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A SURVEY OF PACIFIC WEATHERVANE SCALLOPS (Pecten caurinus) IN KAMISHAK BAY, ALASKA

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABSTRACT

A weathervane scallop *(Pecten caurinus)* bed in Kamishak Bay, Alaska was surveyed. Total estimated live weight for the 192 km² area surveyed was 940,000 kg, and the survey estimate of 879,385 kg for the area of heaviest scallop concentration differed from that derived from the commercial fishery by only 1.0%. Juveniles did not appear to disperse widely but rather were found in numbers proportional to those of adults. Growth as determined from shell heights decreased with age, occurring at three distinct rates from 0-3 years, 4-7 years, and 8 years and older. Age versus average live weight and average meat weight indicated a more linear growth rate for adults. Gonads were examined for identification of sex, but discriminating features could not be discerned at the time the survey was conducted. The majority of incidentally caught animals was small (5-8 cm) Tanner crab *(Chionoecetes bairdi)* with a mortality rate of approximately 8%. The low mortality was due almost entirely to careful on-deck gear handling.

KEY WORDS: Pacific weathervane scallop, *Pecten caurinus*, Kamishak Bay, survey of abundance, biomass, age class structure, meat recovery, incidental catch.

INTRODUCTION

Although interest in a Pacific weathervane scallop *(Pecten caurinus)* fishery has periodically been expressed by fishermen in Lower Cook Inlet, little was known about the resource prior to this study. A directive to the Alaska Department of Fish and Game by the Board of Fisheries in 1983 to allow a restricted scallop fishery in Lower Cook Inlet prompted the Department to develop a scallop assessment program. This report summarizes the results of a research survey on the Pacific weathervane scallop conducted in the Kamishak District of Lower Cook Inlet, 22-29 August 1984 (Figure 1).

Statewide exploratory fishing for weathervane scallops dates back to 1956, and although beds of scallops were located off Yakutat and Kodiak Island, industry paid little attention primarily because few vessels at that time had either the adequate power or proper gear to fish scallops. In 1968 and 1969, the Department chartered the F/V VIKING QUEEN, a New Bedford based scallop vessel, and the M/V NORTH PACIFIC, a converted crabber, to conduct explorations for scallops in the Gulf of Alaska, off Kodiak Island, and within Cook Inlet (Hennick 1973). These studies prompted subsequent fisheries in the Yakutat and Kodiak areas, but no fishery occurred in Cook Inlet because of the limited findings.

Exploratory fishing for scallops in Kachemak Bay was conducted by a commercial fisherman in 1974 and reported by Davis (1974). A total of three short tows (30-45 min) between Point Pogibshi and Barabara Point using a 2.4 m (8 ft) wide New Bedford style dredge produced only 16 scallops. Environmental studies of Kachemak Bay conducted by the Department in 1977 (Driskell et al. 1977) showed that weathervane scallops existed off Bluff Point but no further research was conducted.

One vessel fished scallops in Kamishak Bay during September 1983. Gear was restricted to a single 1.8 m (6 ft) wide dredge. An onboard observer and logbook program was required by the Department. The month-long fishery produced a total of 1,065 kg of meats, representing approximately 11,350 kg of live weight. The estimated ex-vessel value of the catch was $14,076. In 1984, both the Kamishak and Southern Districts were open to limited scallop fisheries. Three boats participated, landing about 2,862 kg of meats valued at $37,800.

A biomass estimate of the scallop bed fished in Kamishak in 1983 was generated from logbooks provided by fishermen. A survey of the bed using the Department research vessel PANDALUS was conducted to compare the Department's abundance estimate with that derived from the commercial fishery. The goal was to estimate biomass and determine the feasibility of estimating biomass from logbook data for scallop beds in Lower Cook Inlet. The survey also provided a data base for age class structure, recruitment, growth rates, size at maturity, and percentage of meat recovery. Incidental catch of commercially exploited species was documented to determine the effects of a scallop fishery on other resources.

