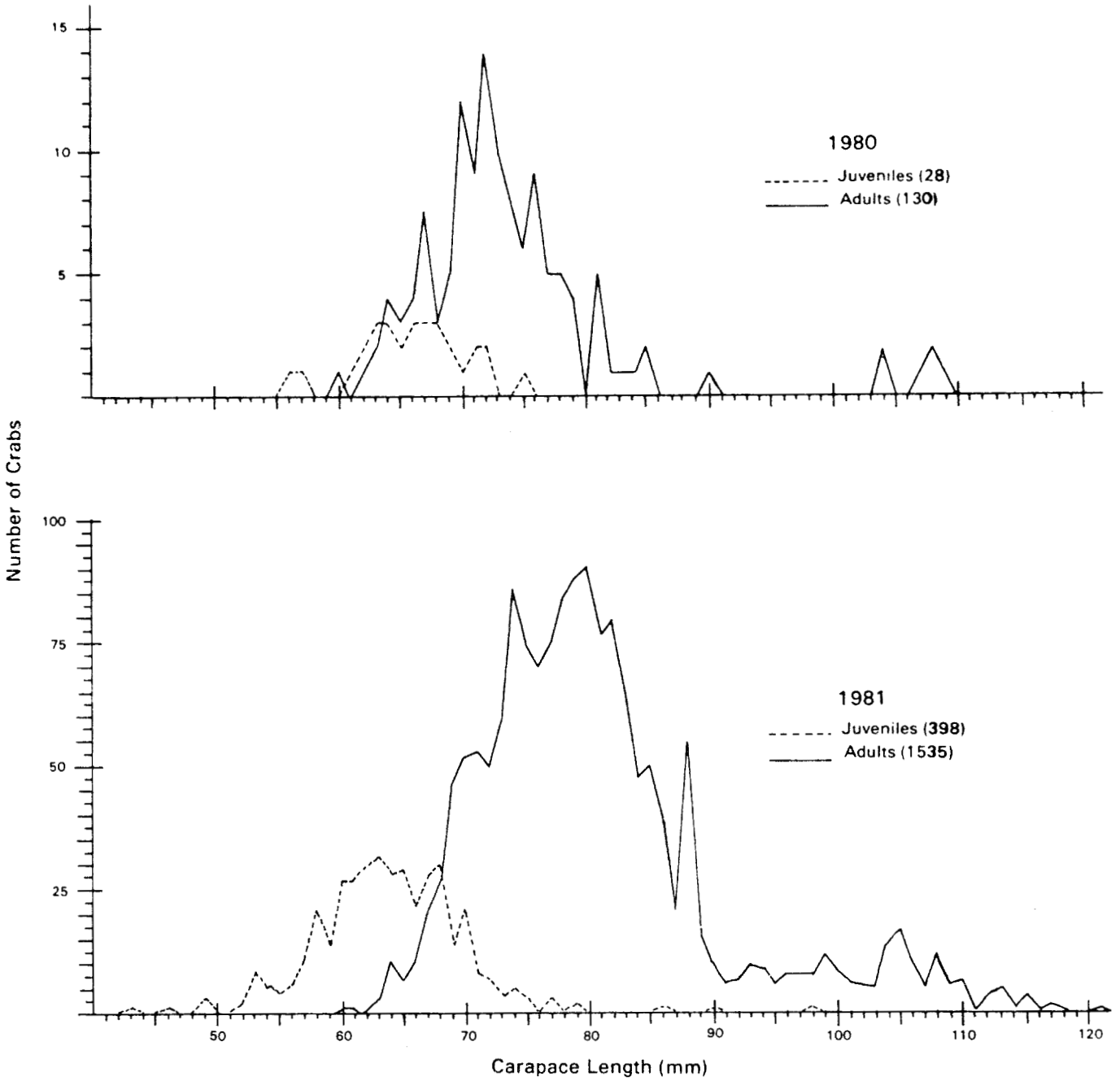

Figure 12. Size distribution of juvenile and adult female red king crabs captured in pots during 1980 and 1981 population studies, Norton Sound, Alaska.

Table 6. Adult female red king crab by size of egg clutch, Norton Sound, Alaska.

Year	Agency[1]	Total ♀'s[2] sampled	Relative size of egg clutch (%)[3] 1 - 29	30 - 59	60 - 89	90 - 100	Total Sample
			Proportion of adult population within year(%)				
1976	N.M.F.S.	111	5	26	28	41	100 %
1980	ADF&G	129	9	9	34	48	100 %
1981	ADF&G	1,535	5	3	9	83	100 %
		1,775	-	-	-	-	-

[1] NMFS signifies the National Marine Fisheries Service of the U.S. Department of Commerce. ADF&G signifies the State of Alaska Department of Fish and Game.

[2] These figures for adults should not be confused with those in Table 11 which include juveniles.

[3] Refers to relative fullness of brood chamber.

Advserse effects caused by intense commercial cropping of legal male crabs on egg production would be expected to first impact egg clutch size of large older females. The majority of crabs in Norton Sound in 1980 and 1981 with very small clutches, however, were small young adult females (59-74 mm carapace length) which in most fisheries have full clutches (Appendix Tables 10 and 11). Comparing 1981 small adults (≤ 84 mm) to large adults (≥ 85 mm) revealed that there were proportionally more small adults (6%) than large adults (2%) with very small egg clutches. A greater proportion of the small females had partial clutches in 1980 than those in 1981, however, the difference between years may be more related to sample size and location than to differences between populations (Figure 13). Very small clutches among young adult females may be related to environmental conditions and unrelated to effects of fishing.

Migrations of Male Crabs

The most practical way to accurately study specific movements of individual king crabs is by tagging, liberating, and recapturing them after various intervals of freedom. Commercial fisherman cooperation in providing precise area of recapture is necessary for a successful program. A quick simplified system for recording capture area utilizes a chart which subdivides Norton Sound into numbered 3.4 km^2 (1 nmi^2) blocks (Figure 14). Nonspecific movements of crab schools frequently were reported by fishermen. Most of the year there was no fishery or research in Norton Sound so movements defined by tag recovery were either short term or those over one or more years. As the commercial fishery operated in basically the same location in each of the the 5 years (1977-1981) and since crabs were not found in abundance in any other area, one could deduce that crabs either remained within this area or returned to this area from wherever they traveled.

In 1978, commercial fishermen reported that the crabs were moving in a westerly direction as the season progressed (Tate et al. 1979). Not until 1981, with the recovery of 283 tagged crabs free up to 3 years, were movements of crab accurately substantiated. Crabs were moving southwesterly as the season progressed. Some legal males averaged 1.9 km (1 nmi) per day moving 56 km (30 nmi) within a month's time (Figure 15A), while others moved shorter distances. Most crabs tagged and recaptured in 1981 moved less than 37 km (20 nmi).

Tagged sublegal males free for 1 year were recaptured approximately 19 to 37 km (10 to 20 nmi) south or west from their point of release (Figure 15B). Legal males free 1 year demonstrated considerably more random movement and on the average were recaptured within 28 km (15 mi) of their point of release 1 year earlier (Figure 15C). Three males free 2 years were recaptured 41, 65, and 69 km (22, 35, and 37 mi) south of their release point (Figure 15D). Six males were free 3 years before they were recaptured during the 1981 season. All were captured within 13 to 56 km (7 to 30 nmi) south of their release point (Figure 15E).

Twenty-two tagged crabs released in May and June 1981 from a skiff within the closed fishing area nearshore Nome and free approximately 1 month, traveled in a southwesterly direction at an average rate of approximately 0.9 km (0.5 nmi) per day. The greatest net movement was 61 km (33 nmi) in 46 days (Figure 16). Recovery rates of crabs from 1981 tagging within closed and open areas, excluding those tagged from the skiff, were 4 and 32%, respectively. Boundaries of the closed areas are presented in Figure 8. Tagging within the closed area occurred

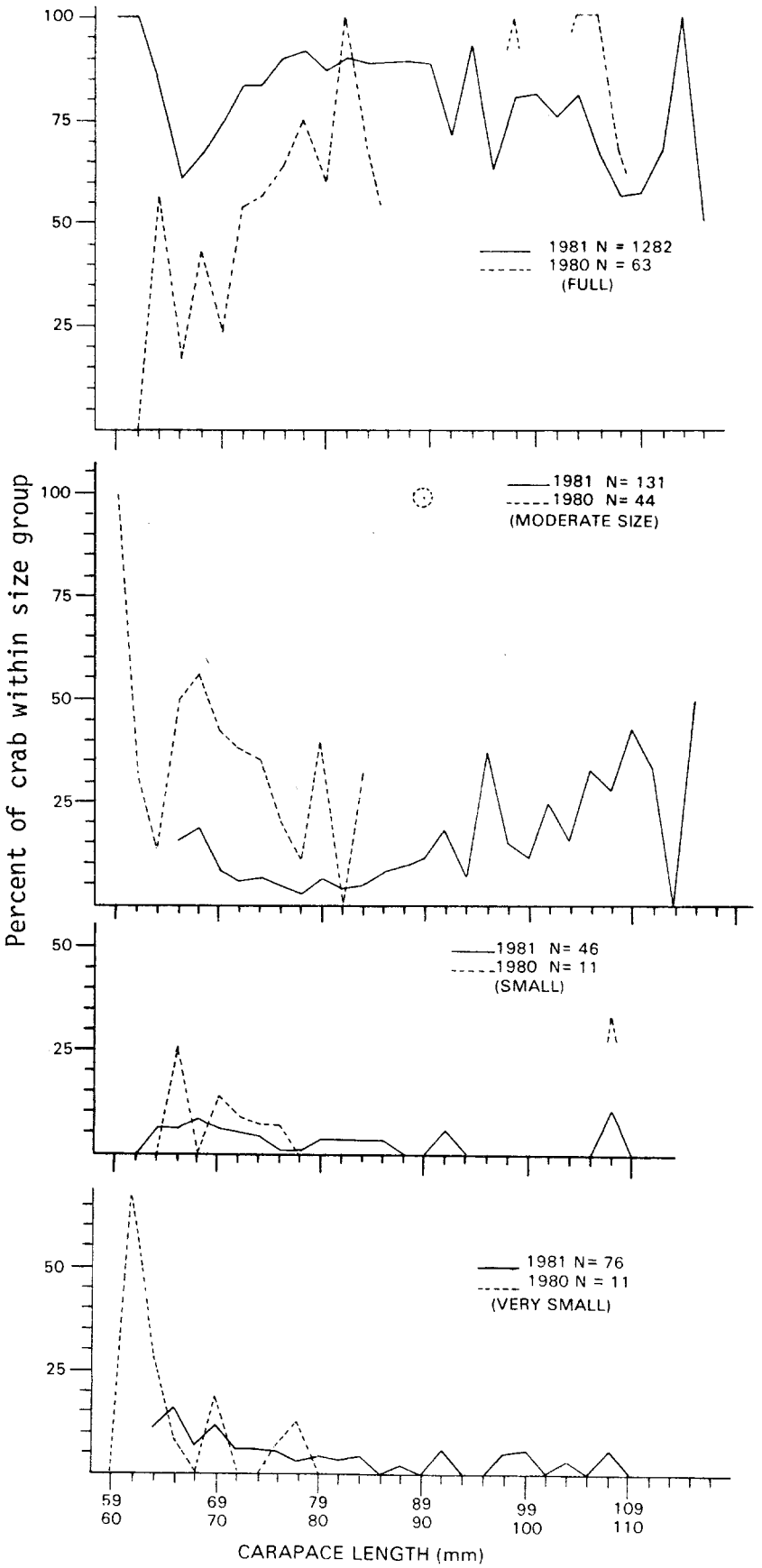

Figure 13. Size comparison between female red king crabs with egg clutches varying from full to very small, Norton Sound, Alaska, 1980 and 1981.

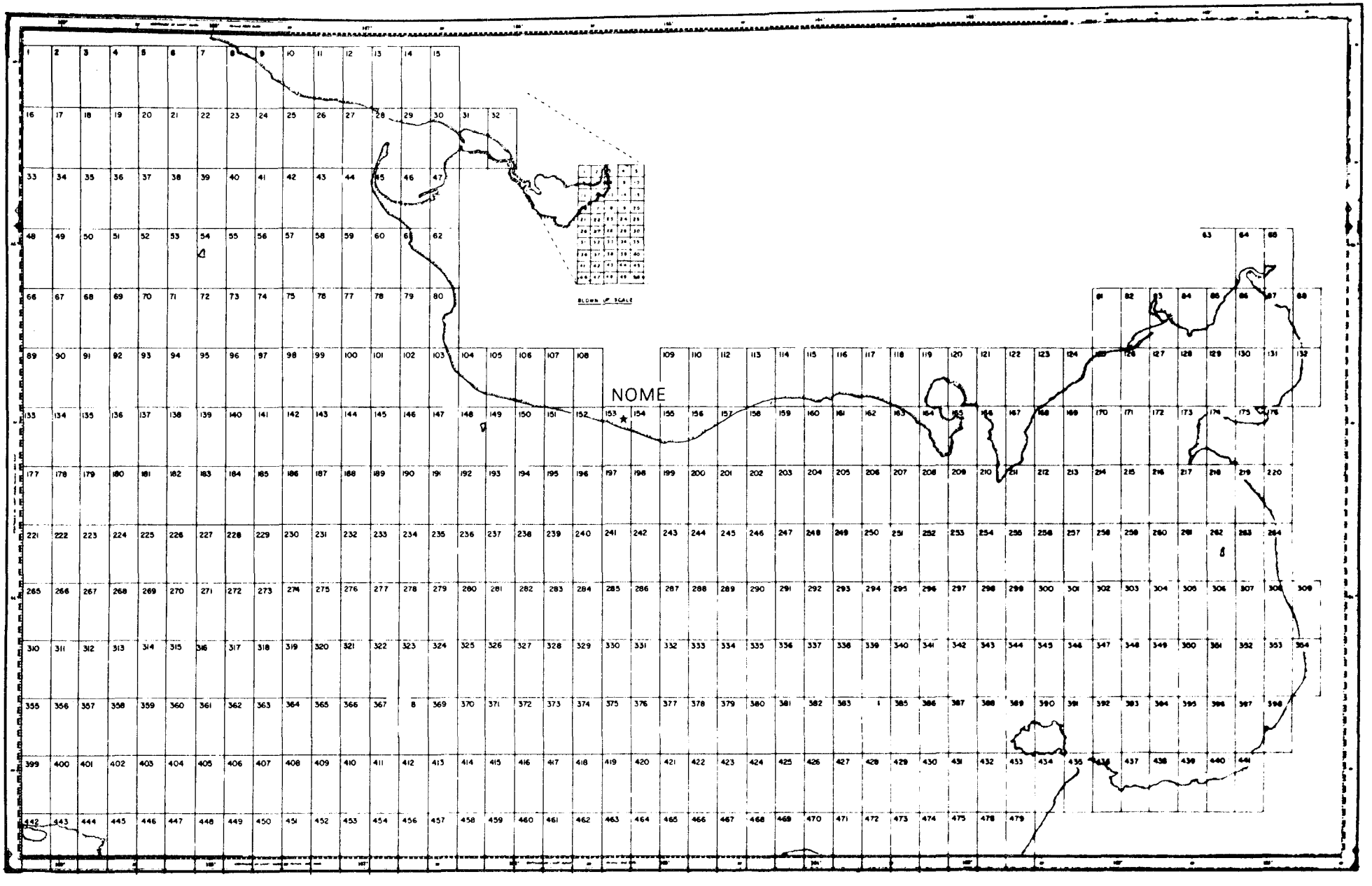

Figure 14. Research grid system consisting of 5 by 10 mile rectangles each of which subdivide into 50 one mile squares. Schematic at the top center used to record tag recovery locations, Norton Sound, Alaska. Each 5 by 10 mile rectangle is subdivided into 50 one mile squares to aid in the recording of tag recovery locations, top insert.

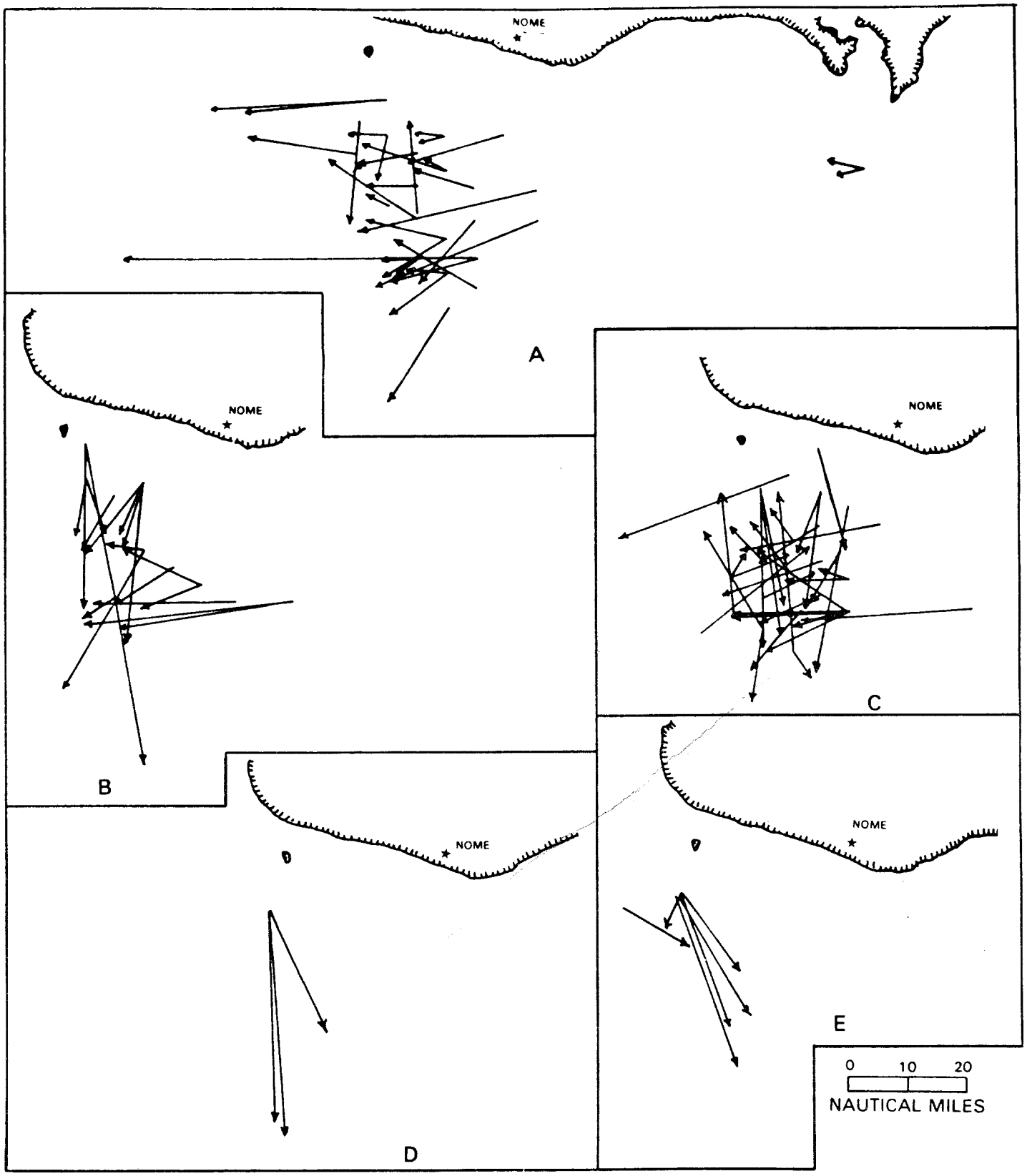

Figure 15. Migrations of male red king crabs, Norton Sound, Alaska; A-Legal males released and recaptured 1981, free 16 to 39 days; B-Sublegal males released 1980 and recaptured 1981, free 1 year; C-Legal males released 1980 and recaptured 1981, free 1 year; D-Legal males released 1978 and recaptured 1980, free 2 years; E-Legal males released 1978 and recaptured 1981, free 3 years.