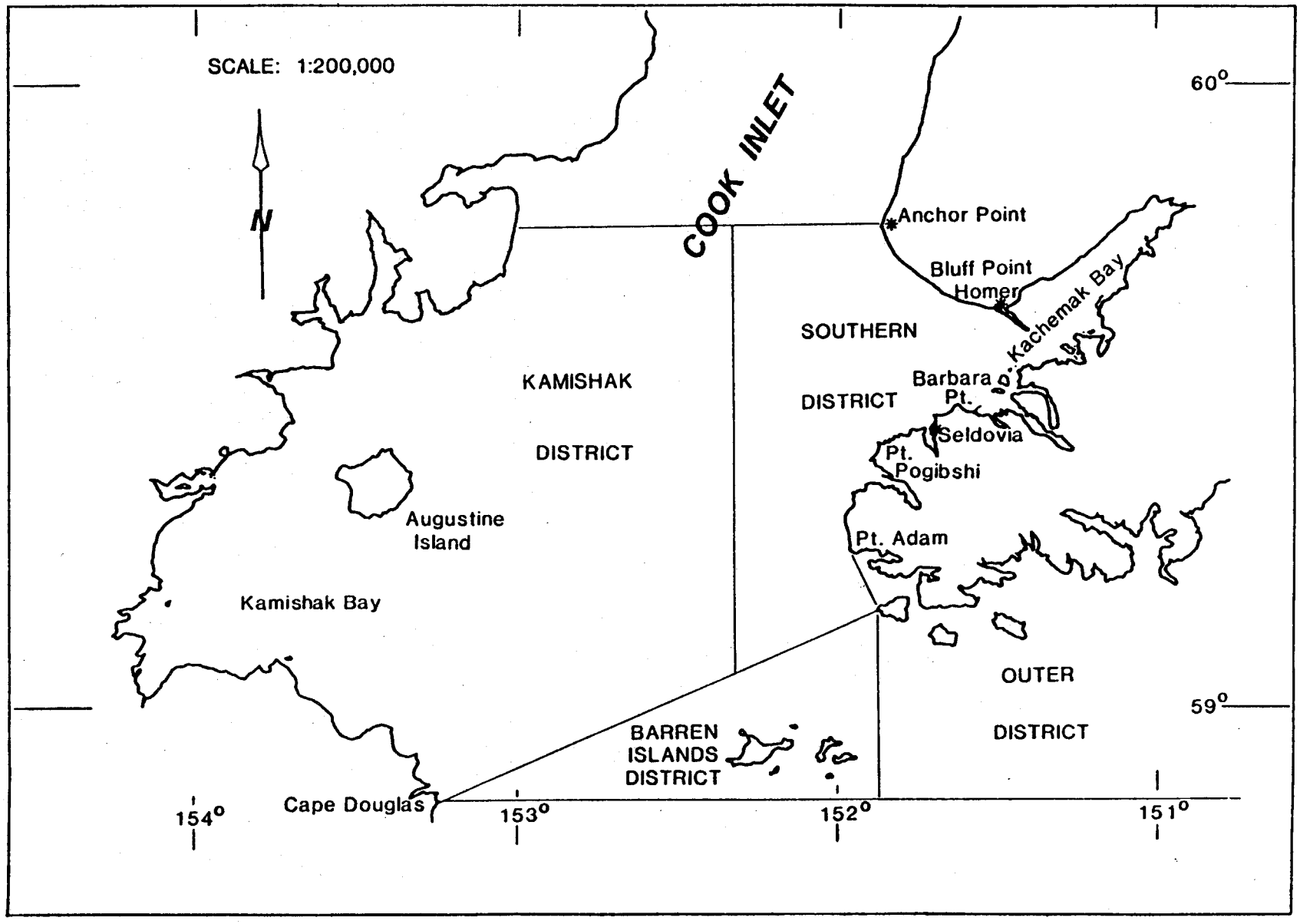

Figure 1. Lower Cook Inlet area district location chart.

METHODS AND MATERIALS

Sampling area for the scallop survey was determined by plotting catch location entries from the logbook of the commercial vessel that participated in the 1983 fishery (Figure 2). Virtually the entire catch in that fishery came from an area of approximately 27.8 km² (Kyle 1983). In order to determine the rough boundaries of this bed, a grid consisting of 192 km² (56 square nautical mi) sampling stations was superimposed on a nautical chart over the area of intensive fishing.

Within each sampling station, a 1.9 km (nautical mi) tow was made using a 2.4 m wide New Bedford style scallop dredge at a vessel speed of approximately 5.6 - 7.4 km/hr (3-4 knots) and a line scope of 5 to 1. The dredge consisted of a net bag of 7.6 cm (3 in) inside diameter steel rings lined with a poly mesh bag to aid in the retention of smaller objects (Figure 3). Catches were recorded and sampled to obtain the following data:

1) Total catch of adult/legal scallops in order to generate a biomass estimate,

2) Extent of pre-recruits (sub 4-year-old) in the population,

3) Size (height) by age class,

4) Meat content/recovery by age class,

5) Sex ratio by color variation, and

6) Incidental catch.

An estimate of total live weight of scallops present at each station was obtained using the area-swept method, according to the formula:

$$N = \frac{C \cdot T}{(w \cdot l)}$$

where:

N = total kg scallops w = width of dredge = (2.4 m)

C = total catch (kg/tow) T = total station area = (3.4 km²)

l = length of tow (1.9 km)

Scallops in each tow were separated into adults (4 years and older) and sub-adults, counted, and weighed collectively. Shell heights were determined on all sub-adults and 20 random adults by measuring the straight line distance from the umbo (hinge) to the outer shell margin of the top valve. Age of shells was determined by counting annual growth rings on the top valve, after methods described for the East Coast sea scallop, *Plactopecten magellanicus*,