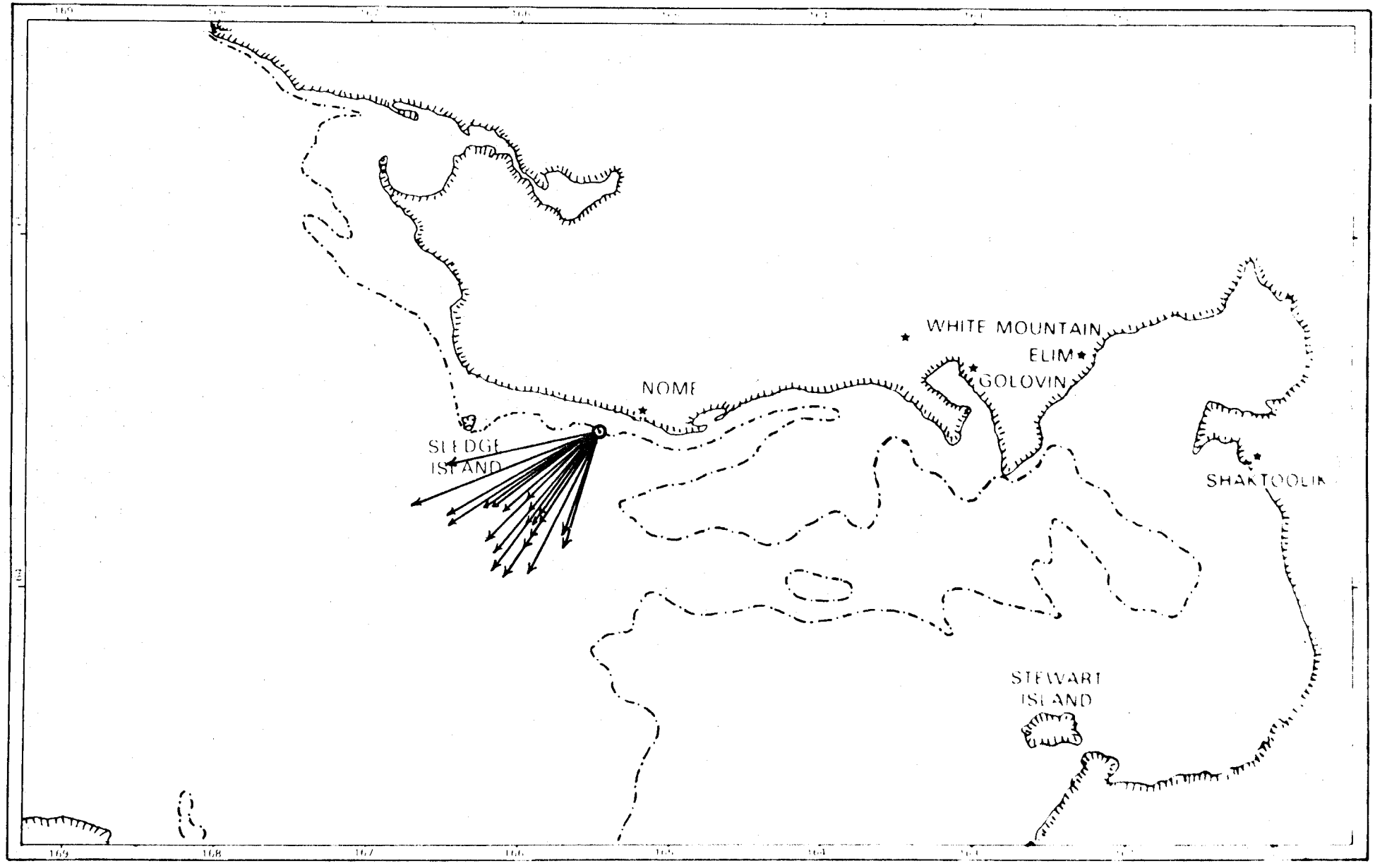

Figure 16. Migrations of 22 male red king crabs, tagged and released from a skiff in May and June 1981, just seaward from Nome, and recaptured in July approximately 30 days later by commercial fishermen.

north of the open area and crabs would have had to migrate southerly and enter the open area in order to be captured. Any westerly or easterly movements would have been unnoticed since the crabs would have remained within the closed area under such conditions. Migrations of crabs tagged within the open area in 1981 were never easterly, but frequently more westerly.

Distribution of Crabs

Present knowledge of king crab distribution in Norton Sound comes primarily from two sources, research and commercial fishing, both of which occurred primarily during the summer and fall, late June through early October. The distribution of crabs during the remainder of the year is poorly understood although they commonly are captured nearshore by subsistence fishing through the ice during winter and early spring.

The 1976 and 1979 federal trawl surveys were much more extensive than the ADF&G pot surveys in 1980 and 1981 (see Figure 11). Much of the area trawled during the early surveys was devoid of red king crabs, consequently in 1980 when ADF&G began to survey Norton Sound with pots these areas did not receive coverage. The commercial fleet continued to fish in the same location and on the same schools of crabs on which research survey efforts occurred.

In 2 years of trawling (1948 and 1949 surveys excluded), 1,783 red king crabs were captured as compared to 11,022 actually captured during the first 2 years of research pot fishing. Table 5 shows 13,336 crabs captured during 1980 and 1981. These data are standardized and should not be confused with the actual raw data. Average catch of red king crabs was greater for pots (9.9 crabs/pot) than for trawls (7.8 crabs/tow) even though trawling occurred during years when the population is believed to have been greater (1976 and 1979). However, pots were fished to a large extent in those areas known to be frequented by crabs. It is difficult to compare catches from trawls in 1976 and 1979 against catches from pots in 1980 and 1981 because the relationship between the two gear types has not been defined.

It is appropriate to define some of the terms used to depict the distribution of various size groups of male and female red king crabs. Juvenile females were those that were sexually immature and, therefore, did not have an external egg mass. The carapace length of most of the juveniles ranged from 50 to 75 mm. Adult females were sexually mature individuals as evidenced by the presence of an external egg mass. Since growth per molt of adults was much less than juveniles, and since adults ranged in length from 60 to 120 mm, adult females represented perhaps seven or more age classes while probably only two age classes were represented in the juvenile catches. All females captured in trawl surveys in 1976 and 1979 were presented as one group, because specific size data were not available to the authors.

Some grouping of males captured during 1976 and 1979 was also necessary for the same reason. Small sublegal males representing not more than two age classes were defined as being less than 90 mm carapace length. Large sublegal males that would become legal size in 1 year (sublegal ones) represented one age class and were greater than or equal to 90 mm. Recruits were recently molted, shell-of-the-year crabs that were legal size but less than 116 mm and represented only one age class. Postrecruits included all other legal males and probably represented at least five age classes. The number of age classes within any of these discre-

tionary groupings varied and, therefore, was not directly comparable. Groups comprised of more age classes frequently yielded greater catches.

Females:

Female crabs were generally found to the north and east of the schools of male crabs (see Figures 17 and 18 for females and Figures 19 through 22 for males). The largest catches in 1976 (those encircled in the figures) were taken in four general locations: just south of Cape Nome, the northern coast just east of Nome, in the mouth of Norton Bay, and just west of Stuart Island (Figure 17A). Trawl catches of females in 1979 were so small (40 crabs) that the data seem to be of little value (Figure 17B). Most of the few females studied in 1980 (158) were captured either at one of the northern fishing stations off the coast of Nome or in the easternmost station (Figure 17C). We suggest that most of the female population in 1980 was not sampled because it lay to the east of the area fished.

Large catches of adult females were made at station 618 (see Figure 11) in 1980 and 1981; 80 and 83 crabs, respectively (Figure 17, C and D). In 1981 concentrations of adult females extended slightly west of station 618 and a considerable distance to the east within the shallow 18.3 m (10 fm) trench pointing towards Unalakleet and Egavik and fished by pots for the first time in 1981 (Figure 17D). Adults and juveniles (Figure 18) appeared to inhabit the same locality. Greater survey catches of adults occurred because adult females were represented by many more age classes. In 1981, twelve times more females were captured than in 1980, primarily as the result of fishing effort within the 18.3 m (10 fm) Egavik trench where females were found to be abundant. Why females were not captured by trawl in the Egavik trench in 1976 and 1979 is unknown.

Males:

The 1981 distribution of males was similar to that of 1980. During both years large males (i.e., postrecruits) were distributed over a large area lying primarily south and slightly east of Sledge Island (Figures 19 and 20D). Smaller males were found east and north of the larger males with considerable intermingling along their common borders (Figures 19 and 20A, B, and C). Males of all sizes inhabited the eastern 18.3 m (10 fm) trench in 1981 with small sublegals predominating (Figure 19A). Sublegal males were captured in the same general vicinity in each of the 4 years surveys were conducted (Figure 21).

The 1976 and 1979 trawl surveys showed that legal males congregated primarily south of Sledge Island and Cape Nome similar to the 1980 and 1981 distribution (Figure 22). Legals in 1976 were relatively small and hence, it was not unexpected that they were slightly more easterly distributed than in 1980 and 1981 when legal males were larger. Additionally, the 1976 survey occurred at a later time than the others, extending into October, and perhaps the crabs had migrated north and eastward from the July and August grounds.

Tag and Recovery Programs

Crabs are often marked with tags so that individual crabs can be identified throughout time. The objectives of these mark and recapture experiments are usually to study migrations and to estimate growth and survivability parameters.

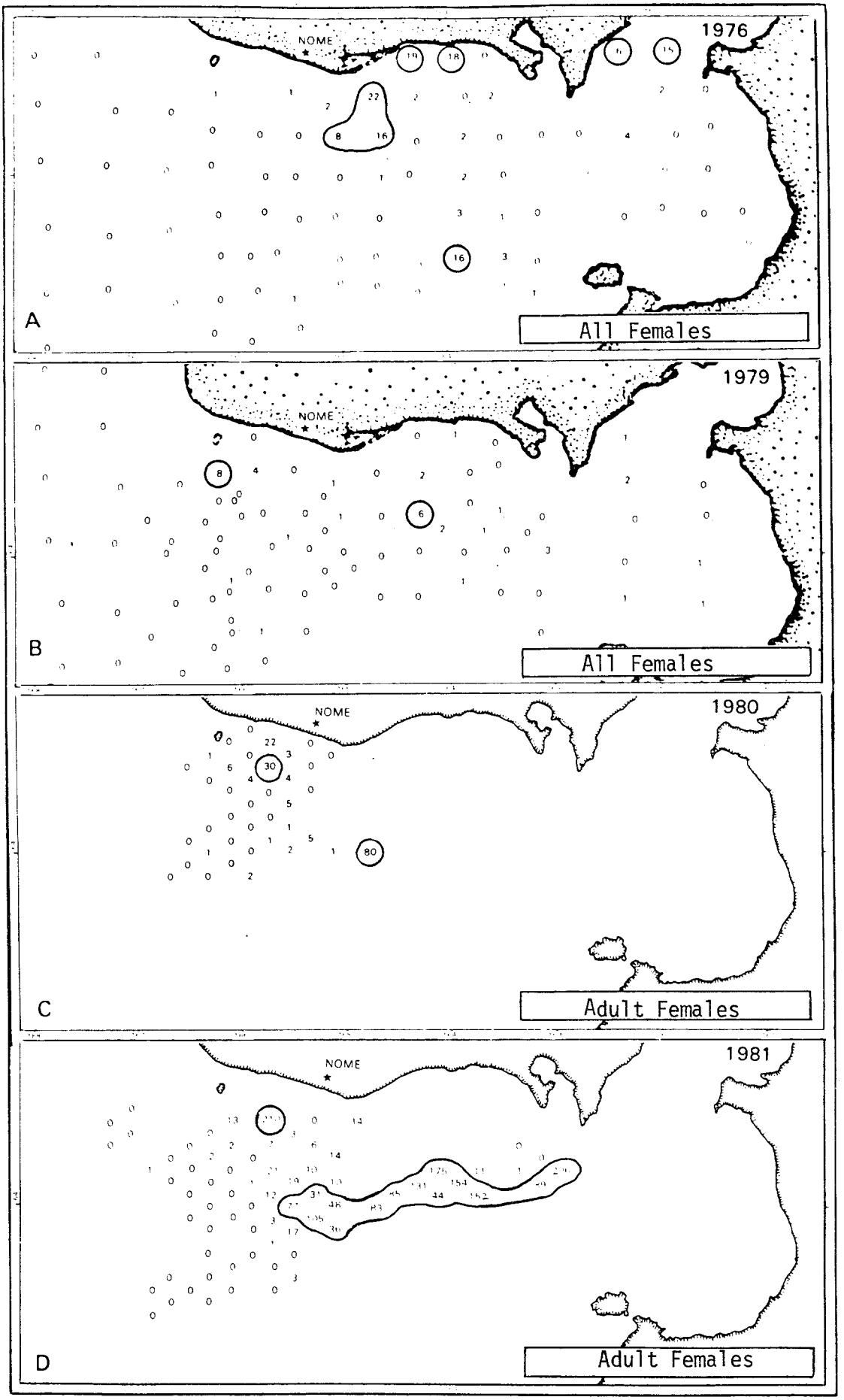

Figure 17. Distribution of female red king crabs for each year of survey, 1976-1981 Norton Sound, Alaska. Number at each station represent total standardized catch of crabs per 30 minute tow (A & B), per 24 hour soak (C & D). (A & B-all females shown; C & D-only adult females shown). Catches greater than 5 (A & B) and greater than 24 (C & D) circled to emphasize locations of greatest concentration.

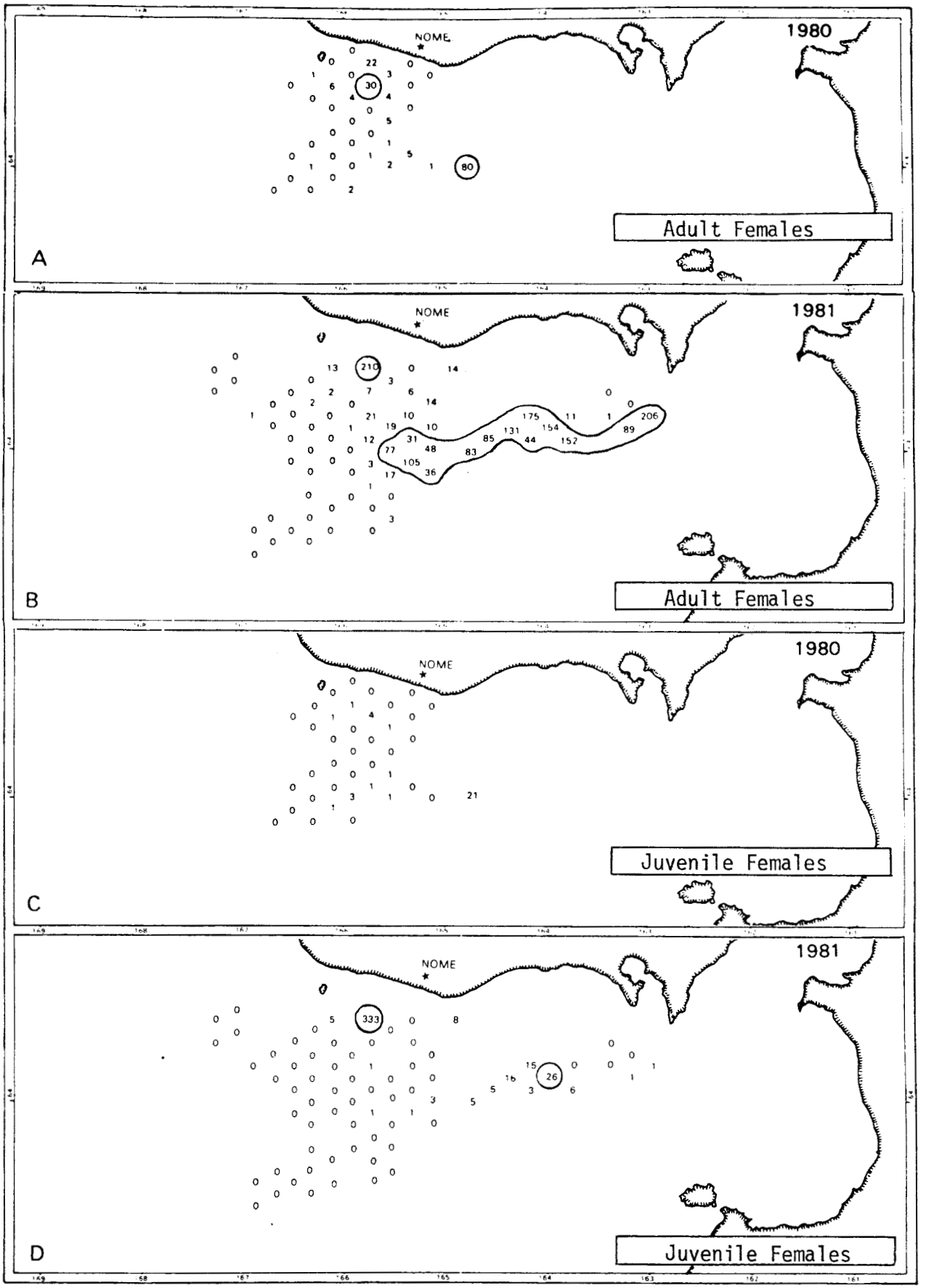

Figure 18. Distribution of juvenile and adult female red king crabs 1980 and 1981, Norton Sound, Alaska. Numbers at each station represent total standardized catch of crabs per 24 hour soak. (A & B-adult females; C & D-juvenile females). Catches greater than 24 crabs are circled for emphasis.

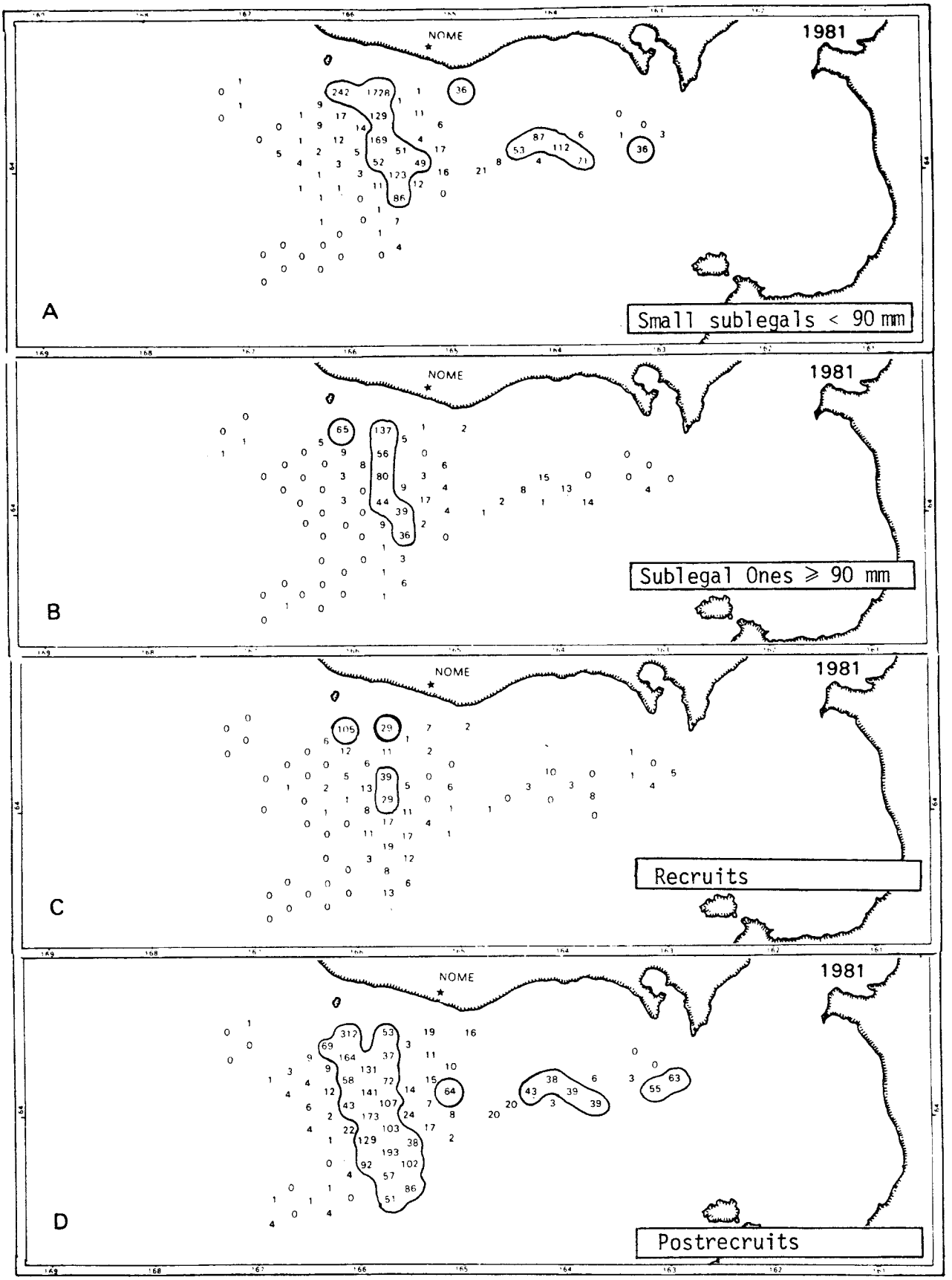

Figure 19. Distribution of various size male red king crabs 6/28/81 to 7/14/81 Norton Sound, Alaska. Numbers at each station represent total standardized catch of crabs per 24 hour soak. (A-Sublegal males < 90 mm; B-"Ones", sublegal males ≥ 90 mm; C-Recruits, legal males ≤ 115 mm with new shells; D-Post-recruits). Catches greater than 24 crabs are circled for emphasis.

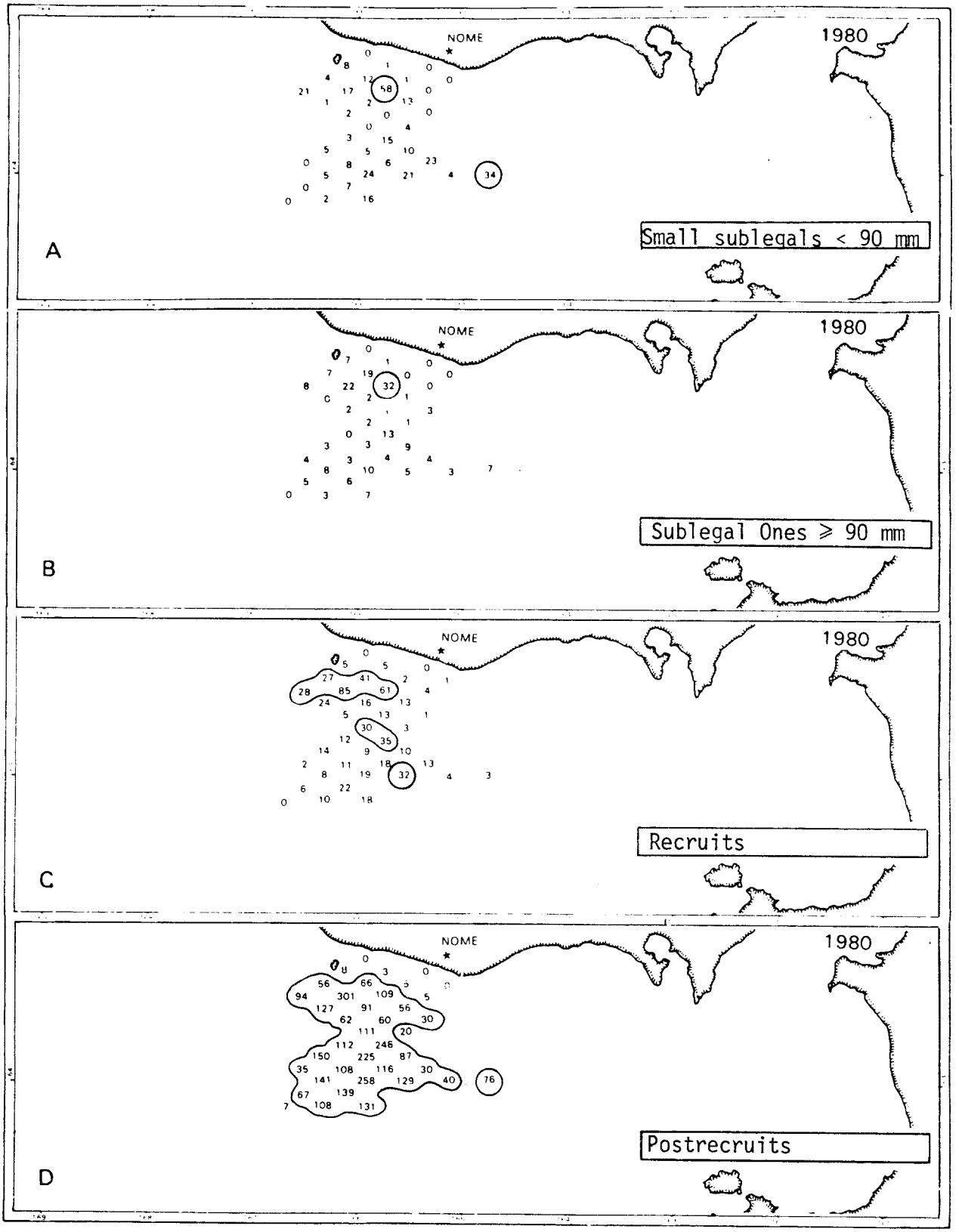

Figure 20. Distribution of various size male red king crabs 7/4/80 to 7/14/80 Norton Sound, Alaska. Numbers at each station represent total standardized catch of crabs per 24 hour soak. (A-Sublegal males < 90 mm; B-"Ones", Sublegal males ≥ 90 mm; C-Recruits, legal males ≤ 115 mm with new shells; D-Post-recruits). Catches greater than 24 crabs are circled for emphasis.

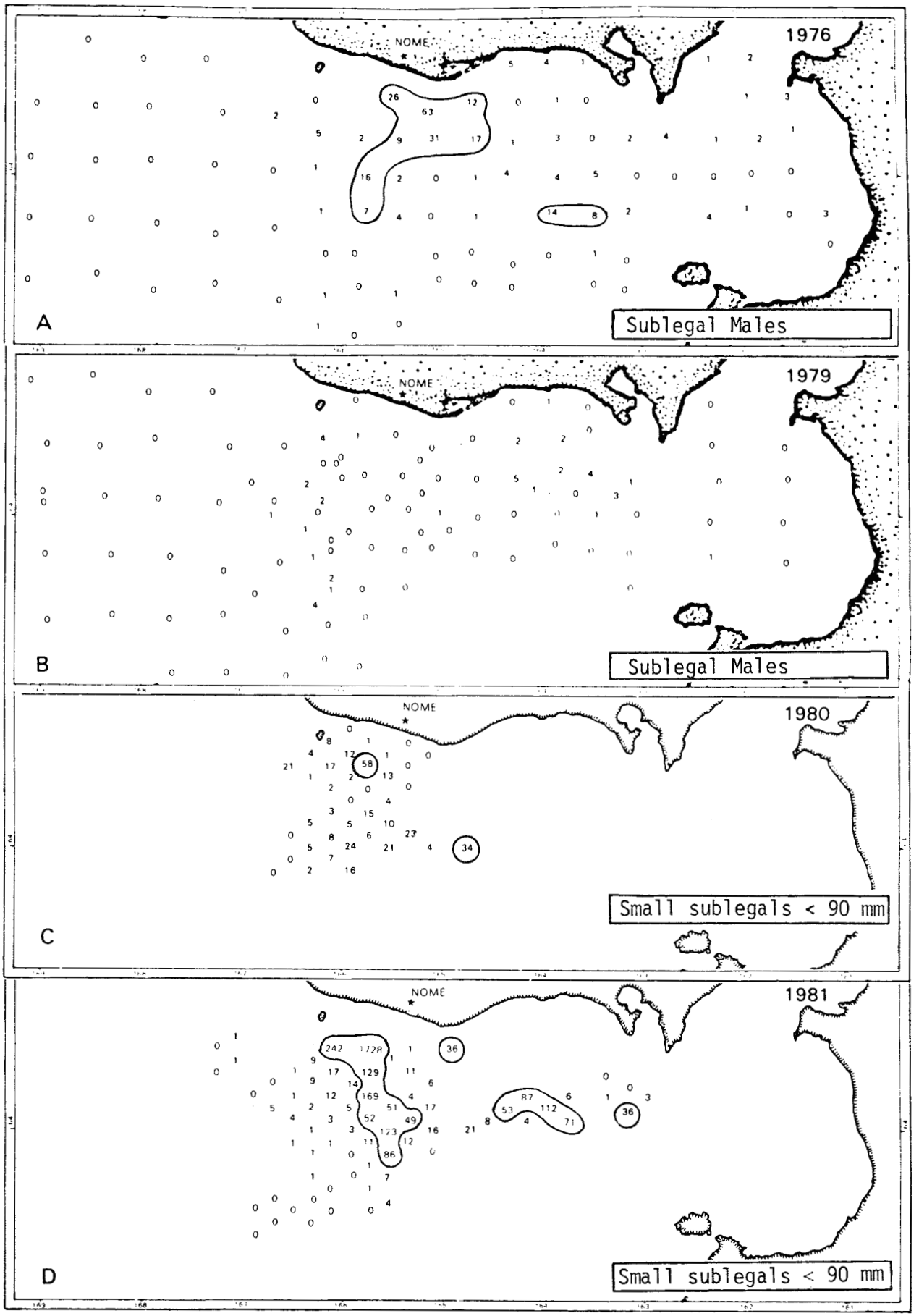

Figure 21. Distribution of sublegal male red king crabs for each year of survey, 1976-1981, Norton Sound, Alaska. Numbers at each station represent total standardized catch of crabs per 30 minute tow (A & B), per 24 hour soak (C & D). (A & B-all sublegal males shown; C & D-only sublegal males < 90 mm shown). Catches greater than 5 (A & B) and greater than 24 (C & D) circled for emphasis.

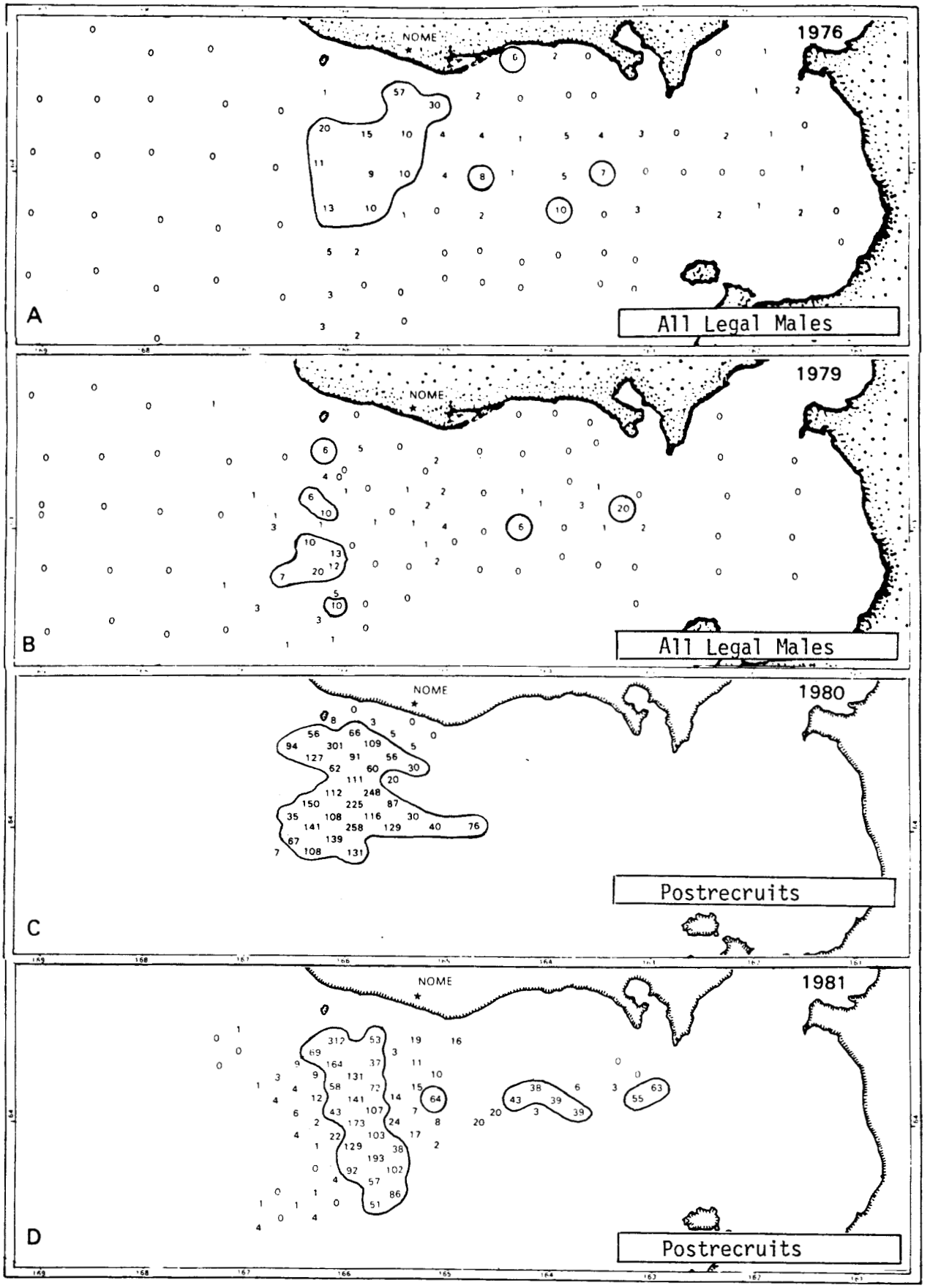

Figure 22. Distribution of legal male red king crabs for each year of survey, 1976-1981, Norton Sound, Alaska. Numbers at each station represent total standardized catch of crabs per 30 minute tow (A & B), per 24 hour soak (C & D). (A & B-all legal males shown; C & D-only postrecruits shown). Catches greater than 5 (A & B) and greater than 24 (C & D) circled to emphasize locations of greatest concentration.

As in many applications the researcher must rely om commercial fishermen and processing industry employees for recoveries after the researcher releases the tags. Cash rewards are offered to encourage cooperation in the return of tagged animals and recovery data.

Tag Releases:

King crabs were first tagged and released in Norton Sound in 1973. Tagging has occurred every year since, except for 1979. Through 1981, a total of 1,944 male crabs (1,779 legal and 165 sublegal) was tagged and released in Norton Sound (Table 7); females were never tagged. All tags used in 1980 and 1981 were permanent isthmus tags of the ring type, first developed in 1978 by the senior author (Powell). Tags used in 1978 were also permanent isthmus tags, but of the old style without discs and with an overhand knot in the plastic tubing. Tagging in 1978 was conducted from a commercial catcher/processor during the commercial season primarily for the purpose of studying growth. Subsequent tagging in 1980 and 1981 was conducted prior to the commercial fishing season aboard chartered research vessels except for a small program in 1981 where 216 tagged crabs were released from a skiff just seaward from Nome (Table 8 and Appendix Table 12). Tagging in 1980 and 1981 was designed to study population size, natural mortality, growth, migrations, and molt frequency. Every seventh legal crab captured aboard research vessels was tagged and released so that tagging was in proportion to abundance. Tags were distributed as evenly as possible among the untagged animals and adequate numbers were released. The number of crabs released at each fishing station for 1980 and 1981 research surveys is shown in Figure 23 and Appendix Tables 13-15.

Tag Recoveries:

Twenty-one percent (408 crabs) of all crabs tagged and released since 1978 were recaptured and returned (Table 7). There is no accurate estimate of the number captured that were not returned. The largest recovery recorded for any 1 year was 26% in 1981 and was partially the result of the thorough coverage provided by five biologists and one technician monitoring the commercial fishery (see Appendix Table 2).

The number of tagged crabs free from one to four seasons prior to recapture was 246, 135, 16, and 11, respectively for all years (Table 9). Of the 408 recoveries, 88 grew, 216 did not grow (48 skipmolted and 168 were recaptured before the molting season), and 104 were recaptured without any size at recovery measurements (Table 9). The total of 216 recoveries that did not grow were considered useful for studying carapace measurement and exoskeletal age bias.

Number of Tag Recoveries Per Vessel:

An annual comparison between tag recovery rates for each commercial vessel provides useful insight into tag recovery data and its dependability. The average ratio of legal crabs captured in the commercial fisheries in 1980 and 1981 per tag recovery was 8,913 and 2,851, respectively (Tables 10 and 11). The recovery rate was three times greater in 1981 than in 1980, indicating that tag recoveries were low in 1980. As research fishing effort and tagging procedures were similar both years, the difference in recovery rates between years suggests that the 1980

Table 7. Recoveries of male red king crabs tagged and released in Norton Sound, Alaska[1].

Year of Tagging	Vessel	Number tagged	Recovery of tagged crabs by year									
			1978		1979		1980		1981		Totals	
			No.	%	No.	%	No.	%	No.	%	No.	%
1978	Commercial	541 legal	38	7	30	6	16	3	11	2	95	18
1980	Research	519 legal	--	-	--	-	37	7	78	16	115	22
1980	Research	161 sublegal	--	-	--	-	4	2	27	17	31	19
1981[2]	Skiff	212 legal	--	-	--	-	--	-	35	17	35	17
1981[2]	Skiff	4 sublegal	--	-	--	-	--	-	0	0	0	0
1981	Research	507 legal	--	-	--	-	--	-	132	26	132	26
Totals		1,779 legal	38		30		53		256		377	21
		165 sublegal	--		--		4		27		31	19
Grand totals		1,944	38		30		57		283		408	21

[1] The 1978 tagging occurred aboard a catcher processor during the commercial season. In 1980 and 1981 all tagging occurred just prior to the commercial season aboard chartered research vessels except for the 216 crabs released in 1981 which were released just offshore Nome from a small skiff powered by an outboard motor.

[2] Tagging occurred in the coastal area closed to commercial fishing.

Table 8. Red king crab tagging from skiff close to Nome, Norton Sound, May and June, 1981[1].

Date of fishing	Station number[2]	Tag numbers released	Total tags released	Number pots pulled	Soak time (days)	Tagger recorder	King crabs captured	
							Males	Females
5/28/81	051	11301 - 11315	15	1	2	Nelson	29	1
5/31/81	052	11316 - 11339	24	2	3	Nelson	118	1
6/2/81	053	11350 - 11388	39	2	2	Schwarz/Nelson	145	2
6/5/81	024	11389 - 11397	9	1	3	Schwarz/Thomas	See Below	See Below
6/5/81	054	11398-11423; 11426; 11430; 11433; 11434; 11435; 11436; 11438; 11440; 11441; 11442; 11444; 11445; 11446; 11447; 11449	41	2	3	Schwarz/Thomas	172[3]	2[3]
6/8/81	025	11424; 11425; 11427; 11428; 11429; 11431; 11432; 11437; 11439; 11443; 11448; 11450; 11451	13	1	3	Schwarz/Thomas	See Below	See Below
6/8/81	055	11452 - 11494	43	2	3	Schwarz/Thomas	94[3]	1[3]
6/12/81	026	None	0	1	4	Schwarz	0	0
6/12/81	056	11495 - 11500	6	1	4	Schwarz	44	0
6/21/81	057	11501 - 11527[4]	26	2	13 & 9	Schwarz	73	2
6/21/81	027	None	0	1	9	Schwarz	0	0
7 days			216	16			675	9

[1] Each of the 3 pots used were different, all hand made, two side entry, one top entry, all small and all light in weight, none were of standard design.

[2] The second integer of the station number designates the distance from shore in miles rounded to the nearest whole number.

[3] Failed to keep crabs from the 2-1/2 and 5 mile stations separate.

[4] Tag 11517 missing.

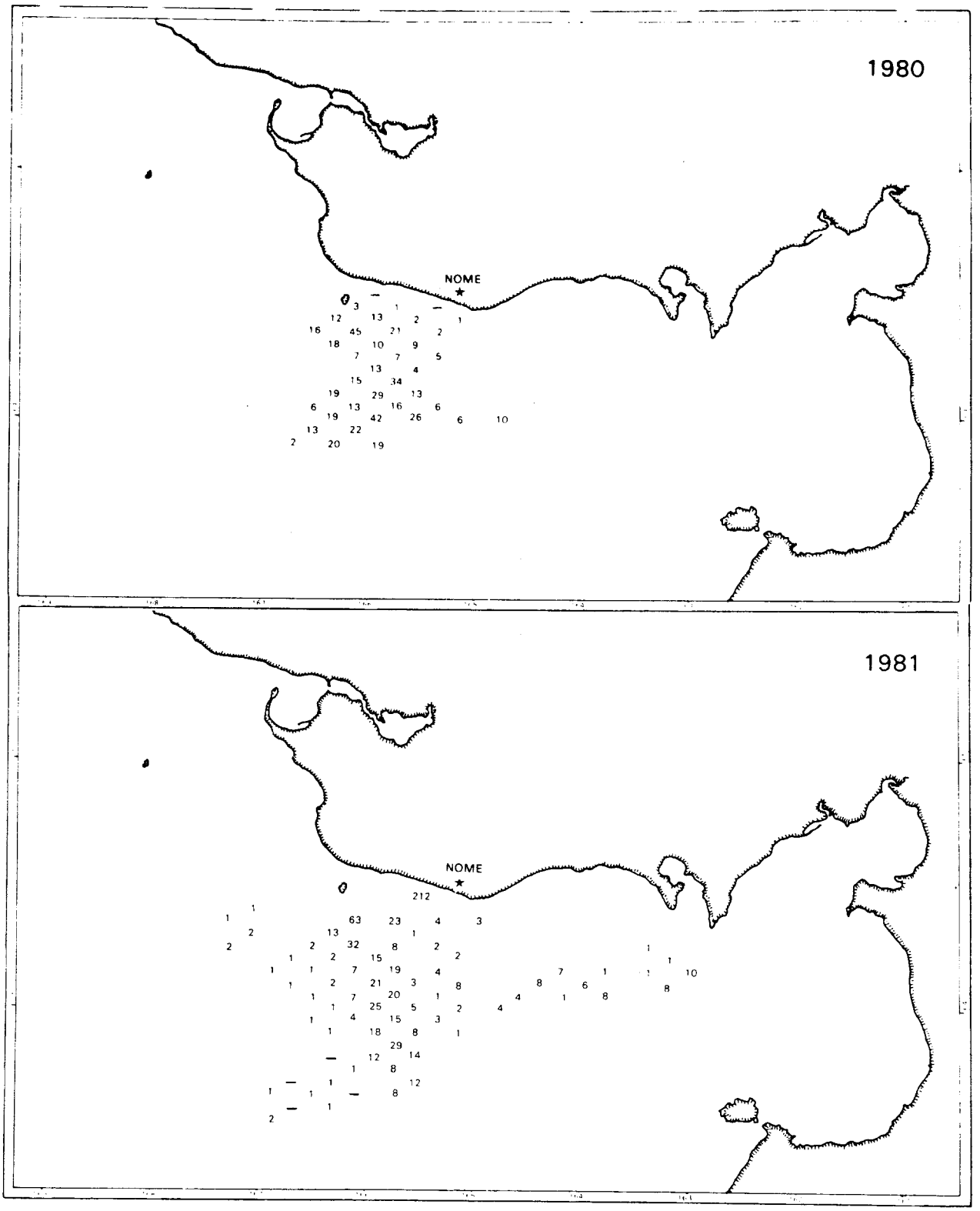

Figure 23. Number of legal male red king crabs tagged and released at each station, Norton Sound, Alaska, 1980 and 1981.