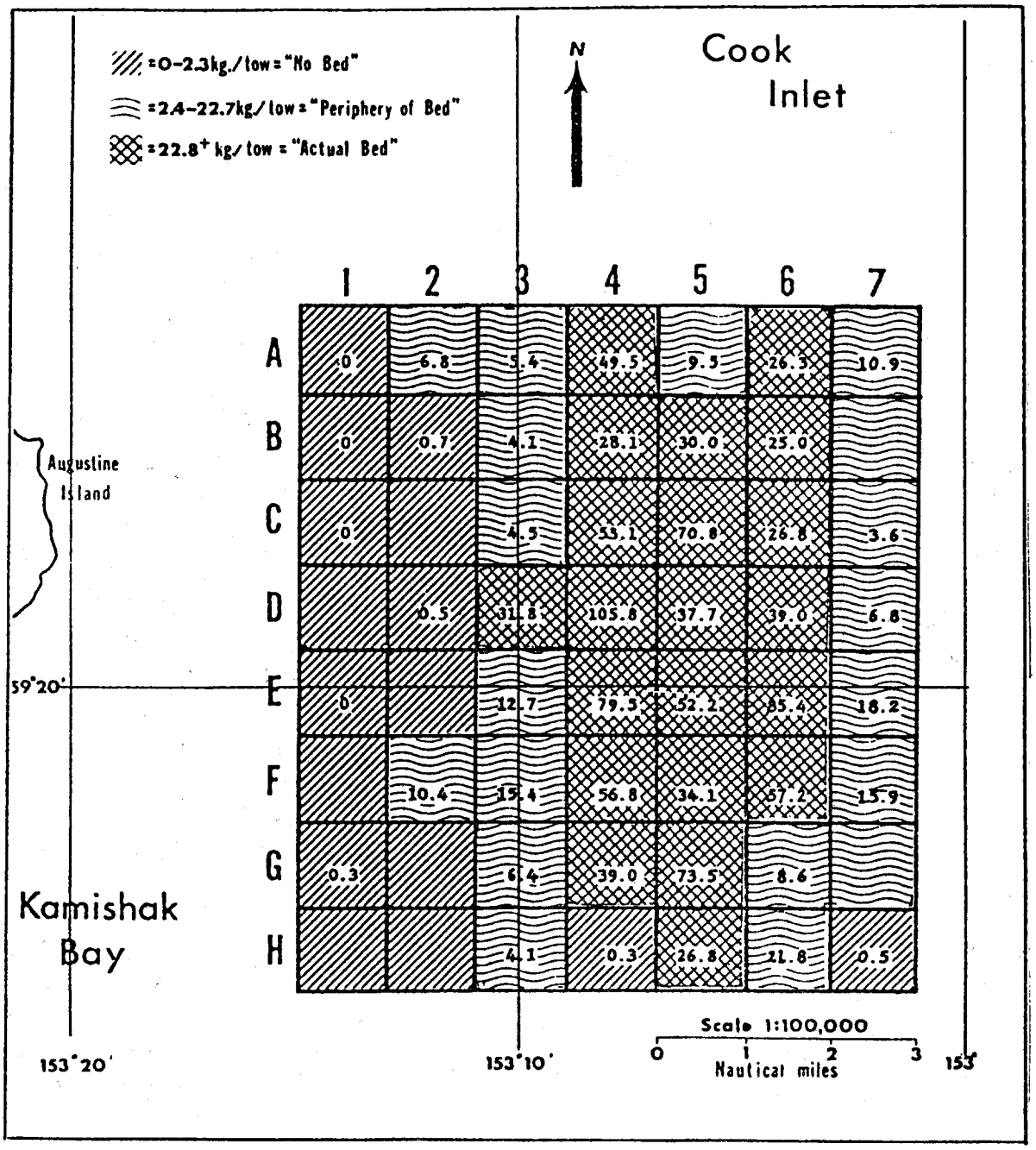

Figure 2. Chart with grid of survey area in Kamishak Bay, August 1984, showing catches of adult Pacific weathervane scallops in kilograms per 1.9 m tow using one 2.4 m wide New Bedford style scallop dredge.

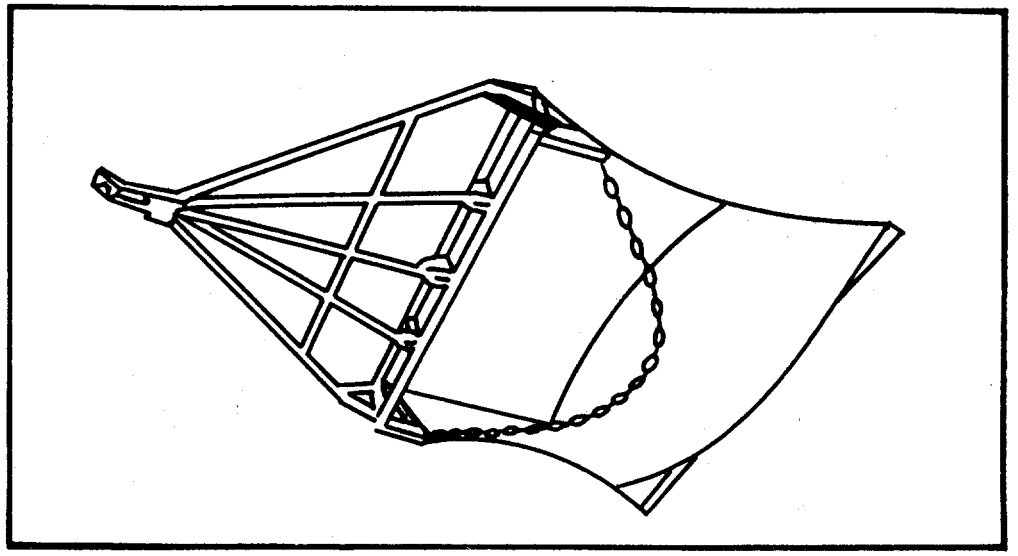

Figure 3. Illustration of a typical New Bedford style scallop dredge (from the National Fisherman. August 1983).

(Baird 1953; Stevenson and Dickie 1954) and for the weathervane scallop (Hennick 1970). Minimum ages were determined by counting annuli. Additional suspected growth rings not evident because of shell wear were denoted by a "+" sign. Ten adults per tow were subsampled for live weight and meat (abductor muscle) weight. Five sub samples were taken to examine scallop gonads for sex ratios. Incidental catches were recorded and estimated for extent of damage, with particular emphasis on king *(Paralithodes camtchatica)* and Tanner crab *(C. bairdi)*.

RESULTS

A total of 47 successful tows was completed. Total catch of adult scallops was 1,195 kg live weight. Catches ranged from no adults to a high of 106 kg adults per tow (Appendix Table 1). Catches were stratified into three categories (0-2.3 kg, 2.4-22.7 kg, and 22.8 kg and above) and plotted on a grid map to show density boundaries of the bed (Figure 2). It appeared that the area surveyed adequately encompassed the scallop bed. There was no significant relationship between adult densities and depth of the area surveyed.

The results of the Department's survey produced an estimate of 879,385 kg live weight of scallops (assuming 100% dredge efficiency) present in a 137 km^2 area, represented by column 2-6 in Figure 2. This was 1.0% less than the live weight estimate (888,701 kg) derived from the vessel participating in the 1983 commercial fishery for the same area. The commercial vessel towed a 1.8 m wide New Bedford style dredge and landed 483 kg of meats (4,830 kg live weight) for an average of 21.9 kg live weight per 1.9 km towed. The similar live weight estimates per given area between the Department's survey results and commercial fishing logbook data indicated that the Department could conduct a scallop survey and generate a biomass estimate comparable to that of a commercial fishery.

An analysis of variance test (Steel and Torrie 1980) determined that juvenile scallop concentrations were significantly correlated ($P \leq 0.005$) to the distribution of dense concentrations of adults (Table 1). Of the 1,345 juveniles collected, 58.5% were 3-year-olds (Table 2).

Average shell height and live weight of both juvenile and adult increased with scallop age (Tables 2 and 3). The adult age distribution appeared to have three modes at 4, 7-8, and 12-13 years, respectively (Figure 4). This was similar to commercial catch data from the 1983 fishery except that there was no 4-year-old mode in the commercial data.