Table 9. Tag and recovery record of male red king crab in Norton Sound, Alaska, 1978-1981.

Year of fishing	Number of crabs tagged	Number of tagged crabs recaptured for each subsequent year																			
		First				Second				Third				Fourth				All years			
		Tag only - No measurements	Measurements No growth	Number of crabs that grew	Total	Tag only - No measurements	Measurements No growth	Number of crabs that grew	Total	Tag only - No measurements	Measurements No growth	Number of crabs that grew	Total	Tag only - No measurements	Measurements No growth	Number of crabs that grew	Total	Tag only - No measurements	Measurements No growth	Number of crabs that grew	Total
1978[1]	541	38	0	0	38	8	20	2	30	4	0	12	16	1	0	10	11	51	20	24	95
1979	None	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	680	16	25	0	41	13	28	64	105	-	-	-	-	-	-	-	-	29	53	64	146
1981	723	24	143	0	167	-	-	-	-	-	-	-	-	-	-	-	-	24	143	0	167
Totals	1,944	78	168	0	246	21	48	66	135	4	0	12	16	1	0	10	11	104	216	88	408

[1] In 1978 commercial fishermen were advised by Fish and Game biologist, Bob Nelson not to keep tagged crabs but to just log the tag number and then return tagged crabs to the water immediately because the primary purpose of tagging in 1978 was to study growth.

Table 10. A comparison of the number of tagged crabs captured by each vessel commercially fishing Norton Sound, Alaska, July 1980.

Vessel Number	Commercial catch (number)	Tag recoveries reported[1] [2]	Tags per 1000 crabs	Ratio Crabs per tag
1	40,306	10	0.2	4,031
2	40,350	7	0.2	5,764
3	41,501	5	0.1	8,300
4	23,908	2	0.1	11,954
5	88,064	6	0.1	14,677
6	88,469	2	0.0	44,234
7	86	0	-	(86)[4]
8	194	0	-	(194)[4]
9	6,900	0	-	(6,900)[4]
Not identified[3]	---	5	-	-
TOTAL	329,778	37	0.1	8,913

[1] Determining what vessels caught tags involved using ADF&G biologist Len Schwarz' daily radio log, tag recovery forms, and commercial fish tickets.

[2] Only crabs tagged and released in 1980 are included.

[3] Radio log data indicate these recoveries are probably from vessels 5 or 6.

[4] No tags reported hence no estimate made, commercial catch shown.

Table 11. A comparison of the number of tagged crabs captured by each vessel commercially fishing Norton Sound, Alaska, July-August 1981.

Vessel Number	Commercial catch (number)	Tag recoveries reported [2]	Tags per 1000 crabs	Ratio Crabs per tag
1	1,745	3	1.7	582
2	8,911	12	1.3	743
3	6,210	6	0.9	1,035
4	6,593	6	0.9	1,099
5	4,495	4	0.8	1,124
6	6,654	5	0.7	1,331
7	1,439	1	0.6	1,439
8	28,103	14	0.4	2,007
9	20,491	10	0.4	2,049
10	29,442	14	0.4	2,103
11	8,059	3	0.3	2,686
12	9,958	3	0.3	3,319
13	13,280	4	0.3	3,320
14	9,972	3	0.3	3,324
15	32,657	9	0.2	3,629
16	7,496	2	0.2	3,748
17	11,602	3	0.2	3,867
18	15,925	4	0.2	3,981
19	28,868	7	0.2	4,124
20	8,885	2	0.2	4,442
21	15,244	3	0.1	5,081
22	5,714	1	0.1	5,714
23	5,968	1	0.1	5,968
24	6,000	1	0.1	6,000
25	19,551	3	0.1	6,517
26	7,443	1	0.1	7,443
27	23,315	3	0.1	7,772
28	776	0	0.0	(776)[1]
29	1,800	0	0.0	(1,800)[1]
30	2,396	0	0.0	(2,396)[1]
31	2,903	0	0.0	(2,903)[1]
32	3,229	0	0.0	(3,229)[1]
33	3,294	0	0.0	(3,294)[1]
34	4,650	0	0.0	(4,650)[1]
35	5,118	0	0.0	(5,118)[1]
36	8,127	0	0.0	(8,127)[1]
Unknown	--	4	---	---
TOTAL	376,313	132	0.3	2,851

[1] No tags reported hence no estimate made, commercial catch shown.

[2] Only crabs tagged and released in 1981 are included.

recovery data was less dependable. The three vessels, numbers 4 to 6 (Table 10) were the most suspect of not reporting tag recoveries because ratios of legal crabs per tag were much greater than average, 11,954, 14,677, and 44,234, respectively. In 1980 the lowest ratio for any vessel was 4,031; by comparison 18 different vessels (numbers 1-18) had ratios lower than 4,031 in 1981 (Table 11). Half of the vessels had ratios of legal crab per tag greater than 8,913 in 1980. All fishing vessels in 1981 had lower ratios (Tables 10 and 11). We propose that tag recovery appeared higher in 1981 than in 1980, not because tag recovery was low in 1980, but because tagged crabs that were captured were not turned in and reported to the technician working in 1980.

Three trained biologists and one trained technician in 1981 maintained close communications with almost every vessel captain throughout the fishery, which aided the recovery of the majority of recaptured tagged crab. The 1981 fishery compared to 1980 is best described as one of considerably greater effort, on a declining population, for a similar length of time, but with less area to fish.

A large portion of the historic commercial grounds were closed to fishing in 1981. All coastal waters totaling approximately 15,215 km^2 (4,430 nmi^2) were closed in hopes of protecting that segment of the population utilized by subsistence fishermen during winter months. In addition, the major fishing grounds that were fished in 1981 were open for only 14 days (see Table 4 and Figure 8). Although the main 1981 season was short, four times more vessels fished (37) than in 1980.

After the initial closing of the major fishing grounds on 29 July 1981, a few vessels fished the relatively unproductive adjacent grounds for another 23 days. In 1981, 26% of the 507 tagged legal crabs were reported recaptured by commercial fishermen. Since the fishery was well monitored, we feel the actual tag recovery rate (26%) is a good minimum estimate of that portion of the stocks harvested. Striving for a more accurate estimate we arbitrarily assumed that 14% (21 tags) of the recoveries went unreported, then the adjusted estimate of stock utilization becomes 30% or 153 recoveries rather than the 132 (26%) reported (see Table 7).

Within year recovery rates of 1981 releases were 50% or greater at 13 of the release stations with 100% being the highest individual station rate (see Figure 27 below in discussion of Estimation of Stock Utilization). For every 2,851 crabs captured in 1981 one tag was returned. Nine of the 36 vessels (25%) did not report any tags captured but in each case their commercial catch was low (Table 11). All butone of the 25 vessels (96%) that caught more than 5,500 crabs reported tag recoveries indicating that cooperation and coverage was good in 1981.

Male Population Size Structure

The size structures of legal males captured during each of the 4 years of research fishing were similar to those obtained at approximately the same time from samples of the commercial catch. Similarities may be seen by comparing Figures 5 and 24. Average size of crabs in the population increased from 1976 through 1981 with average weight of legal size crabs increasing 0.45 kg (1 lb) from 1.2 kg (2.7 lb) in 1977 to 1.7 kg (3.7 lb) in 1981 (Table 1). The relative scarcity of recruit size crabs in recent years is obvious by the shift in the size distribution immediately to the right of the dotted line (Figure 24) or to

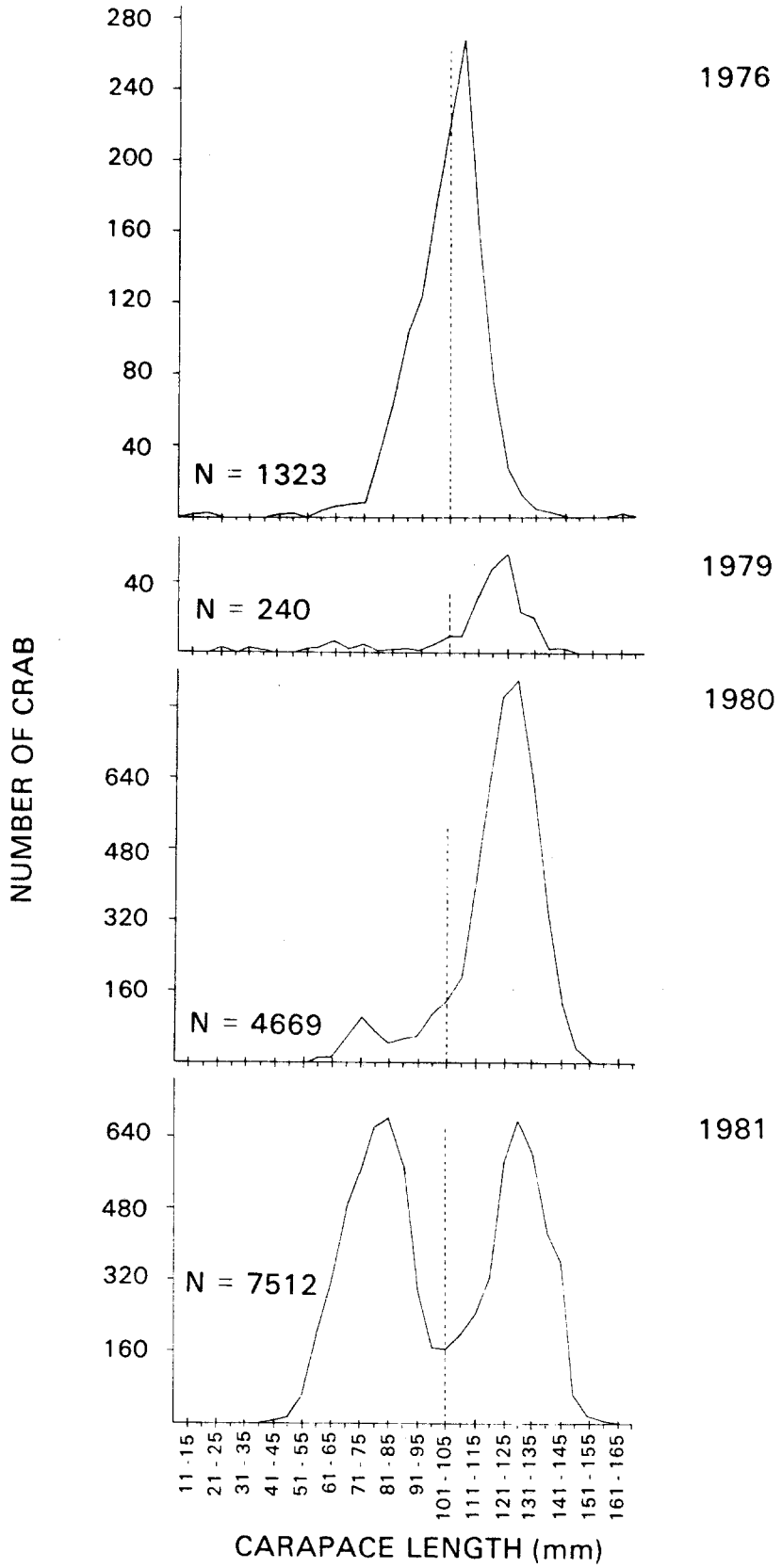

Figure 24. Size structure of the male red king crab population, Norton Sound, Alaska as determined by research fishing. Dotted line represents present minimum legal size.

the right of the vertical axis (Figure 5) caused by crabs molting and growing. In contrast, the large recruitment of 1976 occurs as the high point of the graph immediately to the right of the dotted line (Figure 24). The 1977 graph in Figure 4 does not crowd the vertical axis because the size limit in 1977 was 12.7 cm (5 in), 6.35 mm (0.25 in) larger than in other years.

The relative abundance of sublegal males increased markedly in 1981 with more crabs indicated than has existed for at least the past 5 year period 1978-1981. A large proportion of those crab should enter the fishery at legal size in 1983.

The number of crabs of each size captured per 100 pots lifted for 1980 and 1981 surveys is shown in Figure 25. The decrease in the research catch per effort seen in 1981 is considered to reflect removals by the commercial fishery in 1980, as well as the extension of the 1981 survey into areas of low male abundance.

Male Size Increment Per Molt

The increase in carapace length that occurs when male crabs molt was studied by tagging and releasing crabs and recapturing them in subsequent years.

The precision of growth data is dependent upon two factors: the accuracy of carapace measurements and the subjective determination of the condition (age) of the exoskeleton, i.e., the distinction between shell-of-the-year (frequently called new shell) and skip molt crabs. Estimates of the accuracy of measuring and aging was obtained from tagged crab recoveries. The exoskeletons of Norton Sound were initially difficult to age probably because we didn't know when Norton Sound crabs molted. However, after several years of studying recoveries of tagged crabs, particularly those tagged as recently molted animals, our aging precision was improved.

Carapace Measurement Bias:

Comparing measurements of tagged animals when released and again at recovery for 181 crabs that did not molt revealed an average measurement bias of - 0.53 mm. Separate estimates of 0.64 mm and - 0.47 mm were obtained for 1980 and 1981 tagging, respectively (Tables 12 and 13). Rarely did individual differences exceed ± 2 mm (Figure 26). To compensate for the 0.53 mm bias, + 0.53 mm must be added to average increment per molt. The negative bias indicates that the more careful measuring done at recovery, because of greater availability of time, shows crabs slightly smaller than when the initial and quick measurements were taken aboard charter vessels.

Exoskeletal Aging Bias:

Examination of the shell age data for 105 crabs tagged and recaptured in 1981, where shell age data existed at recovery, indicated that 93% (98 crabs) were recaptured without shell aging errors. Eighty crabs liberated as new shells were recaptured as new shells and 18 liberated as skipmolts were recaptured as skipmolts. Seven shell aging errors were found; two released as new shells were returned as old shells and five released as old shells were recaptured as new shells, but showed no growth.

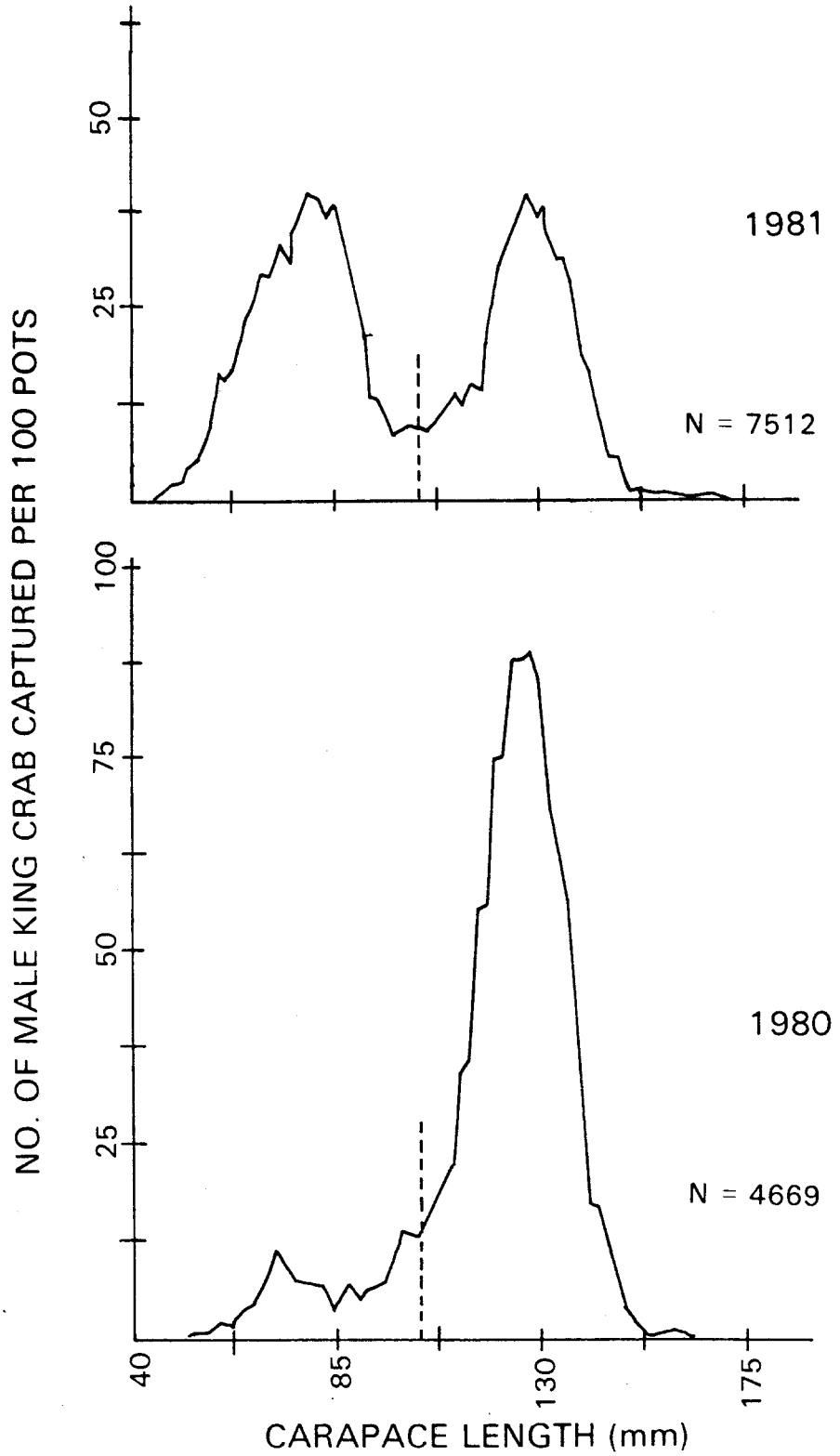

Figure 25. Comparison between size and catch per effort of the research catch of male red king crabs, Norton Sound, Alaska, 1980 and 1981 surveys.

Table 12. Measurement bias of 53 tagged legal male king crabs recaptured prior to the molt, Norton Sound, Alaska, 1980[1].

Release Length (MM)	MEASUREMENT BIAS (MM)[2] -2	-1	0	+1	+2	+3	TOTAL CRABS	SUM OF BIAS
105 - 106	0	1	0	0	0	0	1	-1
107 - 108	0	0	0	0	0	0	0	
109 - 110	0	0	0	1	0	0	1	+1
111 - 112	0	0	0	0	0	0	0	
113 - 114	0	0	0	0	0	0	0	
115 - 116	0	1	1	0	0	0	2	-1
117 - 118	0	0	0	0	0	0	0	
119 - 120	0	0	0	0	1	0	1	+2
121 - 122	1	2	1	0	0	0	4	-4
123 - 124	1	2	1	0	0	0	4	-4
125 - 126	0	2	2	0	0	0	4	-2
127 - 128	0	1	2	0	0	0	3	-1
129 - 130	0	2	1	0	0	0	3	-2
131 - 132	2	9	4	0	0	0	15	-13
133 - 134	0	0	1	0	0	0	1	
135 - 136	1	4	1	0	0	0	6	-6
137 - 138	1	1	1	0	0	0	3	-3
139 - 140	0	2	1	0	0	0	3	-2
141 - 142	0	0	0	0	0	0	0	
143 - 144	0	1	0	0	0	0	1	-1
145 - 146	0	0	0	0	0	1	1	+3
Totals	6	28	16	1	1	1	53	
Sum of bias	-12	-28	0	1	2	3		-34
	$\bar{x}$ bias = -.64 mm							

[1] Twenty-five tagged crabs were recaptured shortly after release and the other 28 were recaptured after one year of freedom.

[2] Carapace length at recovery minus carapace length at release.

Table 13. Measurement bias of 108 tagged legal male king crabs recaptured prior to the molt, Norton Sound, Alaska, 1981.

Release length (mm)	Measurement Bias (MM)[1] -2	-1	0	+1	+2	Total crabs	Sum of bias
101 - 102							
103 - 104							
105 - 106			1			1	0
107 - 108							
109 - 110			2			2	0
111 - 112							
113 - 114		1	1			2	-1
115 - 116		2				2	-2
117 - 118			1			1	0
119 - 120		2	3			5	-2
121 - 122			1	1		2	+1
123 - 124		3	2	1		6	-2
125 - 126	1	4	10	2		17	-4
127 - 128	1	5	2	1		9	-6
129 - 130		6	2	1	1	10	-3
131 - 132		3	2	1		6	-2
133 - 134		5	2	1		8	-4
135 - 136	1	4	3			8	-6
137 - 138	2	8		1		11	-11
139 - 140	1	3	4	1		9	-4
141 - 142		2	1			3	-2
143 - 144		1				1	-1
145 - 146		1	1			2	-1
147 - 148		1				1	-1
149 - 150							
151 - 152							
153 - 154							
155 - 156			2			2	
Totals	6	51	40	10	1	108	- - -
Sum of bias	-12	-51	0	10	2		-51
	$\bar{x}$ bias = -.47 mm						

[1] Carapace length at recovery minus carapace length at release.

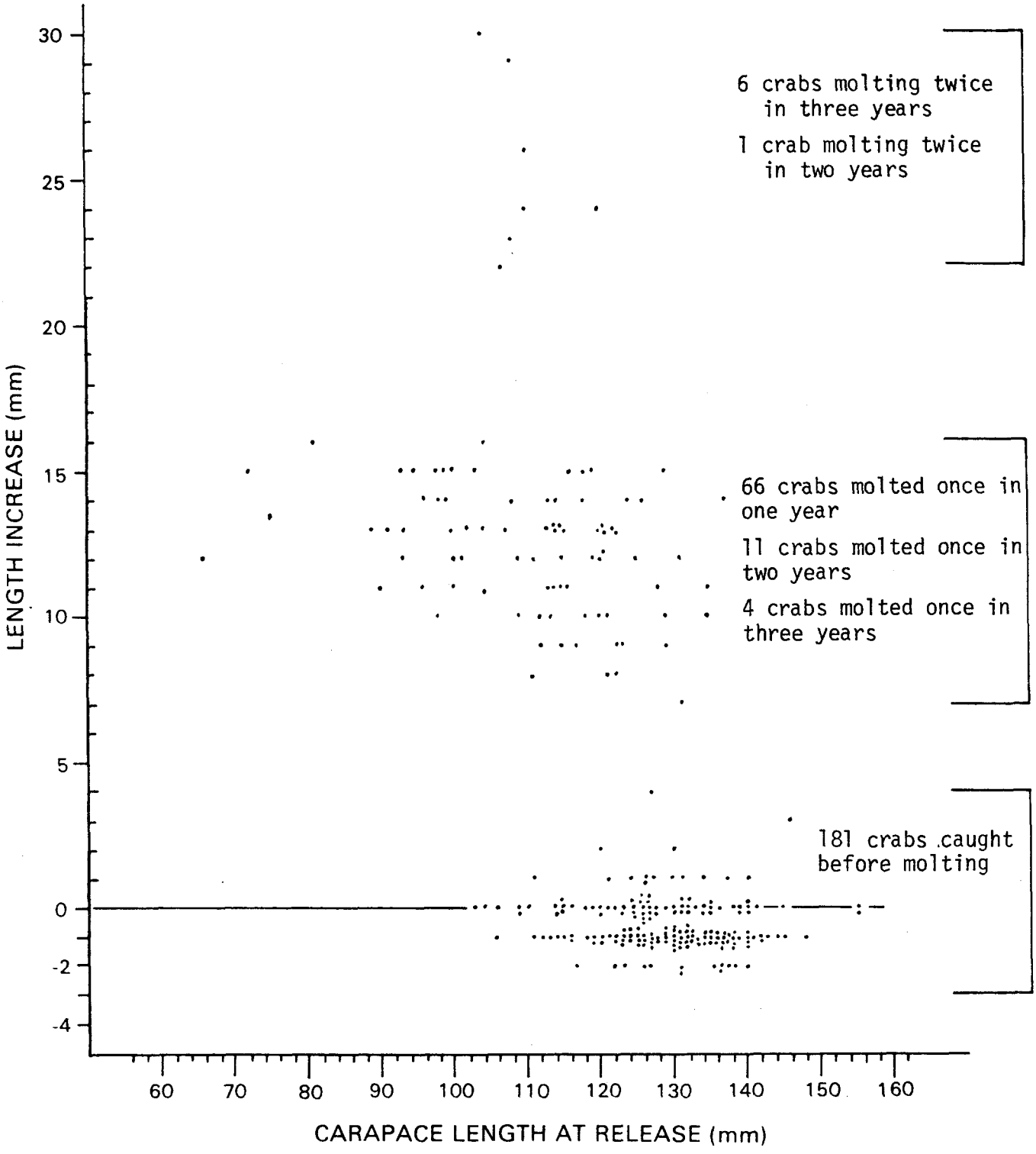

Figure 26. Increase in carapace length of 88 tagged crabs recaptured during three years following release, Norton Sound, Alaska, 1978-1981.

Carapace Size Increase:

Most (73%) of the Norton Sound growth data (64 recoveries) came from 1981 recoveries of 1980 tag releases. Average growth per molt of the 56 crabs tagged in 1980 and molting as shell-of-the-year crabs in 1981 was 12.5 mm (Table 14). The eight skipmolt crabs tagged in 1980 and molting in 1981 averaged 10.5 mm per molt, 2 mm less per molt than shell-of-the-year crabs (Table 15). Growth of skipmolts and shell-of-the-year crabs ranged from 7 to 14 and 8 to 16 mm, respectively.

Seven of the crabs tagged in 1978 molted two times before recapture 2 and 3 years later with increments (between tagging and recapture) of as great as 30 mm (Figure 26 and Table 16). Average increase per molt of these crabs regardless of shell age at release was 12.7 mm which is larger than the 10.5 and 12.5 mm increase of the 64 crabs tagged in 1980. Since four of the seven crabs molted one time as skipmolts, these data may indicate that growth is actually greater than that found for the 1980 recoveries. The 1980 average increment for shell-of-the-year crabs of 12.5 mm may be too small because several of the 56 crabs that molted may have done so as skipmolts. Sixteen crabs increased 11 mm or less, 12 of these (75%) were large crabs, i.e., larger than 108 mm (Table 14). It is possible that several of these crabs really molted as skipmolts since aging of exoskeletons in 1980 was not as accurate as in 1981.

The growth increment per molt of crab classified as shell-of-the-year appeared similar for all sizes 65 to 138 mm carapace length (Table 14). Linear regression suggested that the increment per molt may have decreased with increasing size but the scarcity of data and possible shell aging bias makes it very problematical to conclude so at this time. Similarly, linear regression analysis suggested that the growth increment per molt of skipmolt crabs was smaller than for shell-of-the-year crabs of similar size but again it was impossible to conclude so at this time for the same reasons.

Estimation of Stock Utilization

The direct estimation of stock utilization (fishing mortality) by the use of the Petersen mark-recapture method is commonly used in commercial fisheries. Assuming that a trained field staff is available to personally contact vessel captains at every delivery and to recover tagged crabs, the fraction of tagged crabs recovered in the fishery provides a useful estimate of at least the minimum portion of the population harvested. Tagged to untagged ratios obtained during the commercial season are simultaneously used to calculate total population size. This mark-recapture method was initiated in Norton Sound in 1980 when we began tagging and releasing legal male crabs. In 1980 and 1981 legal crabs were tagged in proportion to their abundance and scattered among the population so that tagged and untagged crabs had an equal chance of being captured. In addition to the constant movement of crabs and the relatively arbitrary decision by many commercial fishermen of where to set their commercial pots would tend to increase the reliability of stock utilization estimates derived from tagging.

Estimations of stock utilization are also made by comparing commercial catch to the total population estimate of legal males, particularly at times when tag and recovery programs do not exist, such as in Norton Sound from 1976 through 1979.

Table 14. Carapace length increase from one molt of 56 legal male red king crabs tagged in 1980 as shell-of-the-year crabs and recaptured one year later by the 1981 commercial fishery, Norton Sound, Alaska.

Release Length (mm)	Growth from one molt: Carapace length increment (mm) 8	9	10	11	12	13	14	15	16	Recoveries	Sum of Growth
65 - 66					1					1	12
67 - 68											
69 - 70											
71 - 72								1		1	15
73 - 74											
75 - 76											
77 - 78											
79 - 80											
81 - 82									1	1	16
83 - 84											
85 - 86											
87 - 88											
89 - 90				1		1				2	24
91 - 92						1				1	13
93 - 94					1	1		1		3	40
95 - 96				1			1	1		3	40
97 - 98			1				1	1		3	39
99 -100				1		1	1	2		5	68
101-102					2	1				3	37
103 104						1		1		2	28
105-106											
107-108						1	1			2	27
109-110			1		1					2	22
111-112											
113-114				2			1			3	36
115-116		1		1	1	2				5	58
117-118		1						1		2	24
119-120					1	3				4	51
121-122	1		1			2				4	44
123-124		2					1			3	32
125-126					1		1			2	26
127-128											
129-130			1					1		2	25
131-132											
133-134											
135-136			1							1	10
137-138							1			1	14
Totals	1	4	5	6	8	14	8	9	1	56	--
Sum of Growth	8	36	50	66	96	182	112	135	16	701	701

$\bar{x}$ growth per molt = 12.5 mm

Table 15. Carapace length increase from one molt of eight legal male king crabs tagged in 1980 as old shells (skipmolts) and recaptured one year later by the 1981 commercial fishery, Norton Sound, Alaska.

Release Length (mm)	Growth from one molt: Carapace length increment (mm)								Recoveries	Sum of Growth
	7	8	9	10	11	12	13	14		
115 - 116							1		1	13
117 - 118								1	1	14
119 - 120				1					1	10
121 - 122		1							1	8
123 - 124										
125 - 126										
127 - 128										
129 - 130			1						1	9
131 - 132	1					1			2	19
133 - 134										
135 - 136					1				1	11
Totals	1	1	1	1	1	1	1	1	8	--
Sum of growth	7	8	9	10	11	12	13	14	84	84

$\bar{x}$ growth per molt = 10.5

Table 16. Carapace length increase from two molts of seven male red king crabs tagged in 1978 and recaptured two and three years later, Norton Sound, Alaska[1].

Release length (mm)	Growth from two molts: Carapace length increments (mm)									Recoveries	Sum of growth
	22	23	24	25	26	27	28	29	30		
104 - 105									1	1	30
106 - 107	1									1	22
108 - 109		1						1		2	52
110 - 111			1		1					2	50
112 - 113											
114 - 115											
116 - 117											
118 - 119											
120 - 121			1							1	24
Totals	1	1	2		1			1	1	7	---
Sum of growth	22	23	48		26			29	30	178	178

$\bar{x}$ growth per molt = 12.7

[1] The crabs that grew 29 and 30 mm molted each time as shell-of-the-year crabs.

Accurate population estimates are necessary before reliable estimates of commercial utilization can be calculated.

A brief summary of stock utilization for each of the 5 years (1977-1981) the Norton Sound fishery existed follows. Utilization was low during the first 2 years (1977 and 1978) of the Norton Sound fishery (5% and 19%) and increased in 1979 and 1981 to 32 and 30%, respectively as effort increased (see Table 1), while at the same time the population declined from an estimated high in 1977 and 1978 of 3.7 million to 1.3 million in 1981 (Table 17). The estimates of utilization in 1977 and 1978 may be imprecise because there were no research surveys in these 2 years. Comparing population estimates from research surveys of 1976 and 1979 while simultaneously studying the 1977 and 1978 commercial fishery data, particularly size of crabs landed, enabled us to back calculate pre-season population estimates for 1977 and 1978 (Table 17). Utilization in 1979 yielded the largest commercial harvest to date of approximately 1,330 mt (2.9 million lb). Initial estimates of utilization for 1980 and 1981, using only tag and recapture data were 7% and 26%, respectively. Current best estimates for the 1980 and 1981 fishery, after considering all of the data and its limitations, were 18% and 30%, respectively (Table 17).

To explain the dramatic increase in the current utilization estimate over the initial one requires a discussion of the 1980 tag recovery data. In 1980 the season was open for 16 days with nine vessels fishing and delivering to four processors. The entire fishery was monitored by only one relatively untrained technician living aboard the catcher-processor, BILLIKEN. During the season somewhat less than 30% of the harvest was handled by the BILLIKEN. Hence, the tag recovery was marginal at best.

Post-season intensive study of all pertinent data indicated that the original 7% recovery rate of tags was a gross underestimate of the actual number of tags captured by the fishing fleet during the 1980 season. During 1980 only 37 crabs tagged in that year were returned from a commercial harvest of approximately 330,000 crabs. During the 1981 fishery 78 of the remaining 1980 tagged crabs were recaptured from a harvest of approximately 376,000 crabs. The return of over twice as many 1980 tags after a year of freedom with a similar commercial harvest indicated major under-reporting during 1980. An additional indicator of under-reporting in 1980 was the differing recovery rates for crabs released at various stations in the heart of the area commercially utilized (Figure 27). The highly variable recovery rates between stations indicated that some vessels were not turning in their tags.

Our initial 1980 legal population estimate as presented to the Alaska Board of Fisheries in the spring of 1981 of 6,350 mt (14.0 million lb) (Powell and Peterson 1981) is presently considered too high because of incomplete tag recoveries. We assumed incorrectly that the tag recovery data were complete and our fishery statistics accurate. We feel lowering the 1980 population estimate because of unreported tag recoveries is more accurate and more reasonable than assuming that unusually heavy natural mortality drove the population down to the 1981 level. Further, lack of recruitment in 1980 makes it difficult to explain how the 1980 population could increase above that of 1979 (Table 5). Our post-season intensive study of all pertinent data now yields the revised estimate of stock utilization for 1980 of 18%. Consequently, we estimate that 93 tagged crabs were actually

Table 17. Current best estimates of the legal male red king crab population, Norton Sound, Alaska.

Year	Population Estimate of Legal Males[1]		Commercial Catch	Estimates of Stock Utilization	Average Weight
	Millions		Millions of Pounds	%	Pounds
	Crab	Pounds			
1976	3.1	8.1	none	--	2.6
1977	3.7	10.0	0.5	5%	2.7
1978	3.7	11.0	2.1	19%	3.0
1979	3.0	9.0	2.9	32%	3.0
1980	1.9	6.6	1.2	18%	3.4
1981	1.3	4.7	1.4	30%	3.7
1982	0.8[2]	2.8[2]	0.2	8%	3.6

[1] Prior to commercial harvest.

[2] Estimate made a year in advance.

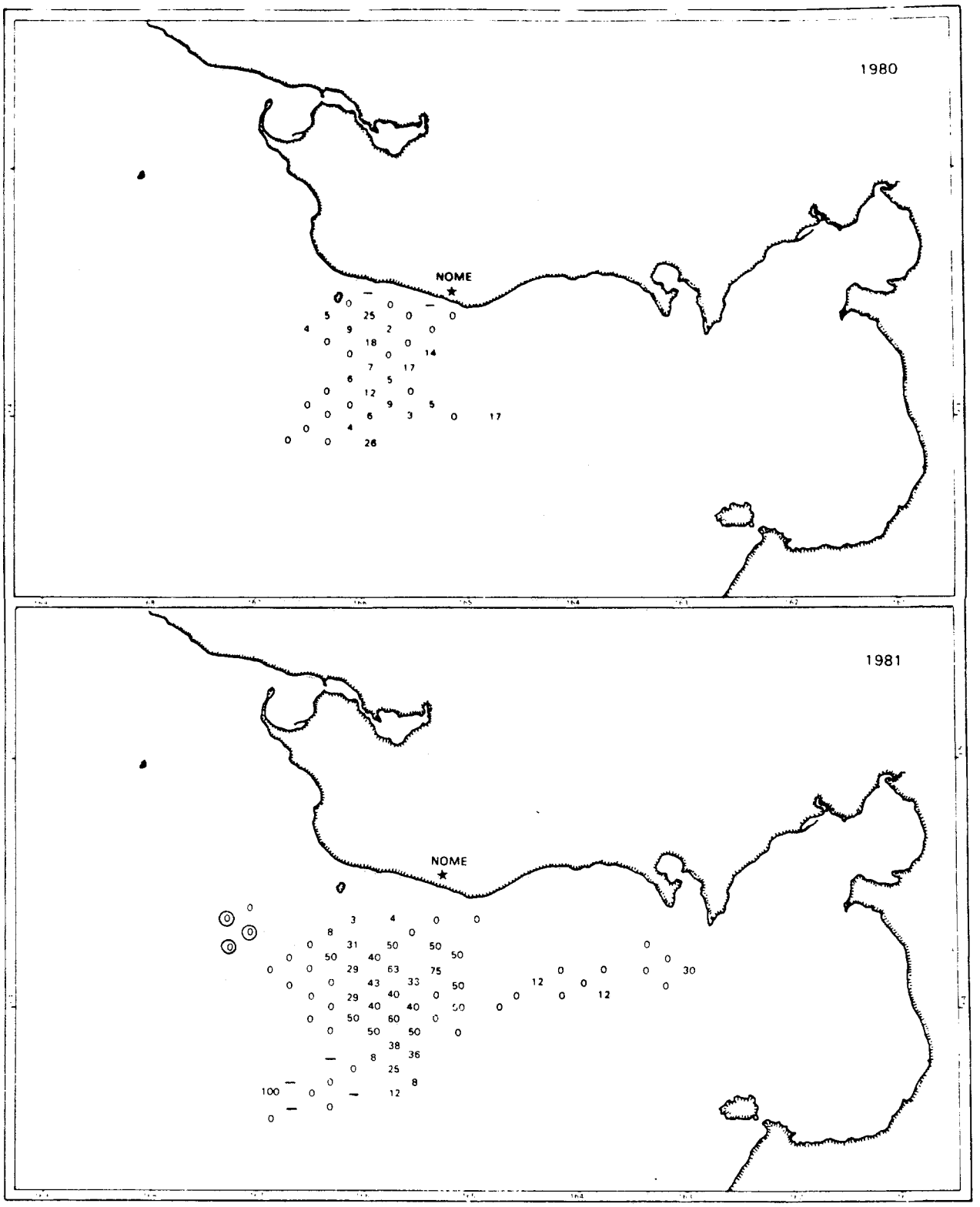

Figure 27. Fishing mortality estimates of legal male king crabs (in percent) at each station where tagging occurred, Norton Sound, Alaska, 1980 and 1981 (short dashes indicate stations where no legal crabs were captured - the 3 circles indicate stations where blue king crab were tagged).

recaptured and that 56 of them (60%) were unreported. The current estimate of the utilization of the 1980 legal male population was obtained by comparing the harvest of 538 mt (1,186,596 lb) with the adjusted total population size of 2,994 mt (6.6 million lb).

Estimating Legal Male Population

Catches from trawls are directly used in calculating population size using the area-swept technique which assumes that a known percentage of all crabs in the path of the trawls are captured; therefore, total trawl catch can be expanded by that portion of the area that was not sampled to obtain an estimate of total population size. Trawl surveys characteristically sample only a small portion of the ocean bottom (commonly 1/50 thousand), consequently 10 legal crabs captured in a research survey may represent as much as 454 mt (1.0 million lb) in the population (Powell 1960).

Catches from current ADF&G research pot fishing on the other hand are analyzed in conjunction with tag and recovery data utilizing the Petersen mark recapture technique in order to obtain estimates of population size.

Four different research surveys conducted in Norton Sound in 1976, 1979, 1980, and 1981 provided data from which estimates of the population of legal males were made. Sampling was done with trawls in 1976 and 1979 and with pots in 1980 and 1981. Useful estimates of what the population size may have been during non-survey years (1977 and 1978) were made by studying 1976 and 1979 survey data, size of crabs in the 1977 and 1978 commercial catches, and making certain assumptions about molting, growth, recruitment, and mortality.

Examining the king crab population data for Norton Sound in a time sequence from 1976 through 1982 revealed that some original estimates were either high or low (compare Tables 5 and 17). At the time original estimates were calculated discrepancies were not obvious but have been detected by further analysis.

Table 5 presents the original estimates while Table 17 presents ones modified for conformance with other supporting fisheries data. The changing population over time, obvious inconsistencies, and modified population estimates are discussed below.

The 1976 trawl survey indicated a population of approximately 3,679 mt (8,111,480 lb) of legal males (see Table 5), the majority of which were recruits, and good recruitment for 1977 (Wolotira et al. 1977). Since there was no commercial fishing in 1976 and recruitment was good in 1977 we have estimated that the population increased to perhaps 4,536 mt (10.0 million lb) by 15 July 1977 (Table 17). The 1977 fishery reduced the population by 235 mt (517,787 lb), less than gains from recruitment. Therefore, we estimated that the population was still increasing up to this point and peaked at perhaps 4,990 mt (11.0 million lb) by 15 July 1978. Table 1 shows that the 1978 fishery took 949 mt (2,091,961 lb) with recruitment declining greatly. The population is considered to have begun its decline from this point on. The 1979 survey was the only one to occur after the commercial harvest had taken place, consequently, the harvest was added to the survey estimate to obtain a comparable pre-season figure. All of the recruit size crabs captured in the 1979 survey were identified as old shells (skipmolts)

indicating that recruitment in 1979 was low. Commercial harvest in 1979 reduced the population by another 1,330 mt (2,931,672 lb). The population estimate made in 1979 from the NMFS trawl survey differs from our current estimate of the 1979 population by about 1,628 mt (3,588,277 lb). There is now general agreement that the 1979 estimate of 2,471 mt (5,443,395 lb) underestimated the population and for some reason the survey missed the crabs (see Table 5). We further propose that the commercial fishermen could not harvest 54% of the crabs (1,330 mt or 2,931,672 lb) in 2 weeks if the population were only 2,469 mt (5,443,395 lb). The average catch per pot in 1979 of 28 crabs with 35 vessels fishing, and in 1980 of 29 per pot with eight vessels fishing also suggested that the population was larger than indicated by the 1979 survey. By 15 July 1979 the population is currently considered to have been close to 4,082 mt (9.0 million lb) rather than 2,469 mt (5,443,395 lb) and by 15 July 1980 was down to 2,994 mt (6.6 million lb) rather than the 6,078 mt (13.4 million lb) calculated earlier. Inaccurate catch statistics obtained in 1980 from the industry caused erroneous assumptions to be made and contributed to the inflated 6,078 mt (13.4 million lb) estimate. The population declined another 30% to 2,132 mt (4.7 million lb) by July 1981 just prior to the commercial season, as evidenced by a decrease in the research catch per 100 pots from 85 to 40 crabs (see Figure 25). A further decline to as low as 1,361 mt (3.0 million lb) was expected to occur by July of 1982.

The 1982 population of legal size males is believed the lowest since 1976 when investigations of the population began. Average catch per pot by commercial fishermen declined from 64 to 11 over the 4-year period 1978 to 1981 (see Table 1).