Growth as determined from shell height appears to decrease with age, occurring at three distinct rates from ages 0-3 years, 4-7 years, and 8 years and above (Figure 5). Age versus average live weight and average meat weight (Figures 6 and 7), however, indicated more of a single linear growth rate for adults. These relationships were similar to those found for scallops caught commercially in the Yakutat, westside Kodiak, and Marmot-Portlock-Albatross areas (Hennick 1973). Average meat recovery, expressed as the average meat weight divided by average live weight in percent, was 10.1% for all individuals sampled and peaked in the 7- and 8-year-old age class.

Table 1. Analysis of variance for mean number of juvenile scallops per tow by stratified densities of adult abundance (kg/tow).

	Strata		
	0-2.3 kg	2.4-22.7 kg	22.8+kg
Mean no. juveniles	1.11	13.00	53.00
Standard deviation	1.76	14.54	34.25
Sample number	9	17	21

	SS	df	MS	F
Strata	23,440.43	2	11,720.22	19.20
Error	26,864.89	44	610.57	
Total	50,305.32	46		

Table 2. Shell heights of juvenile scallops caught in Kamishak Bay, August 1984.

Age	Number	Percent	Shell height range (mm)	Avg. shell height (mm)
3	787	58.5	54 - 119	101.4
2	302	22.5	48 - 78	62.0
1	256	19.0	17 - 38	29.0
	1,345	100.0		

Table 3. Average shell heights, live weights, meat weights, and meat recoveries of adult scallops sampled in Kamishak Bay, August 1984[1].

Age	Height (mm) No.	Height (mm) Ave.	Live Weight (g) No.	Live Weight (g) Ave.	Meat Weight (g) Ave.	Meat Recovery %
4	91	122.6	39	204.8	22.2	10.8
5	3	133.7	1	331.0	33.0	10.0
6	13	142.9	9	342.4	34.9	10.2
7	82	150.8	47	385.2	43.7	11.3
8	65	154.3	37	399.9	46.4	11.6
9	18	158.7	9	432.9	46.3	10.7
10 +	41	163.0	18	500.5	51.9	10.4
11 +	62	165.2	21	506.6	50.5	10.0
12 +	99	170.4	50	564.2	53.9	9.5
13 +	86	173.7	47	595.5	58.1	9.8
14 +	58	176.5	34	592.5	56.3	9.5
15 +	18	177.9	14	635.6	60.8	9.6
16 +	15	177.7	12	636.3	60.3	9.5
17 +	2	189.0	1	590.0	68.0	11.5

-Continued-

Table 3. Average shell heights, live weights, meat weights, and meat recoveries of adult scallops sampled in Kamishak Bay, August 1984[1] (continued).

Age	Height (mm) No.	Height (mm) Ave.	Live Weight (g) No.	Live Weight (g) Ave.	Meat Weight (g) Ave.	Meat Recovery %
18 +	1	185.0	1	640.0	49.0	7.7
TOTALS	654	159.1	340	476.3	48.3	10.1

[1] Does not include 8 individuals from the sample which could not be measured, weighed, or aged due to damage.