Estimate of 1982 Population:

A brief but detailed explanation of the procedures used to estimate the population size of 1982 legal males is presented to aid the reader. The first of several population estimates for any particular season (1982 season in this case) is really a forecast calculated 1 year in advance. The forecast made in 1981 requires estimating what the recruitment, as well as what the carryover of surviving legal crab will be to the 1982 fishery. The following year another set of data supports a second estimate that is compared to the first. We will discuss procedures only for the first estimate, as both are quite similar. The population that remains after the 1981 fishery is calculated by determining what portion was commercially harvested. Magnitude of harvest is frequently obtained from within year tag recoveries.

During July of 1981, 507 legal male crabs were tagged and released in Norton Sound, of which 132 (26%) were soon recaptured during the 1981 commercial fishery, 7 July - 8 August. We assume that 147 (29%) tagged crabs were actually recaptured, i.e., that 10% (15 crabs) were not reported for a variety of reasons. Using the standard mark and recapture method, the exploitation rate of legal male king crab in Norton Sound in 1981 is calculated to be 29% (147 ÷ 507).

If the 1981 Norton Sound king crab harvest of 626 mt (1,379,014 lb) represented a 29% exploitation, then the total legal population prior to the 1981 fishery was 2,157 mt (4,755,221 lb). The legal population remaining after the fishery, therefore, would then be 1,531 mt (3,376,207 lb). Next we must estimate how many of these crabs will die prior to the 1982 fishery. An estimate of natural

mortality which can be applied to these crab can be obtained from the 1980 and 1981 tag releases and their subsequent recoveries. This is done by equating the 1981 recovery rate of 1981 releases to the 1981 recovery rate of 1980 survivors. The 1980 survivors here are those 1980 releases which both escaped capture during the 1980 fishery and then were not lost to natural mortality prior to the 1981 fishery. In 1980, 18% (93 tags) of the original 519 1980 tag releases were estimated to have been captured. This would leave 426 (519-93) tagged crabs at large after the 1980 fishery. The recovery rate of 1981 releases in 1981 was calculated to be 29%. Assuming this same rate for the 1980 survivors, then the 78 tags released in 1980 and recovered in 1981 would have come from 269 (78 ÷ 0.29) tags at large at the start of the 1981 fishery. These 269 survivors remaining from the original 426 tags released in 1980 and not captured in 1980 constitutes a 37% reduction which is our estimate of natural mortality. Since natural mortality of legal crabs usually increases with age and since the 1982 population will largely be comprised of postrecruits that will be 1 year older at the start of the 1982 fishery, some natural mortality factor larger than 37% should be expected, hence the assumption that natural mortality will be 40% is reasonable. Some of the crabs surviving the 1981 fishery will molt, grow, and increase in weight during 1981-82. Assuming a 10% gain in weight by the remaining legal crabs the biomass would increase to 1,011 mt (2,228,296 lb). Recruitment to the fishery must also be estimated. Based on current Norton Sound growth data, crabs between 90 - 103 mm will become legal size before the 1982 commercial fishery. The 1981 ADF&G survey estimate or prerecruit ones, i.e., male crabs between 90 and 103 mm, was 300 mt (660,229 lb). Assuming a 10% natural mortality, 270 mt (594,207 lb) should be recruited into the 1982 fishery. Adding recruitment to the survivors from postrecruit age classes gives an estimate for the 1982 Norton Sound legal king crab population of 1,270 mt (2.8 million lb).

Subsistence and Recreational Fishing

The period of ice cover in Norton Sound extends for 7 months of the year from approximately late October through mid May (Stringer 1980). During winter months red king crab are utilized by Norton Sound residents. Subsistence and recreational fishing is conducted through the ice in water depths of less than 10 fm (60 ft) using handlines, baskets , ringnets, and pots, with most, but not all, fishing occurring adjacent to village communities within 1.6 km (1 nmi) from shore (Thomas 1981). He states that stories told by elders indicate that subsistence crabbing has occurred for several generations and probably for hundreds of years. An almost total absence of data prior to 1978 and scanty data to the present time make discussions of the subsistence fishery necessarily brief. Documentation of the fishery for years 1978, 1979, and 1980 is presented by Thomas (1981).

To facilitate collections of subsistence harvest data, the Board of Fisheries enacted a regulation in 1977 requiring Norton Sound subsistence fishermen to obtain a permit prior to fishing. The regulation is not rigidly enforced, but it has results in improved harvest data.

During the winter of 1977-78, 263 Nome fishermen harvested 18,618 crabs for an average of approximately 71 crabs per fisherman for the season (Table 18). During the next 3 winters, 1978-79, 1979-80, and 1980-81, very few subsistence fishermen fished, 38, 9, and 23, respectively (Table 18). The reduced effort

Table 18. Winter commercial and subsistence red king crab catches, Nome area, Norton Sound, 1978-1981[1].

	Commercial			Subsistence Permits					
							Catch		
Winter[3]	Effort	Crab	Pounds	Issued	Returned	#Fished	Crab	Pounds	Crabs Per Household
1977-1978	37	9,625	25,193	290	206	263[2]	18,618[2]	48,408[2]	71
1978-1979	1	221	641	48	43	38	224	582	6
1979-1980	1	22	75	22	14	9	213	554	24
1980-1981	0	0	0	51	39	23	360	1,332	16
1981-1982[4]	-	-	-	104	77	54	1,203	- - -	22

1 1978-1981 represents finalized and rechecked data.

2 Catches do not represent total harvest since many people do not obtain permits. At the end of the season each permit holder is asked how many crabs they caught.

3 Extends from November through April, each winter occurs partly in two calendar years.

4 Preliminary figures 21 July 1982.

and resultant catch was attributed to unavailability of crabs. To what extent commercial fishing, or ice conditions contributed to the decline in subsistence catch is speculative. Average seasonal catch per fisherman was 6, 24, and 16 crabs per person for 1978-79, 1979-80, and 1980-81, respectively. The subsistence catch in numbers of crabs in 1981-82 was over three times greater than any of the previous 3 years even though the p9pulation of legal males was considerably smaller.

User Group Conflicts:

Commercial fishing of Norton Sound red king crabs began in 1977 and by 1981 over 3,629 mt (8.0 million lb) had been harvested. The Nome subsistence-recreational fishery reportedly declined abruptly in the 1978-79 season, increased in the winter of 1982 but did not return to earlier catch levels. The only information available was from the memories of those people that were willing to cooperate and that could remember in 1980 (the year the survey began) how many crabs they caught in their 1977-78 and earlier fishing. The outer, or Nome subsistence fishery should be impacted by the commercial fishery more than the others because it is adjacent to the commercial grounds. Conversely subsistence fisheries of the inner Sound should be less impacted because little commercial harvest occurs inside. Migrations of crabs indicate that outer Norton Sound crabs are larger and do not return to the inner Sound from which many may have earlier originated. The research completed by the Subsistence Section of the ADF&G in 1980 and 1981 was unable to determine whether or not the summer commercial fishery caused the decline in the winter Nome subsistence harvest (Thomas 1981). Regardless, the impact on the local populace from hearing that commercial fishermen from as far away as the continguous United States were harvesting crab just seaward from Nome was considerable. User group "people problems" gradually grew to serious proportions by 1980 (Appendix A, Documents 12, 13, 14, 18, 22) and lack of data helped emotional arguments to flourish (Document 18). Additionally, the amount of waste through deadloss in vessel holding tanks before processing was excessive during the initial 3 years of the fishery, 333 mt (734,847 lb, Table 1). Accumulative deadloss for the first 5 years was 333 mt (735,159 lb), over 14 times the total recent combined 4 year subsistence catch. Commercial fishing (including through-the-ice commercial fishing) by Nome residents in the subsistence fishing area, beginning January 1978, was blamed by many of the total decline in spite of the fact that other factors such as poor ice conditions and crab population redistribution probably had a major impact on subsistence fishing success. Some local residents realized, however, that success of fishing through the ice might be related to factors other than commercial fishing as witnessed by various statements: "the winter 1978-79 fishing proved extraordinarily poor due to inclement weather and poor ice conditions" (Document 12); "in April-May 1979 catch success was showing signs of improvement" (Document 12); "In 1979 and 1980 the ice was unstable (i.e., frequently moving in and out) during the winter months. This condition caused some people to wait until later in the year to undertake serious crabbing" (Thomas 1981); "Two crabbers stated that the months crabbed depended on when the crabs migrated into water near shore" (Thomas 1981); "Crabbing is better when the current is moving and poor if it is slack" (Thomas 1981); "A number of crabbers mentioned that for the last three years (1980, 1979, and 1978) the ice had been thinner than in previous years (Thomas 1981).

In 1978 after commercial fishermen harvested 953 mt (2.1 million lb), a population of 4,037 mt (8.9 million lb) of legal males still remained (Table 17). In

spite of this and the fact that females and undersize males were available to the fishery, the smallest documented Nome subsistence catch per household of six crabs (Table 18) was taken in 1978-79. It seems probable then that the decline was largely because of the unavailability of crabs resulting from a population redistribution rather than a population reduction caused by commercial fishing.

Many Norton Sound residents have insisted that the summer commercial fishery be eliminated, arguing that the fishery which has produced an average of over 454 mt (1.0 million lb) annually, should be closed to protect the Nome subsistence-recreational fishery that produces 22 mt (48,408 lb) during a good year. It seemed possible that the fishery might be managed so that the unharvested population of legal males together with female and small male populations (all legal for subsistence fishermen) could support the subsistence-recreational fishery. Clearly, the commercial fishery was reducing abundance of legal males and the impact upon subsistence fishing success might have been magnified because commercial catches were occurring close to subsistence fishing grounds. Harvesting 40% or less of the legal males more distant from subsistence fishing grounds was one possible way to reduce the impact on the subsistence fishery.

Considerable data on subsistence use and fishing success, commercial fishery exploitation rates, and crab population size had been collected by 1981. Consequently decisions were made to accommodate each user group through policies developed by the Alaska Board of Fisheries so that use of this public resource served all concerns. In April 1981 the Board placed restraints upon commercial fishing in an attempt to minimize adverse impacts upon the subsistence-recreational fishery. Approximately 15,215 km^2 (4,430 nmi^2) of the coastal area, within approximately 28 km (15 nmi) from shore (inside 64°15') including some of the most productive grounds, areas 347-41 and 346-41 (Figure 3) were closed to commercial fishing. This closure protected approximately 680 mt (1.5 million lb) of legal male crabs from harvest in 1981. Tagging within this closed zone in May and June 1981 and subsequent recoveries by the commercial fleet verified that commercial utilization of legal male crabs inhabiting this area was reduced as a result of the closure because only a portion of the crabs became vulnerable to capture by migrating into the open area (Figure 16). The subsistence harvest for the winter of 1981-82 improved over the previous season (Table 18) even though total population of legal males had declined to approximately 1,497 mt (3.3 million) lb), 4.7 minus 1.4 (see Table 17). Improved fishing may have at least partially resulted from restricting the commercial fishery to offshore waters.

Research pot fishing in May and June 1981, 4.6 to 9.3 km (2.5 to 5 nmi) south of Nome yielded 675 crabs in 16 pot lifts. All pots were small and were pulled by hand from a skiff. The average of 42 crabs per pot verified that crabs were in nearshore waters during the spring but that subsistence fishermen were unable to catch them primarily because of inadequate ice cover and the fact that most fishermen use inefficient methods compared to pots. The average catch per household for the entire season was 16 crabs (Table 18), less than the catch in one research pot. One subsistence fisherman lowering pots through the ice reported a catch of 155 crabs during March and April 1981, almost half the total reported subsistence harvest by all 23 people who reported fishing. Conceivably replacing traditional hand-line gear with small lightweight pots could increase subsistence catches considerably.

Oceanography of Norton Sound

In the interest of time no attempt was made to summarize available oceanographic data as it may pertain to king crab. The recent publication of a text on the oceanography and resources of the Eastern Bering Sea Shelf (Hood and Calder 1981) containing 37 chapters written by 53 scientists is a major accomplishment and hopefully will prove valuable to king crab researchers and managers. A cursory look at oceanographic documents suggests that satellite images may enable biologists to predict seasonal distribution of crabs and establish relationships between crab distribution and polynya and floe locations. Satellite data has been routinely collected from 1972 to the present, 3 days in a row every 18 days and occasionally every 9 days when three satellites were operational. A third NOAA weather satellite has also provided ice data, up to three times per day since 1979 but not as clearly as the other two satellites; however, neither satellite performs if cloud cover exists. A perfect opportunity exists for biologists to confer closely with oceanographers and geophysicists to determine if the various oceanographic data may serve the king crab commercial and subsistence fisheries.

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LITERATURE CITED

Alverson, D.L. and N.J. Wilimovsky. 1966. Fishery investigations of the Chukchi Sea. In N.J. Wilimovsky and J.N. Wolf (editors), Environmental of the Cape Thompson region, Alaska, pp. 843-860. U.S. Atomic Energy Com., Washington, D.C.

Burbank, D.C. 1979. Drift bottle trajectories and circulation in the N.E. Bering Sea and S.E. Chukchi Sea. Marine Coastal Habitat Management. Habitat Protection Section. Alaska Dept. of Fish and Game. 52 pp.

Eaton, M.F. 1980. United States king and Tanner crab fishery in the eastern Bering Sea. International North Pacific Fisheries Commission Document #2368. 47 pp.

Ellison, J.G., Boris Knake, and John Dassow. 1949. Report of Alaska exploratory fishing expedition to the northern Bering Sea in June and July, 1949. U.S.F.W.S. Fishery Leaflet 342, June 1949, pp. 1-25.

Ellison, J.G., Donald E. Powell, and Henry H. Hildebrand. 1960. Exploratory fishing expedition to the northern Bering Sea in June and July, 1949. U.S.F.W.S. Fishery Leaflet 369. March 1950, pp. 56.

Flemming, R.H. and D. Heggarty. 1966. Oceanography of the southeastern Chukchi Sea. In N.J. Wilimovsky and J.N. Wolf (editors) Environment of the Cape Thompson region, Alaska, pp. 697-754. U.S. Atomic Energy Commission, Washington, D.C.

Griffin, Kenneth and Paul Reusch. 1979. Westward Region shellfish report to the Alaska Board of Fisheries. April 1979, pp. 88-91.

Griffin, Kenneth, Paul Reusch, and Dan Dunaway. 1980. Westward Region shellfish report to the Alaska Board of Fisheries, March 1980, pp. 181-184.

Hood, Donald W. and John A. Calder. 1981. Editors. The eastern Bering Sea shelf oceanography and resources. Volume 1. U.S. Dept. of Commerce, NOAA, Office of Marine Pollution Assessment. 611 pp.

McNutt, Lyn. 1981. Ice conditions in the eastern Bering Sea from NOAA and landsat imagery: Winter conditions 1974, 1976, 1977, 1979. NOAA Technical Memorandum ERL PMEL-24. Pacific Marine Environmental Laboratory, Seattle, Washington. February 1981: pp. 1-179.

Muench, R.D. and K. Ahlnas. 1976. Ice movement and distribution in the Bering Sea from March to June 1974. Journal of Geophysical Research. Vol. 81, No. 24. August 20, 1976, pp. 4467-4476.

Muench, R.D., R.B. Tripp, and J.D. Clinel. 1980. Circulation and hydrography of Norton Sound. From "The Eastern Bering Sea Shelf: Oceanography and Resources." Vol. I. (D.W. Wood and J.A. Calder, Eds.). U.S. Dept. of Commerce, 1981.

Powell, Guy C. 1980. Westward Region shellfish report to the Alaska Board of Fisheries. March 1980, pp. 254-284.

Powell, Guy C., Brian Shafford, and Michael Jones. 1973. Reproductive biology of young adult king crabs *Paralithodes camtschatica* (Tilesius) at Kodiak, Alaska. National Shellfisheries Association, Vol. 63, June 1973, pp. 77-87.

Powell, Guy and Rich Peterson. 1981. Westward Region shellfish report to the Board of Fisheries, March 1981, pp. 190-201

Schwarz, Leonard. 1980. Annual management report for Norton Sound, Port Clarence, Kotzebue. ADF&G.

Stringer, William J. 1980. Nearshore ice characteristics in the eastern Bering Sea. Geophysical Institute, University of Alaska, Fairbanks, Alaska, July 1980, pp. 1-32.

Stringer, William J. 1980. The role of sea ice as a physical hazard and a pollutant transport mechanism in the Bering Sea. Geophysical Institute, University of Alaska, Fairbanks, July 1980, pp. 1-26.

Stringer, William J. and R.D. Henzler. 1981. Ice displacement vectors measured in Norton Sound and the adjacent Bering Sea, 1973-1979. Geophysical Institute, University of Alaska, Fairbanks, Alaska. March 1981, pp. 1-37.

Stringer, William J. 1981. Interaction of Bering Sea and Norton Sound pack ice. Geophysical Institute, University of Alaska. Fairbanks, Alaska. 16 pp.

Stringer, William J. 1981. Ice motion in western Norton Sound. Geophysical Institute, University of Alaska, Fairbanks, Alaska. 21 pp.

Tate, Paul, Robert Nelson, and Ronald Regnart. 1978. Westward Region shellfish report to the Alaska Board of Fisheries, April 1978, pp. 128-129 and pp. 148-150.

Thomas, Dan. 1981. Norton Sound - Bering Strait subsistence king crab fishery. Typed manuscript. Alaska Dept. of Fish and Game. Subsistence Section. 152 pp.

Wieczorek, D.H. 1977. Observer report of forage fish and crab fishing and processing operations aboard the M/V ALL ALASKAN, summer 1977. Typed manuscript. Alaska Dept. of Fish and Game. 55 pp.

Wieczorek, D.H. 1977. Comments on the temperatures and salinities encountered in Norton Sound 4 - 8 July and 14 - 20 July 1977 and their relationship to the deadloss of king crab delivered to the M/V ALL ALASKAN. Typed manuscript. Alaska Dept. Fish and Game. 17 pp.

Wolotira, R.H., Jr., T.M. Sample, and M. Morin, Jr. 1977. Demersal fish and shellfish resources of Norton Sound, the Southeastern Chukchi Sea and adjacent waters in the baseline year 1976. Northwest and Alaska Fisheries Center Report. U.S. Dept. of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. 292 pp.

APPENDICES

Appendix A. A chronological list of various documents pertaining to the Norton Sound red king crab fishery[1] [2].

Document Number	Date	Type of Document	Author	Subjects Presented
1.	9/15/67	Short report	Rae Baxter	Norton Sound shellfish investigations, 1966 and 1967.
2.	4/15/77	3 pages typed	Staff	Emergency regulations for Bering Sea Northern District.
3.	6/7/77	News Release	Kodiak Management office	Emergency regulations for red and blue king crabs, Tanner crab *(C. bairdi, C. opilio* and hybrids*)* for the Bering Sea.
4.	7/15/77	Court case documentation	Alaska Court	Case No. 77-17340 - In the Superior Court for the State of Alaska third judicial district at Kodiak. All Alaska, Inc., Elizabeth F., Inc. plaintiffs versus State of Alaska.
5.	9/15/77	6 pages typed	Jack Lechner	Prepared for the Commissioner of the Department of Fish and Game - a summary of the early fishery, regulations, and 1976 research survey.
6.	12/13/77	Memo to Jeff Haines	Fritz Kuhlman	Recommend regulation changes for winter commercial king crab fishery.
7.	1/24/78	Memo, 2 pages	Ron Regnart	Discussion of events of the 1977 Norton Sound king crab fishery.
8.	2/17/78	Memo report	Rod Kaiser	Studied 73 Norton Sound king crabs shipped to Kodiak from Nome for processing, February 1978.
9.	5/16/78	Memo to Fred Kuhlman	Ron Regnart	Norton Sound red king crab summary commercial and subsistence fisheries.
10.	6/15/78	Graph	Unknown	Measurements of 410 Norton Sound crabs caught during the commercial winter ice fishery January-April 1978.
11.	4/15/79	Plan	Martin Eaton	1979 Fishery Management Plan.
12.	5/8/79	Memo	Paul Cunningham	Early research, early commercial fishery, 1978-79 winter commercial fishery, critical review of data, management options.

(Continued)

Appendix A. A chronological list of various documents pertaining to the Norton Sound red king crab fishery[1] [2] (continued).

Document Number	Date	Type of Document	Author	Subjects Presented
13.	5/8/79	Memo to Subsistence Section	Paul Cunningham	Nome king crab fishery - Response to Kawererak's inquirty and concern re: overfishing of king crab resource in Norton Sound (Nome) section of Northern Bering Sea District.
14.	6/4/79	Letter	Martin Eaton	Sending 1979 fishery management plan to Guy Martin.
15.	6/20/79	Letter	Ronald Skoog	Possible overfishing of Norton Sound red king crab.
16.	8/79	Monthly Report	Staff	Northwest and Alaska Fisheries Center Monthly Report p. 24-25. Special crab survey in Norton Sound, Alaska.
17.	8/15/79	Monthly Report	Northwest and Alaska Fisheries Center Staff	Rationale for 1979 Federal trawl survey.
18.	8/15/79	Short report	Leonard Schwarz	Preliminary end of the fishery report 1979 Norton Sound comercial king crab fishery.
19.	8/17/79	Letter	Guy Martin	Concern for Norton Sound king crab resource.
20.	8/27/79	Letter/Report	Robert Wolotira	Comments regarding BCM-OCS Norton Sound area oil and gas lease.
21.	9/28/79	Newspaper	Unknown	1978-79 winter commercial fishery.
22.	10/4/79	Letter	Ronald Skoog	ADF&G's concern and management strategy.
23.	10/4/79	Letter	Guy Martin	Request for a copy of Fishery Conservation and Management Act of 1976.
24.	9/15/80	2 pages typed	Schwarz & Powell	Norton Sound population estimate, 1980.
25.	10/15/80	22 pages typed	Leonard Schwarz	1981 Fishery Management Plan for Norton Sound section red king crab fishery (summer fishery only), from 1980 Norton Sound-Kotzebue annual management report.

(Continued)

Appendix A. A chronological list of various documents pertaining to the Norton Sound red king crab fishery[1] [2] (continued).

Document Number	Date	Type of Document	Author	Subjects Presented
26.	1/20/81	23 pages typed	Various staff	Annual Westward Regional shellfish staff meeting report entitled, Results from the Alaska Department of Fish and Game's Westward Regional 1980 Crab Research Charters in the Kodiak, Alaska Peninsula-Chignik, Dutch Harbor, and Norton Sound Management Areas and their Catch Data for the 1980-81 Commercial King Crab Fishing Season.
27.	3/2/81	3 pages summary	Rich MacIntosh	Preliminary results of the Norton Sound trawl survey July 26-August 5, 1979.
28.	6/7/77	10 pages typed	James W. Brooks	Emergency regulations governing areas of state jurisdiction, registration, lawful limits, and Bering Sea fishing requirements.
29.	1/27/78	3 pages typed	Ronald O. Skoog	Regulations providing for a winter king crab fishery near Nome, Alaska. Alaska Board of Fisheries finding of emergency.
30.	7/12/77	Emergency Order	Jack Lechner	Emergency Order 4-S-13-77 Norton Sound.
31.	8/14/78	Emergency Order	Martin F. Eaton	Emergency Order 4-S-20-78 Norton Sound.
32.	7/24/79	Emergency Order	Jack Lechner	Emergency Order 4-S-15-79 Norton Sound.
33.	7/29/80	Emergency Order	Len Schwarz	Emergency Order 3-Z-11-80 Norton Sound.
34.	7/1/81	Emergency Order	Len Schwarz	Emergency Order 3-Z-17-81 Norton Sound.
35.	7/25/81	Emergency Order	Len Schwarz	Emergency Order 3-Z-27-81.
36.	1977	Regulations	Alaska Board of Fisheries	1977 ADF&G Statistical Area Q King Crab Fishery Regulations
37.	1978	Regulations	Same as above	1978 - Same as above.

(Continued)

Appendix A. A chronological list of various documents pertaining to the Norton Sound red king crab fishery[1] [2] (continued).

Document Number	Date	Type of Document	Author	Subjects Presented
38.	1979	Regulations	Alaska Board of Fisheries	1979 ADF&G Statistical Area Q King Crab Fishery Regulations
39.	1980	Regulations	Same as above	1980 - Same as above.
40.	1981	Regulations	Same as above	1981 - Same as above.
41.	1981	Regulations	Same as above	1981 ADF&G general provisions applicable to Norton Sound king crab fishery, Chapter 39.
42.	1981	Regulations	Same as above	1981 ADF&G statewide king crab fishery regulations applicable to Norton Sound, Chapter 34.
43.	8/82	8 typed pages	Leonard Schwarz	Procedure of ice fishing, dates fished, size, sex, and numbers of crabs caught.

[1] Information underlined is assumed.

[2] Documents 28 through 42 all pertain to regulations and emergency orders.

Appendix Table 1. List of fishing vessels, catcher-processors, and processors involved in the Norton Sound red king crab fishery, 1977-1981.

FISHING SEASON			COMMERCIAL VESSELS				
YEAR	OPEN	CLOSE	NO.	PROCESSORS	CATCHER PROCESSORS	FISHING VESSELS	ADF&G NO.
1977	JULY 6	AUG 15[1]	1	ALL ALASKAN (ANCHORED FACTORY)	NONE	ELIZABETH F	14767
			2			GOLDEN VIKING	5
			3			NORTH PACIFIC	6205
			4			PAUL TIM	6936
			5			PROGRESS	6
			6			ROYAL VIKING	3718
			7			PROVIDER	58
1978	JULY 15	SEP 3	1	ALL ALASKAN	BILLIKEN	STARLITE*	20745 39684
			2	PACIFC PEARL @ DUTCH HARBOR		LAWRENCE D*[2]	- -
			3	WHITNEY FIDALGO @ DUTCH HARBOR		AQUARIAN	38
			4			ELIZABETH F	14767
			5			GEMINI	42
			6			JUNO	6460
			7			NORTH PACIFIC	6205
			8			OCEAN SPRAY	956
			9			PACIFIC VIKING	47
			10			SHAMAN	36
			11			NORTH AMERICAN	25216
			12				

(Continued)

Appendix Table 1. List of fishing vessels, catcher-processors, and processors involved in the Norton Sound red king crab fishery, 1977-1981 (continued).

FISHING SEASON			COMMERCIAL VESSELS				
YEAR	OPEN	CLOSE	NO.	PROCESSORS	CATCHER PROCESSORS	FISHING VESSELS	ADF&G NO.
1979	JULY 15	JULY 31	1	MOKUHANA (ANCHORED FACTORY)	ALASKA ENTERPRISE	PACIFIC SUN	32728 35977
			2	PAVLOF (ANCHORED FACTORY)	BILLIKEN	NORTHWIND	20745 35733
			3	UNIVERSAL SEAFOODS DUTCH HARBOR	BOUNTIFUL	ALASKA SPIRIT	34053 35949
			4	WHITNEY FIDALGO DUTCH HARBOR	COURAGEOUS	AMERICAN BEAUTY	35833 24255
			5	PACIFIC PEARL DUTCH HARBOR		ARCTIC WIND	1112
			6	PACIFIC PEARL CAPTAINS BAY		COMMODORE	29
			7			CONSTELLATION	23131
			8			ELIZABETH F	14767
			9			ERLA N	20556
			10			GEMINI	42
			11			NEPTURE	8411
			12			NORDIC FURY	200
			13			NORTH AMERICAN	25216
			14			NORTHERN ENDEAVOR	35523
			15			NORTH PACIFIC	6205
			16			NORTH SEA	36047
			17			NORTHWESTERN	29962
			18			NORTHWIND	35733
			19			PACIFIC ANGEL	987
			20			PACIFIC APOLLO	33015
			21			PACIFIC FURY	33
			22			PACIFIC VIKING	47
			23			ROYAL ATLANTIC	46
			24			ROYAL VIKING	3718
			25			SHAMAN	36

(Continued)

Appendix Table 1. List of fishing vessels, catcher-processors, and processors involved in the Norton Sound red king crab fishery, 1977-1981 (continued).

FISHING SEASON			COMMERCIAL VESSELS				
YEAR	OPEN	CLOSE	NO.	PROCESSORS	CATCHER PROCESSORS	FISHING VESSELS	ADF&G NO.
1979	JULY 15	JULY 31	26			SILVER DOLPHIN	121
			27			U.S. DOMINATOR	8668
			28			VIKING EXPLORER	36045
			29			VIRGO	77
			30			WESTWARD WIND	32660
			31			WICKMAN COMMAND	4067
1980	JULY 15	JULY 31	1	ALASKA ENTERPRISE (ANCHORED FACTORY)	BILLIKEN	ERLA N	20745 20556
			2	NOME B VENTURES (AT NOME)	ARTIC COMMAND	WESTWARD WIND	36502 32660
			3			NORTHWEST ENTERPRISE	36808
			4			WIZARD	35265
			5			EAGER BEAVER*	28254
			6			SHISALDIN	38923
			7			STARLITE*	39684
1981	JULY 15	SEPT 3[3]	1	ALL ALASKAN (ANCHORED FACTORY)	BILLIKEN	ALASKA INVADER	20745 409L7
			2	SEA ALASKA (ANCHORED FACTORY)	BOUNTIFUL	ALEUTIAN SPRAY	34053 991
			3	ARCTIC PRODUCER (ANCHORED FACTORY	ALASKA ENTERPRISE	ALLIANCE	32728 31944
			4	JEFFRON (ANCHORED FACTORY)	NORDIC MONARCH	AQUARIAN	38549 38
			5			ARIES	38547
			6			EQUINOX	35156
			7			HAZEL LORAINE	38989
			8			JUNO	6460
			9			LADY FAME	40835
			10			LIBRA	38565

(Continued)

Appendix Table 1. List of fishing vessels, catcher-processors, and processors involved in the Norton Sound red king crab fishery, 1977-1981 (continued).

FISHING SEASON			COMMERCIAL VESSELS				
YEAR	OPEN	CLOSE	NO.	PROCESSORS	CATCHER PROCESSORS	FISHING VESSELS	ADF&G NO.
1981	JULY 15	SEPT 3[3]	11			MAR PACIFICO	23131
			12			NORTHWEST ENTERPRISE	36808
			13			OCEAN GRACE	41030
			14			PACIFIC APOLLO	33015
			15			PACIFIC INVADER	40918
			16			PACIFIC VIKING	47
			17			POLAR LADY	36822
			18			POLAR STAR	43
			19			RHONDYS	3725
			20			ROLLO	30
			21			SEA MACK	6151
			22			SEA VENTURE	8225
			23			SEA VIEW	990
			24			SHARON LORAINE	40638
			25			STARLITE	34931
			26			STORMY SEA	104
			27			VALIANT	996
			28			VIKING EXPLORER	36045
			29			VIRGO	77
			30			VITUS BERING	31792
			31			WESTWARD WIND	32660
			32			WIND RUNNER	21655
			33			STARLITE*	39684

* Small local Nome boat.

[1] Small area off Nome closed for short time by Emergency Order #4-5-13-77 (see Wieczorek) - 9/2/77, pg. 31).

[2] This captain fished a small local vessel whose name is unknown.

[3] A partial closure occurred 7/29/81 (see Emergency Order #3-2-27-81); the last delivery from Norton Sound was made 8/22/81.

Appendix Table 2. Alaska Department of Fish and Game staff assigned to monitor the Norton Sound red king crab commercial fishery, 1977-1981.

Year	Staff monitoring fishery		Quarters
	Name	Position	
1977	Bob Nelson	Biologist, Permanent	All Alaskan, floating factory-ship with side trips on F/V Elizabeth F and F/V Royal Viking
	Daniel Wieczorek	Biologist, Temporary	All Alaskan, floating Processor
1978[1]	Bob Nelson	Biologist, Permanent	Billiken, catcher processor
	John Mitchell	Technician, Temporary	Billiken, catcher processor
1979	Bob Sanderlin	Biologist, Temporary	Mokahana, floating processor
	Ken Griffin	Biologist, Permanent	Dutch Harbor ADF&G office, poor daily radio contact with vessels
1980[2]	Issac Queral	Technician, Seasonal	Billiken, catcher processor[2]
	Leonard Schwarz	Biologist, Permanent	Nome ADF&G office, daily radio contact with commercial vessels
1981	Guy Powell	Biologist, Permanent	All Alaskan, floating processor and F/V Pacific Apollo
	Becky Wetherell	Biologist, Seasonal	Bountiful, catcher processor
	Dan Bergstrom	Biologist, Seasonal	Arctic Producer, floating processor
	Mike McCormick	Technician, Seasonal	Sea Alaska, floating processor and F/V Alliance
	Leonard Schwarz	Biologist, Permanent	Nome ADF&G office, daily radio contact with commercial vessels and tank inspections.
	Andrea Meyer	Biologist, Seasonal	Nome ADF&G office, daily radio contact with commercial vessels and tank inspections

[1] The winter fishery was monitored by Fritz Kuhlmann who was stationed in Nome.

[2] Approximately one-third of total catch was processed by the Billiken.

Appendix Table 3. Commercial harvest of red king crabs from Norton Sound, Alaska by statistical area, 1981 (summer fishery only)[1].

Statisitcal Area	Landings	Different Vessels	Total Harvest		Total pots lifted	Average Crabs/Pot	Average Weight	Deadloss	
			Number	Pounds				Pounds	Number
346-41	1	1	25	98	31	1	3.9	0	0
346-51	51	27	68,793	250,387	5,404	13	3.6	0	0
346-53	12	5	16,939	61,823	1,583	11	3.6	0	0
346-54	1	1	105	399	56	2	3.8	0	0
346-61	52	28	107,638	399,662	8,708	12	3.7	0	0
347-42	2	2	94	373	91	1	4.0	0	0
347-51	59	27	104,567	383,510	9,458	11	3.7	182	48
347-52	14	8	26,112	92,026	2,212	12	3.5	0	0
347-61	33	20	38,696	141,513	4,483	9	3.7	0	0
347-62	2	2	4,975	18,734	280	18	3.8	0	0
347-71	4	4	2,645	9,167	415	6	3.5	107	31
347-81	1	1	20	77	40	<1	3.8	0	0
346-52	1	1	360	1,319	54	7	3.7	0	0
346-62	3	3	1,226	4,716	165	7	3.8	0	0
346-71	8	6	4,108	15,174	735	6	3.7	23	6
347-32	1	1	10	36	30	<1	3.6	0	0
Totals	108	36	376,313	1,379,014	33,745	11	3.7	312	85

[1] Data from Alaska Department of Fish and Game, Kodiak printout R80S, 9/29/81.

Appendix Table 4. Commercial harvest of red king crabs from Norton Sound, Alaska by statistical area, 1980 (summer fishery only).

Statistical Area	Landings	Different Vessels	Total Harvest		Total pots Lifted	Average Crabs/Pot	Average Weight	Deadloss (pounds)	Number dead crab
			Number	Pounds					
346-41	7	2	280	918	190	2	3.3	-0-	-0-
346-51	6	2	33,815	121,147	1,119	30	3.6	-0-	-0-
346-53	2	1	3,802	12,398	199	19	3.3	-0-	-0-
346-54	1	1	1,509	4,830	94	16	3.2	-0-	-0-
346-61	10	2	20,080	72,735	845	24	3.6	-0-	-0-
347-41	12	5	53,269	183,581	1,959	27	3.4	-0-	-0-
347-42	1	1	-0-	-0-	11	-0-	-0-	-0-	-0-
347-51	9	3	58,462	205,400	1,600	36	3.5	-0-	-0-
347-52	1	1	61	274	34	2	4.5	-0-	-0-
347-61	14	4	100,713	367,446	3,358	30	3.6	-0-	-0-
347-62	1	1	1,926	6,762	75	26	3.5	-0-	-0-
347-71	7	4	22,645	84,874	824	28	3.7	-0-	-0-
347-72	6	1	33,216	126,231	891	37	3.8	-0-	-0-
Totals	50	9	329,778	1,186,596	11,199	29	3.6	-0-	-0-

R80S-11S 1/28/81

Appendix Table 5. Commercial harvest of red king crabs from Norton Sound, Alaska by statistical area, 1979 (summer fishery only).

Statistical Area	Landings	Different Vessels	Total Harvest		Total pots Lifted	Average Crabs/Pot	Average Weight	Deadloss (pounds)	Number dead crab
			Number	Pounds					
346-41	3	3	100,689	288,869	1,740	58	2.9	201,013	71,790
346-51	6	6	45,704	138,011	1,683	27	3.0	13,309	4,740
346-52	5	3	50,316	155,972	1,271	40	3.1	2,016	679
346-61	11	11	100,931	323,518	2,530	40	3.2	9,501	2,998
346-71	4	4	48,141	161,699	673	72	3.4	2,826	797
347-31	7	7	53,000	146,029	2,544	21	2.8	2,254	855
347-41	22	20	194,172	534,938	8,336	23	2.8	163,262	59,081
347-42	3	3	4,146	12,309	432	10	3.0	-0-	-0-
347-51	23	23	160,136	486,947	7,464	21	3.0	18,531	6,454
347-52	4	4	10,767	33,856	642	17	3.1	97	30
347-61	19	14	160,134	505,050	5,635	28	3.2	11,639	3,463
347-62	4	3	24,665	81,798	1,034	24	3.3	2,301	694
347-63	1	1	660	1,860	108	6	2.8	-0-	-0-
347-71	3	3	17,501	60,816	681	26	3.5	925	266
Totals	76	34	970,962	2,931,672	34,773	28	3.0	427,674	151,847

R51-11S -2020A dated 10/11/79
R52-11S -2020A dated 10/12/79

Appendix Table 6. Commercial harvest of red king crabs from Norton Sound, Alaska by statistical area, 1978 (summer fishery only).

Statistical Area	Landings	Different Vessels	Total Harvest		Total pots Lifted	Average Crabs/Pot	Average Weight	Deadloss (pounds)	Number dead crab
			Number	Pounds					
346-41	6	4	31,447	90,187	537	58	2.9	14,000	4,844
347-41	15	5	172,572	515,778	3,844	44	2.9	50,503	18,417
347-42	1	1	1,258	3,811	30	41	3.0	-0-	-0-
347-51	4	2	58,120	179,212	551	105	3.0	160	50
347-52	17	8	217,686	667,130	3,662	59	3.0	23,325	7,868
347-61	5	3	115,910	353,016	1,230	94	3.0	30	10
347-62	2	2	17,131	51,304	190	90	2.9	3,000	1,100
347-71	2	1	52,372	162,795	420	124	3.1	3,700	1,134
347-72	1	1	4,442	13,238	53	83	2.9	-0-	-0-
347-81	1	1	19,472	55,490	300	65	2.8	280	100
Totals	54	8	690,410	2,091,961	10,817	64	3.0	95,025	33,523

3/3/79) R21-11S-2020
) R26-11S-2020

Appendix Table 7. Commercial harvest of red king crabs from Norton Sound, Alaska by statistical area, 1977 (summer fishery only).

Statistical Area	Landings	Different Vessels	Total Harvest		Total pots Lifted	Average Crabs/Pot	Average Weight	Deadloss (pounds)	Number dead crab
			Number	Pounds					
346-41	10	5	117,359	306,302	3,386	34	2.6	109,802	42,584
346-42	3	3	31,017	80,969	769	40	2.6	5,727	2,198
346-44	2	2	13,785	38,995	253	54	2.8	31,927	11,267
346-54	1	1	12,050	31,572	440	27	2.6	20,960	8,000
346-64	1	1	14,042	40,020	350	40	2.8	33,533	11,766
346-65	1	1	3,013	7,893	110	27	2.6	5,240	2,000
347-41	1	1	4,611	12,036	149	30	2.6	4,959	1,900
Totals	13	7	195,877	517,787	5,457	36	2.7	212,148	79,715

R55-11S -2020 7/30/78
R52-11S -2020A 10/26/77

Appendix Table 8. Proportion of male red king crabs that are legal size as related to carapace length, Norton Sound charter data, 1980[1].

Carapace Length (mm)	Sublegals			Legals[2]			Percent Sublegals	Percent Legals
	New shell	Old shell	Very Old shell	New shell	Old shell	Very Old shell		
90	8	0	0	0	0	0	100	0
91	8	0	0	0	0	0	100	0
92	10	0	0	0	0	0	100	0
93	15	0	0	0	0	0	100	0
94	6	0	0	0	0	0	100	0
95	11	0	0	0	0	0	100	0
96	11	0	0	0	0	0	100	0
97	12	0	0	0	0	0	100	0
98	16	1	0	0	0	0	100	0
99	17	0	0	0	0	0	100	0
100	22	0	0	4	0	0	85	15
101	11	0	0	7	0	0	61	39
102	9	0	0	14	0	0	39	61
103	3	0	0	18	0	0	14	86
104	7	0	0	12	0	0	40	60
105	1	0	0	16	1	0	6	94
106	0	0	0	29	2	0	0	100
107	0	0	0	30	1	0	0	100
108	0	0	0	34	0	0	0	100
109	0	0	0	31	2	0	0	100
110	0	0	0	35	1	0	0	100
111	0	0	0	39	8	0	0	100
112	0	0	0	54	7	0	0	100
113	0	0	0	59	4	0	0	100
114	0	0	0	45	5	0	0	100
115	0	0	0	77	10	0	0	100
116	0	0	0	67	17	0	0	100
117	0	0	0	67	13	0	0	100
118	0	0	0	78	19	0	0	100
119	0	0	0	88	15	0	0	100
120	0	0	0	95	32	0	0	100
121	0	0	0	77	23	0	0	100
122	0	0	0	106	27	0	0	100
123	0	0	0	127	22	0	0	100
124	0	0	0	111	21	0	0	100
125	0	0	0	106	16	0	0	100
126	0	0	0	133	22	0	0	100
127	0	0	0	130	16	0	0	100
128	0	0	0	116	21	0	0	100
129	0	0	0	109	14	0	0	100
130	0	0	0	127	20	0	0	100
131	0	0	0	106	12	0	0	100
132	0	0	0	90	14	0	0	100
133	0	0	0	99	8	0	0	100
134	0	0	0	81	12	0	0	100
135	0	0	0	89	15	0	0	100

(Continued)

Appendix Table 8. Proportion of male red king crabs that are legal size as related to carapace length, Norton Sound charter data, 1980[1] (continued).