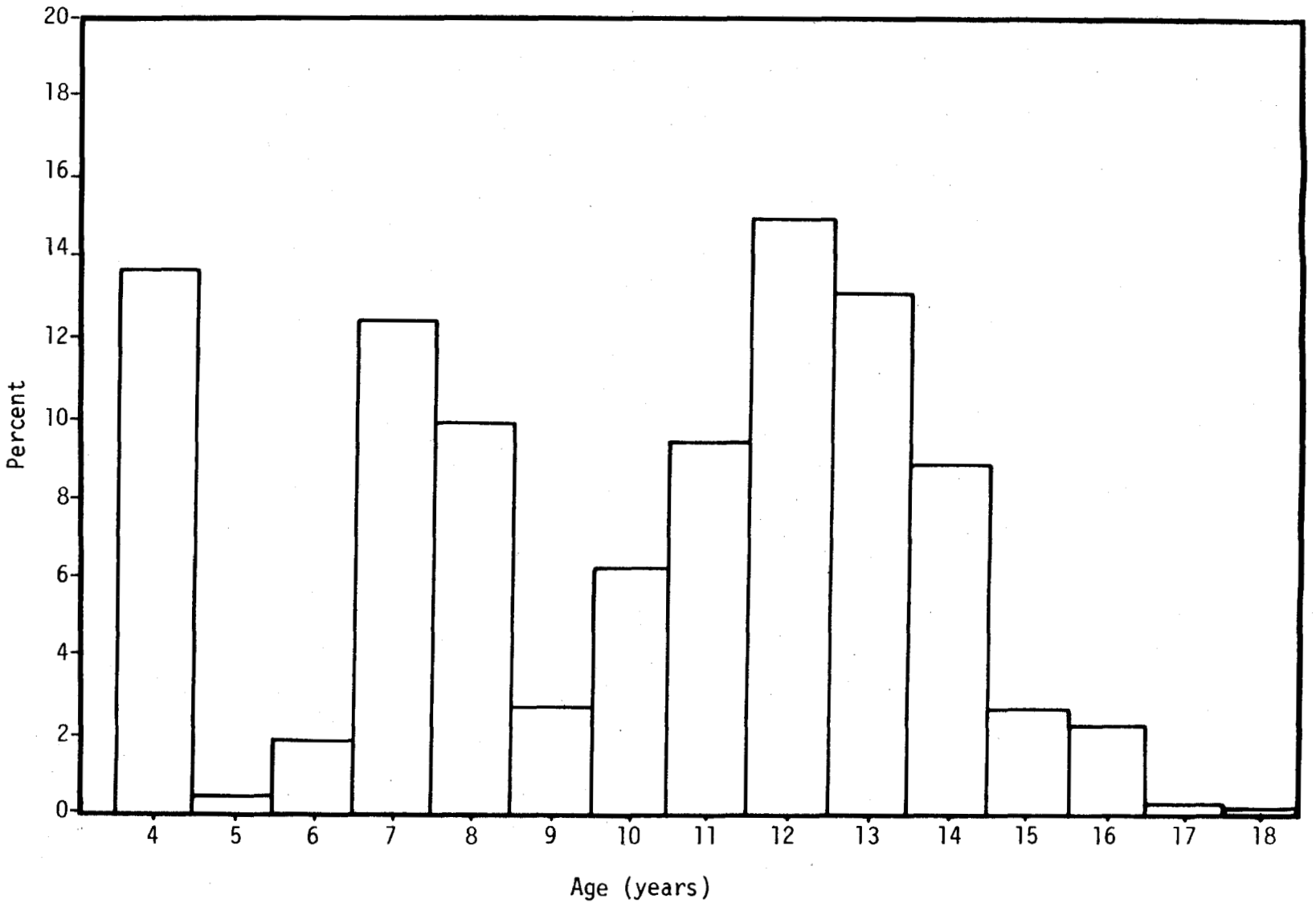

Figure 4. Age class structure for adult scallops sampled in Kamishak Bay, August 1984.

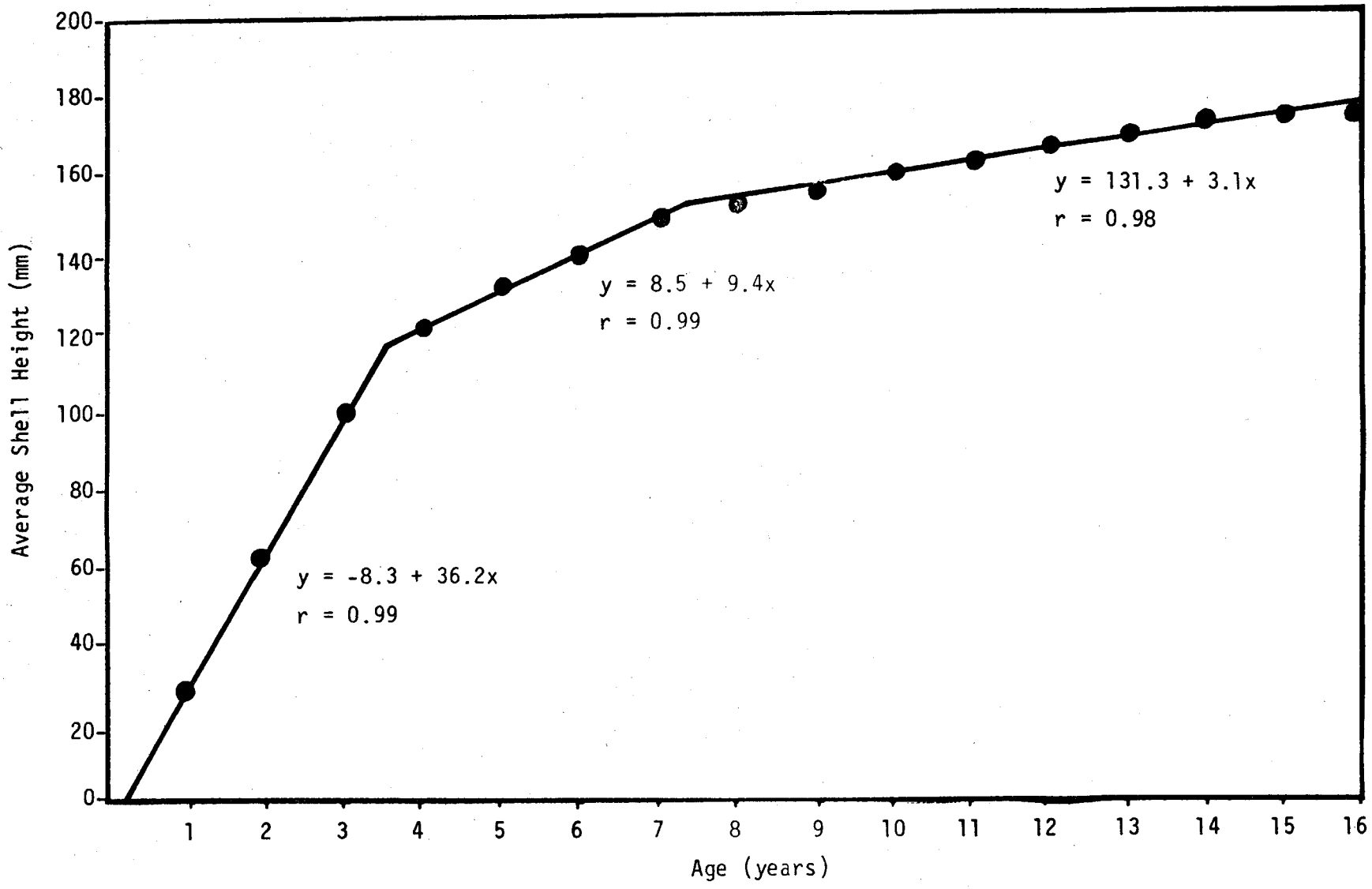

Figure 5. Regressions of average shell height versus age for scallops sampled in Kamishak Bay, August 1984.