Carapace Length (mm)	Sublegals			Legals[2]			Percent Sublegals	Percent Legals
	New shell	Old shell	Very Old shell	New shell	Old shell	Very Old shell		
136	0	0	0	68	6	0	0	100
137	0	0	0	64	9	0	0	100
138	0	0	0	48	7	0	0	100
139	0	0	0	20	3	0	0	100
140	0	0	0	28	4	0	0	100
141	0	0	0	27	4	0	0	100
142	0	0	0	21	1	0	0	100
143	0	0	0	29	1	0	0	100
144	0	0	0	12	0	0	0	100
145	0	0	0	11	0	0	0	100
146	0	0	0	12	0	0	0	100
147	0	0	0	7	0	0	0	100
148	0	0	0	2	0	0	0	100
149	0	0	0	3	0	0	0	100
150	0	0	0	1	1	0	0	100
151	0	0	0	1	0	0	0	100
152	0	0	0	0	0	0	0	0
153	0	0	0	0	0	0	0	0
154	0	0	0	0	0	0	0	0
155	0	0	0	1	0	0	0	100
156	0	0	0	0	0	0	0	0
157	0	0	0	0	0	0	0	0
158	0	0	0	0	0	0	0	0
159	0	0	0	1	0	0	0	100
160	0	0	0	1	0	0	0	100
161	0	0	0	0	0	0	0	0
162	0	0	0	0	0	0	0	0
163	0	0	0	0	0	0	0	0
164	0	0	0	0	0	0	0	0
165	0	0	0	1	0	0	0	100
166	0	0	0	0	0	0	0	0
167	0	0	0	0	0	0	0	0
168	0	0	0	0	0	0	0	0
	434	2	0	2,854	436	0	12	88
		436		3,290				

[1] Accuracy of aging exoskeletons is limited. Crabs smaller than 90 mm and larger than 168 mm are omitted from this table because they were excluded by the computer program that produced this table.

[2] A legal size male is one that measures 121 mm (4.75 in) or larger in carapace width outside the spine.

Appendix Table 9. Proportion of male red king crabs that are legal size as related to carapace length, Norton Sound charter data, 1981[1].

Carapace Length (mm)	SUBLEGALS			LEGALS[2]			Percent Sublegals	Percent legals
	New-shell	Old-shell	Very old-shell	New-shell	Old-shell	Very old-shell		
90	69	0	0	0	0	0	100	0
91	52	0	0	0	0	0	100	0
92	65	0	0	0	0	0	100	0
93	32	0	0	0	0	0	100	0
94	41	0	0	0	0	0	100	0
95	44	1	0	0	0	0	100	0
96	23	0	0	0	0	0	100	0
97	20	0	0	0	0	0	100	0
98	21	0	0	0	0	0	100	0
99	26	0	0	0	0	0	100	0
100	24	0	0	0	0	0	100	0
101	23	1	0	2	0	0	92	8
102	20	2	0	9	0	0	71	29
103	14	0	0	7	0	0	67	33
104	9	0	0	18	2	0	31	69
105	3	0	0	27	0	0	10	90
106	1	1	0	23	0	0	8	92
107	0	0	0	39	2	0	0	100
108	0	0	0	24	2	0	0	100
109	0	0	0	40	3	0	0	100
110	0	0	0	35	1	0	0	100
111	0	0	0	30	5	0	0	100
112	0	0	0	47	5	0	0	100
113	0	0	0	36	4	0	0	100
114	0	0	0	34	4	0	0	100
115	0	0	0	38	9	0	0	100
116	0	0	0	34	9	0	0	100
117	0	0	0	34	10	0	0	100
118	0	0	0	31	12	0	0	100
119	0	0	0	39	18	0	0	100
120	0	0	0	59	23	0	0	100
121	0	0	0	53	17	0	0	100
122	0	0	0	71	38	0	0	100
123	0	0	0	50	38	0	0	100
124	0	0	0	65	41	0	0	100
125	0	0	0	72	28	0	0	100
126	0	0	0	74	35	0	0	100
127	0	0	0	75	41	0	0	100
128	0	0	0	68	47	0	0	100
129	0	0	0	60	34	0	0	100
130	0	0	0	73	38	0	0	100
131	0	0	0	73	38	0	0	100
132	0	0	0	72	27	0	0	100
133	0	0	0	62	29	0	0	100
134	0	0	0	66	22	0	0	100
135	0	0	0	60	37	0	0	100
136	0	0	0	61	17	0	0	100

(Continued)

Appendix Table 9. Proportion of male red king crabs that are legal size as related to carapace length, Norton Sound charter data, 1981[1] (continued).

Carapace Length (mm)	SUBLEGALS New-shell	SUBLEGALS Old-shell	SUBLEGALS Very old-shell	LEGALS[2] New-shell	LEGALS[2] Old-shell	LEGALS[2] Very old-shell	Percent Sublegals	Percent legals
137	0	0	0	64	13	0	0	100
138	0	0	0	55	15	0	0	100
139	0	0	0	41	14	0	0	100
140	0	0	0	43	7	0	0	100
141	0	0	0	39	8	0	0	100
142	0	0	0	29	11	0	0	100
143	0	0	0	22	11	0	0	100
144	0	0	0	22	1	0	0	100
145	0	0	0	11	5	0	0	100
146	0	0	0	12	1	0	0	100
147	0	0	0	11	5	0	0	100
148	0	0	0	9	4	0	0	100
149	0	0	0	3	2	0	0	100
150	0	0	0	1	0	0	0	100
151	0	0	0	2	0	0	0	100
152	0	0	0	2	2	0	0	100
153	0	0	0	2	1	0	0	100
154	0	0	0	1	0	0	0	100
155	0	0	0	2	1	0	0	100
156	0	0	0	1	0	0	0	100
157	0	0	0	0	1	0	0	100
158	0	0	0	1	0	0	0	100
159	0	0	0	0	0	0	0	0
160	0	0	0	1	0	0	0	100
161	0	0	0	1	0	0	0	100
162	0	0	0	0	0	0	0	0
163	0	0	0	0	0	0	0	0
164	0	0	0	0	0	0	0	0
165	0	0	0	1	0	0	0	100
166	0	0	0	0	0	0	0	0
167	0	0	0	1	0	0	0	100
168	0	0	0	0	1	0	0	100
Totals	2,371	6	0	2,038	740	0	46	54
	2,377			2,778				

[1] Some of the oldshell crabs were recorded as newshells, particularly during the early portion of the 1981 population study. For convenience, the crabs smaller than 90 mm and larger than 168 mm are omitted from this table.

[2] A legal size male is one that measures 121 mm (4.75 in) or larger in carapace width outside the spines.

Appendix Table 10. Proportion of adult female red king crabs within 2 mm size groups with various size egg clutches, Norton Sound, 1980.

Carapace length (mm)	Relative size of egg clutch in percent: < 29 Very small clutches %	No.	30-59 Small clutches %	No.	60-89 Moderate size clutches %	No.	90-100 Full clutches %	No.	Total No.	Cumulative Total No.
59-60	0	0	0	0	100	1	0	0	1	1
61-62	67	2	0	0	33	1	0	0	3	4
63-64	29	2	0	0	14	1	57	4	7	11
65-66	8	1	25	3	50	6	17	2	12	23
67-68	0	0	0	0	57	4	43	3	7	30
69-70	19	4	14	3	43	9	24	5	21	51
71-72	0	0	8	2	38	9	54	13	24	75
73-74	0	0	7	1	36	5	57	8	14	89
75-76	7	1	7	1	21	3	64	9	14	103
77-78	12	1	0	0	12	1	75	6	8	111
79-80	0	0	0	0	40	2	60	3	5	116
81-82	0	0	0	0	0	0	100	2	2	118
83-84	0	0	0	0	33	1	67	2	3	121
85-86	0	0	0	0	0	0	0	0	0	121
87-88	0	0	0	0	0	0	0	0	0	121
89-90	0	0	0	0	100	1	0	0	1	122
91-92	0	0	0	0	0	0	0	0	0	122
93-94	0	0	0	0	0	0	0	0	0	122
95-96	0	0	0	0	0	0	0	0	0	122
97-98	0	0	0	0	0	0	100	1	1	123
99-100	0	0	0	0	0	0	0	0	0	123
101-102	0	0	0	0	0	0	0	0	0	123
103-104	0	0	0	0	0	0	100	2	2	125
105-106	0	0	0	0	0	0	100	1	1	126
107-108	0	0	33	1	0	0	67	2	3	129
Totals	9	11	9	11	34	44	49	63	129	129

Appendix Table 11. Proportion of adult female red king crabs within 2 mm size groups with various size egg clutches, Norton Sound, 1981.

Carapace length (mm)	Relative size of egg clutch in percent: < 29 Very small clutches %	No.	30-59 Small clutches %	No.	60-89 Moderate size clutches %	No.	90-100 Full clutches %	No.	Total No.	Cumulative Total No.
59-60	0	0	0	0	0	0	100	2	2	2
61-62	0	0	0	0	0	0	100	3	3	5
63-64	11	2	6	1	0	0	83	15	18	23
65-66	16	5	6	2	16	5	61	19	31	54
67-68	7	5	8	6	19	14	67	50	75	129
69-70	12	13	6	6	8	8	74	78	105	234
71-72	6	7	5	5	6	6	83	91	109	343
73-74	6	10	4	7	7	11	83	133	161	504
75-76	5	7	1	1	5	7	90	130	145	649
77-78	3	6	1	1	3	6	92	159	172	821
79-80	4	6	3	5	7	11	87	145	167	988
81-82	3	5	3	4	4	6	90	130	145	1,133
83-84	4	4	3	3	5	5	88	86	98	1,231
85-86	0	0	3	2	8	5	88	53	60	1,291
87-88	2	1	0	0	9	4	89	41	46	1,337
89-90	0	0	0	0	12	2	88	14	16	1,353
91-92	6	1	6	1	18	3	71	12	17	1,370
93-94	0	0	0	0	7	1	93	14	15	1,385
95-96	0	0	0	0	38	6	62	10	16	1,401
97-98	5	1	0	0	15	3	80	16	20	1,421
99-100	6	1	0	0	12	2	81	13	16	1,437
101-102	0	0	0	0	25	3	75	9	12	1,449
103-104	3	1	0	0	16	5	81	25	31	1,480
105-106	0	0	0	0	33	5	67	10	15	1,495
107-108	6	1	11	2	28	5	56	10	18	1,513
109-110	0	0	0	0	43	3	57	4	7	1,520
111-112	0	0	0	0	33	3	67	6	9	1,529
113-114	0	0	0	0	0	0	100	3	3	1,532
115-116	0	0	0	0	50	1	50	1	2	1,534
117-118	0	0	0	0	0	0	0	0	0	1,534
119-120	0	0	0	0	100	1	0	0	1	1,535
Totals	5	76	3	46	9	131	84	1,282	1,535	1,535

Appendix Table 12. Tagging summary, legal male king crabs released near shore from a Boston whaler skiff, Norton Sound, Alaska, 1981.

VESSEL Skiff TAGGER Nelson and Schwarz RECORDER Thomas/Nelson/Schwarz/Rose MEASURER Nelson/Schwarz/Thomas

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
301	315	5 miles south NOME	15	5/28/81	15
316	339	5 miles south NOME	24	5/31/81	39
350	388	5 miles south NOME	39	6/2/81	78
389	397	2.5 mi. south NOME	9	6/5/81	87
398	423	5 miles south NOME	26	6/5/81	113
424	425	2.5 mi. south NOME	2	6/8/81	115
426	426	5 miles south NOME	1	6/5/81	116
427	429	2.5 mi. south NOME	3	6/8/81	119
430	430	5 miles south NOME	1	6/5/81	120
431	432	2.5 mi. south NOME	2	6/8/81	122
433	436	5 miles south NOME	4	6/5/81	126
437	437	2.5 mi. south NOME	1	6/8/81	127
438	438	5 miles south NOME	1	6/5/81	128
439	439	2.5 mi. south NOME	1	6/8/81	129
440	442	5 miles south NOME	3	6/5/81	132
443	443	2.5 mi. south NOME	1	6/8/81	133
444	447	5 miles south NOME	4	6/5/81	137
448	448	2.5 mi. south NOME	1	6/8/81	138
449	449	5 miles south NOME	1	6/5/81	139
450	451	2.5 mi. south NOME	2	6/8/81	141
452	494	5 miles south NOME	43	6/8/81	184
495	500	5 miles south NOME	6	6/12/81	190

(Continued)

Appendix Table 12. Tagging summary, legal male king crabs release near shore from a Boston whaler skiff, Norton Sound, Alaska, 1981 (continued).

VESSEL Skiff TAGGER Nelson and Schwarz RECORDER Thomas/Nelson/Schwarz/Rose MEASURER Nelson/Schwarz/Thomas

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
501	516	5 miles south NOME	16	6/21/81	206
518	527	5 miles south NOME	10	6/21/81	216
			216		

[1] Ring tags were used, they consisted of a yellow oval disc with two lengths of spaghetti plastic tubing (one red and one yellow). Legends on the disc include: tag number on one side, and, leave tag on crab, ADF&G, Reward - $3-KD on other side. Tag number also on yellow tube under clear plastic sleeve.

Appendix Table 13. Tagging summary, legal male king crabs, Norton Sound, Alaska, 1980[1].

VESSEL ALTAIR #3 TAGGER Powell RECORDER Haskins MEASURER Powell

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
0000	0001	418	2	7/5/80	2
0002	0021	469	20	7/5/80	22
0022	0034	444	13	7/5/80	35
0035	0040	443	6	7/6/80	41
0041	0059	468	19	7/6/80	60
0060	0081	500	22	7/6/80	82
0082	0100	522	19	7/6/80	101
0101	0110	618	10	7/7/80	111
0111	0116	596	6	7/7/80	117
0117	0142	561	26	7/7/80	143
0143	0184	521	42	7/7/80	185
0185	0197	499	13	7/8/80	198
0198	0216	467	19	7/8/80	217
0217	0231	498	15	7/8/80	232
0232	0260	520	29	7/8/80	261
0261	0294	540	34	7/9/80	295
0295	0307	560	13	7/9/80	308
0308	0313	578	6	7/9/80	314
0314	0329	541	16	7/9/80	330
0330	0333	559	4	7/10/80	334
0334	0338	576	5	7/10/80	339
0339	0347	558	9	7/10/80	348

(Continued)

Appendix Table 13. Tagging summary, legal male crabs, Norton Sound, Alaska, 1980[1] (continued).

VESSEL ALTAIR #3 TAGGER Powell RECORDER Haskins MEASURER Powell

Tag Numbers Lowest	Tag Numbers Highest	Station	Number Tagged	Date Released	Cumulative Total Released
0348	0368	538	21	7/10/80	369
0369	0370	557	2	7/11/80	371
0371	0372	575	2	7/11/80	373
0373	0373	592	1	7/11/80	374
0374	0383	518	10	7/12/80	384
0384	0390	497	7	7/12/80	391
0391	0403	519	13	7/12/80	404
0404	0410	539	7	7/12/80	411
0411	0455	496	45	7/13/80	456
0456	0473	465	18	7/13/80	474
0474	0489	440	16	7/13/80	490
0490	0501	464	12	7/13/80	502
0502	0504	495	3	7/14/80	505
0505	0517	517	13	7/14/80	518
0518	0518	537	1	7/14/80	519
			519		

[1] Ring tags were used, they consisted of a yellow oval disc with two lengths of spaghetti plastic tubing (one red and one yellow). Legends on the disc include: tag number on one side, and, Leave tag on crab, ADF&G, Reward - $3-AE on other side.

Appendix Table 14. Tagging summary sublegal male king crabs, Norton Sound, Alaska, 1980[1].

VESSEL ALTAIR #3 TAGGER Powell and Eaton RECORDER Haskins MEASURER Powell

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
2639	2651	618	13	7/7/80	13
2652	2655	596	4	7/7/80	17
2656	2661	561	6	7/7/80	23
2662	2670	521	9	7/7/80	32
2671	2675	499	5	7/8/80	37
2676	2679	467	4	7/8/80	41
2680	2681	498	2	7/8/80	43
2682	2686	520	5	7/8/80	48
2687	2695	540	9	7/9/80	57
2696	2699	560	4	7/9/80	61
2700	2714	578	15	7/9/80	76
2715	2721	541	7	7/9/80	83
2722	2723	559	2	7/10/80	85
2724	2725	576	2	7/10/80	87
2726	2734	558	9	7/10/80	96
2735	2757	538	23	7/10/80	119
2758	2758	557	1	7/11/80	120
2759	2759	518	1	7/13/80	121
2760	2760	497	1	7/12/80	122
2761	2764	539	4	7/12/80	126
2765	2774	496	10	7/13/80	136
2775	2784	440	10	7/13/80	146

(Continued)

Appendix Table 14. Tagging summary sublegal male king crabs, Norton Sound, Alaska, 1980[1] (continued).

VESSEL ALTAIR #3 TAGGER Powell and Eaton RECORDER Haskins MEASURER Powell

Tag Numbers Lowest	Tag Numbers Highest	Station	Number Tagged	Date Released	Cumulative Total Released
2785	2791	464	7	7/13/80	153
2792	2796	495	5	7/14/80	158
2797	2799	517	3	7/14/80	161
			161		

[1] Ring tags were used, they consisted of a yellow oval disc with two lengths of spaghetti plastic tubing (one red and one yellow). Legends on the disc include: tag number on one side, and, Leave tag on crab, ADF&G, Reward - $3-DD on other side. Tag number also on yellow tube under clear plastic sleeve.

Appendix Table 15. Tagging summary legal male king crabs, Norton Sound, Alaska, 1981[1].

VESSEL ALTAIRE TAGGER Powell RECORDER Wetherell MEASURER Powell

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
1	8	539	8	6/29/81	8
9	40	497	32	6/29/81	40
41	53	465	13	6/29/81	53
54	116	496	63	6/29/81	116
117	139	538	23	6/29/81	139
140	141	466	2	6/30/81	141
142	148	498	7	6/30/81	148
149	163	519	15	6/30/81	163
164	167	577	4	7/1/81	167
168	175	595	8	7/1/81	175
176	176	578	1	7/1/81	176
177	178	596	2	7/1/81	178
179	193	542	15	7/2/81	193
194	198	561	5	7/2/81	198
199	218	541	20	7/2/81	218
219	221	560	3	7/2/81	221
222	240	540	19	7/2/81	240
241	261	520	21	7/3/81	261
262	268	499	7	7/3/81	268
269	293	521	25	7/3/81	293
294	297	500	4	7/3/81	297
298	298	469	1	7/4/81	298

(Continued)

Appendix Table 15. Tagging summary legal male king crabs, Norton Sound, Alaska, 1981[1] (continued).

VESSEL ALTAIRE TAGGER Powell RECORDER Wetherell MEASURER Powell

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
299	299	444	1	7/4/81	299
300	300	468	1	7/4/81	300
301	301	443	1	7/4/81	301
302	303	467	2	7/4/81	303
304	304	442	1	7/5/81	304
305	306	441	2	7/5/81	306
307	307	415	1	7/5/81	307
308	308	386	1	7/5/81	308
309	309	416	1	7/5/81	309
310	311	323	2	7/6/81	311
312	313	355	2	7/6/81	313
314	314	322	1	7/6/81	314
315	315	354	1	7/6/81	315
316	316	391	1	7/7/81	316
317	318	392	2	7/7/81	318
319	319	447	1	7/7/81	319
320	320	481	1	7/8/81	320
321	321	480	1	7/8/81	321
322	322	502	1	7/8/81	322
323	340	522	18	7/9/81	340
341	369	543	29	7/9/81	369
370	377	562	8	7/9/81	377

(Continued)

Appendix Table 15. Tagging summary legal male king crabs, Norton Sound, Alaska, 1981[1] (continued).

VESSEL ALTAIRE TAGGER Powell RECORDER Wetherell MEASURER Powell

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
378	380	579	3	7/9/81	380
381	381	597	1	7/9/81	381
382	395	563	14	7/10/81	395
396	407	564	12	7/10/81	407
408	415	545	8	7/10/81	415
416	423	544	8	7/10/81	423
424	435	523	12	7/10/81	435
436	437	576	2	7/11/81	437
438	439	594	2	7/11/81	439
440	443	618	4	7/11/81	443
444	447	627	4	7/11/81	447
448	455	637	8	7/11/81	455
456	462	646	7	7/12/81	462
463	463	647	1	7/12/81	463
464	469	657	6	7/12/81	469
470	477	667	8	7/12/81	477
478	478	666	1	7/12/81	478
479	479	687	1	7/13/81	479
480	487	696	8	7/13/81	487
488	497	705	10	7/13/81	497
498	498	695	1	7/13/81	498
499	499	686	1	7/13/81	499

(Continued)

Appendix Table 15. Tagging summary legal male king crabs, Norton Sound, Alaska, 1981[1] (continued).

VESSEL ALTAIRE TAGGER Powell RECORDER Wetherell MEASURER Powell

Tag Numbers		Station	Number Tagged	Date Released	Cumulative Total Released
Lowest	Highest				
500	502	605	3	7/14/81	502
503	503	558	1	7/14/81	503
504	507	575	4	7/14/81	507
			507		

[1] Ring tags were used, they consisted of a yellow oval disc with two lengths of spaghetti plastic tubing (one red and one yellow). Legends on the disc include: tag number on one side, and, Leave tag on crab, ADF&G, Reward - $3- CF on other side.

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