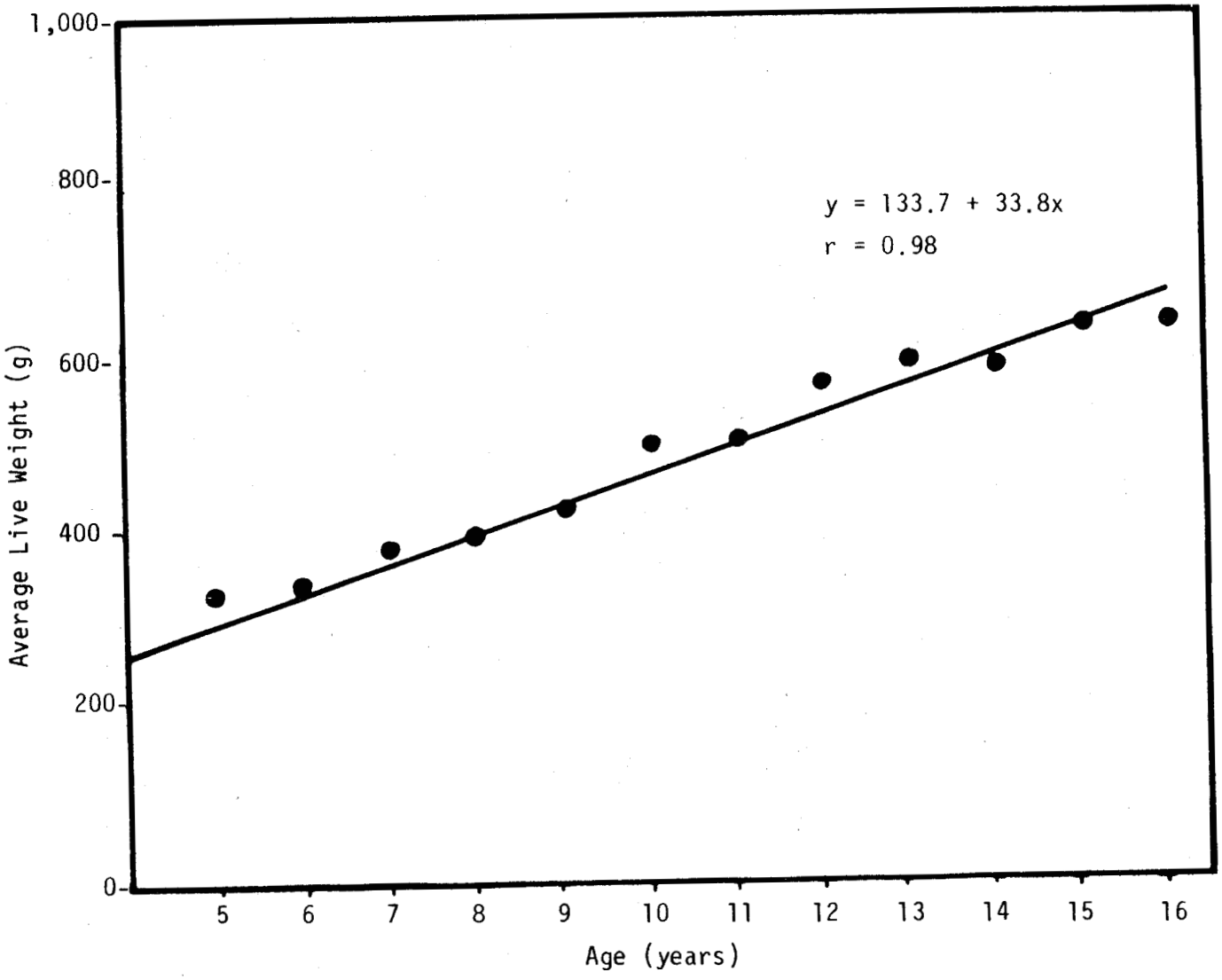

Figure 6. Regression of average live weight versus age for adult scallops sampled in Kamishak Bay, August 1984.

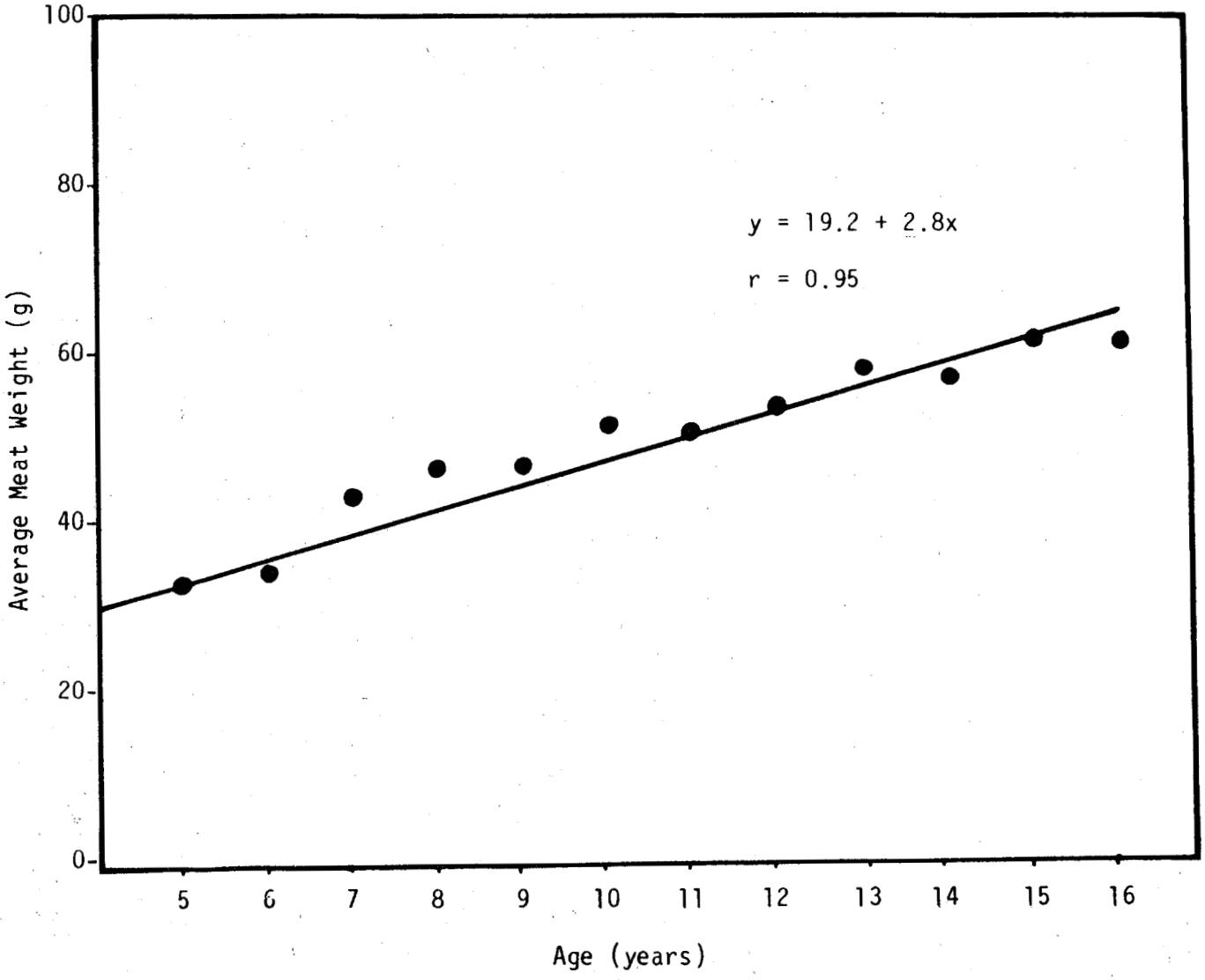

Figure 7. Regression of average meat weight versus age for scallops sampled in Kamishak Bay, August 1984.

Very few king crab and legal size Tanner crab were caught throughout the survey. The bulk of the incidental catch was of sub-legal and female Tanner crabs. Careful on-deck gear handling resulted in low mortality (8%) of Tanner crab 5-8 cm in size. Several stations contained substantial quantities of very small (1-4 cm) Tanner crab which were not enumerated or inspected for damage.

Gonads were examined for identification of sex, but discriminating features could not be discerned at the time the survey was conducted.

DISCUSSION

The ADF&G was successful in conducting a scallop survey which obtained basic life history data and generated a biomass estimate comparable to that derived from commercial fishery data. This can assist managers in assessing scallop abundance from commercial logbook data. The calculated live weights, however, can be very misleading since they assume 100% dredge efficiency. In reality, research has shown that the New Bedford style dredge is anywhere from 5 to 15% efficient on adult sea scallops (Dow 1956), inferring that a much larger biomass of scallops could be present here. However, because of low dredge efficiency, it is questionable whether or not this larger amount of scallops would ever become available to commercial harvest.

Juvenile and adult concentrations overlapped, indicating that either progeny may not disperse widely, or viable habitat for juveniles is similar to that of adults. Retention of juveniles in the dredge may not be complete but is assumed to be relative to abundance.

This study did not encompass any size or age at maturity research. Hennick (1970), however, found that the majority of scallops (87% in Kodiak and 59% in Yakutat) 3-year-old were sexually mature, while all scallops 2-years-old were immature and all scallops 4-years-old were mature. Since very few scallops of age 4 and no scallops of age 3 were taken during the 1983 commercial fishery (Kyle 1983), most scallops will be sexually mature 2 years before being recruited into the fishery if the present gear restrictions are continued. (Commercial gear is limited to a net bag consisting of 10 cm (4 in) inside diameter rings, and no inner mesh liner is allowed). Present gear restrictions may maintain some spawning success even if commercial fishing alters the adult age structure of the bed.

Damage to species incidentally caught, particularly crab, was an initial concern to both biologists and fishermen. Results of this work indicated that both juvenile and female Tanner crab inhabit some areas of scallop concentrations (Appendix Table 2), so scallop dredging could have significant impacts. Most crab damage appeared to occur during loading and unloading gear on deck. Careful handling of the gear appears to be the most effective method of reducing damage to crab. The importance of this must be stressed to all scallop fishermen in order to avoid conflicts with crab fishermen.

The scallop survey was successful in accomplishing all its initial objectives except for determining the sex ratios. Conventional methods for sexing involve

inspecting the gonads for color variations (Hennick 1970). However, it appears that gonadal development during August and September is insufficient to distinguish between the sexes; color was uniformly semi-transparent in all individuals and is similar to the findings of Hennick (1970) near Yakutat and Kodiak Island. Therefore, no inferences can be made on sex ratios and their importance to the scallop resources. Studies should be conducted when the gonads are ripe so that sex ratio data can be collected.

ACKNOLWEDGMENTS

Scott Kyle participated in data collection during the survey and provided commercial fisheries data. The crew of the R/V PANDALUS, Paul Desjardin and Craig M.K. Forrest, operated the vessel and gear during the survey. Donna Coble, Hazel Vanderbrink, and Teddi Velsko typed the report.

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APPENDICES

Appendix Table 1. Scallop catches in Kamishak Bay during August 1984 (tows are 1.9 km using a 2.4 m wide New Bedford style scallop dredge).

Date	Tow No.	Station	Avg. Depth (m)	Adult Total Kg	Adult Total No.	Juvenile Total Kg	Juvenile Total No.
8/22	1	H-6	56.7	21.8	41	1.1 est.	8
8/22	2	H-4	58.5	0.3	1	1.1 est.	5
8/22	3	H-2	53.0	Dredge overturned			
8/23	4	G-1	47.5	0.3	1	0.1 est.	1
8/23	5	E-1	51.2	0	0	0	0
8/23	6	C-1	45.7	0	0	0	0
8/23	7	A-1	45.7	0	0	0	0
8/23	8	B-2	45.7	0.7 est.	2	0	0
8/23	9	D-2	47.5	0.5 est.	1	0.1 est.	1
8/23	10	F-2	51.2	10.4	19	0.1 est.	1
8/23	11	G-3	54.9	6.4	15	0.3 est.	4
8/23	12	E-3	53.0	12.7	29	0.2 est.	4
8/23	13	C-3	51.2	4.5	7	0.1 est.	1
8/23	14	A-3	45.7	5.4	9	0.5 est.	4
8/23	15	A-2	43.9	6.8	6	1.8 est.	12
8/23	16	B-1	45.7	0	0	0	0
8/27	17	B-4	43.9	28.1	48	2.3	19
8/27	18	D-4	47.5	105.8	203	6.8	113
8/27	19	F-4	53.0	56.8	121	5.7	87
8/27	20	G-5	56.7	73.5	141	4.1	47
8/27	21[1]	E-5	53.0	5.4[1]	13[1]	0.1 est.	3[1]
8/27	22	C-5	49.4	70.8	120	10.0	128
8/27	23	A-5	47.5	9.5	18	2.3	15
8/27	24	B-6	51.2	25.0	48	2.5	25
8/27	25	D-6	54.9	39.0	71	9.0	92
8/27	26	F-6	56.7	57.2	127	5.9	60
8/27	27	H-5	62.2	26.8	57	5.9	70
8/27	28	H-3	60.4	4.1	9	0.9	6
8/28	29	F-3	47.5	15.4	26	1.1	12
8/28	30	D-3	47.5	31.8	67	0.7	5
8/28	31	B-3	42.1	4.1	8	1.1	9
8/28	32	A-4	42.1	49.5	105	4.1	32
8/28	33	C-4	47.5	53.1	95	4.5	35
8/28	34	E-4	49.4	79.5	166	7.7	78
8/28	35	B-5	49.4	30.0	53	3.2	33

-Continued-

Appendix Table 1. Scallop catches in Kamishak Bay during August 1984 (tows are 1.9 km using a 2.4 m wide New Bedford style scallop dredge) - continued.

Date	Tow No.	Station	Avg. Depth (m)	Adult Kg	Adult Total No.	Juvenile Kg	Juvenile Total No.
8/28	36	A-6	51.2	26.3	51	2.7	29
8/28	37	C-6	53.0	26.8	49	3.2	33
8/29	38	G-4	53.0	39.0	78	1.8	33
8/29	39	F-5	51.2	34.1	62	3.4	33
8/29	40	E-5	51.2	52.2	97	2.7	28
8/29	41	D-5	47.5	37.7	67	3.2	32
8/29	42	E-6	51.2	85.4	180	9.0	101
8/29	43	G-6	53.0	8.6	15	1.4	8
8/29	44	H-7	51.2	0.5	est 1	0.2	est. 3
8/29	45	F-7	56.7	15.9	29	2.5	25
8/29	46	E-7	56.7	18.2	38	3.9	58
8/29	47	C-7	54.9	3.6	8	1.1	8
8/28	48	A-7	51.2	10.9	18	3.6	36
8/29	49	D-7	58.5	6.8	13	1.1	10
Total	47	Successful tows	51.0	1,201.2	2,320	123.1	1,344
		Average/tow	27.9	25.6	49.4	2.6	28.6

[1] Not counted as valid because it was felt dredge fished improperly. Made up with tow #40.

Appendix Table 2. Incidental catch and estimated damage to Tanner crab during scallop survey in Kamishak Bay August 1984, utilizing a 2.4 m wide New Bedford style scallop dredge[1].

Date	Tow #	Station	LEGAL MALES			SUBLEGAL MALES			FEMALES		
			DM	DA	UND	DM	DA	UND	DM	DA	UND
8/22	1	H-6									
8/22	2	H-4						1			
8/22	3	H-2			----------	--DREDGE OVERTURNED--		----------			
8/23	4	G-1						1			
8/23	5	E-1					3	5		4	
8/23	6	C-1									
8/23	7	A-1					1	1			1
8/23	8	B-2									
8/23	9	D-2							1		1
8/23	10	F-2					1	1	1	1	2
8/23	11	G-3									
8/23	12	E-3							1		
8/23	13	C-3									
8/23	14	A-3							1		
8/23	15	A-2						2			
8/23	16	B-1									
8/27	17	B-4									1
8/27	18	D-4				1		7	1		6
8/27	19	F-4						2			
8/27	20	G-5						2			
8/27	21	E-5			----------	----------	BAD TOW, SEE	TOW #40	----------		
8/27	22	C-5									6
8/27	23	A-5				1					1
8/27	24	B-6				1	1	3	3	3	7
8/27	25	D-6				1		5	2		5

-Continued-

Appendix Table 2. Incidental catch and estimated damage to Tanner crab during scallop survey in Kamishak Bay August 1984, utilizing a 2.4 m wide New Bedford style scallop dredge[1] (continued).

Date	Tow #	Station	LEGAL MALES			SUBLEGAL MALES			FEMALES		
			DM	DA	UND	DM	DA	UND	DM	DA	UND
8/27	26	F-6									
8/27	27	H-5						2			
8/27	28	H-3									
8/28	29	F-3									
8/28	30	D-3					1	1			
8/28	31	B-3									
8/28	32	A-4									1
8/28	33	C-4						1			1
8/28	34	E-4									
8/28	35	B-5					2	1	3	4	3
8/28	36	A-6							3	3	8
8/28	37	C-6						1			9
8/29	38	G-4					1	3	2		
8/29	39	F-5				1		5			2
8/29	40	E-5						7		1	7
8/29	41	D-5				1		3		1	8
8/29	42	E-6				1	1	13	1		9
8/29	43	G-6						1			
8/29	44	H-7									
8/29	45	F-7						1			
8/29	46	E-7				1	6	14			7
8/29	47	C-7			1	3	3	10			27
8/29	48	A-7		1			2	7			26
8/29	49	D-7			3	3	3	46			35
TOTAL	47		0	1	4	14	25	146	19	18	172
				0.2	1.0	3.5	6.3	36.6	4.8	4.5	43.1

-Continued-

Appendix Table 2. Incidental catch and estimated damage to Tanner crab during scallop survey in Kamishak Bay August 1984, utilizing a 2.4 m wide New Bedford style scallop dredge[1] (continued).

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[1] Symbols: DM = Damaged mortality = Damaged crab, not expected to survive.
DA = Damaged alive = Damaged crab, but expected to live.
UND = Undamaged.

Also, the preceding table does not include the following figures for incidental catch of king crab:

Legal male = 0
Sublegal male = 0

Female = DM = 0 DA = 1 UND = 4

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