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THE WESTWARD REGION SHRIMP FISHERY AND SHRIMP RESEARCH PROGRAM, 1968-1981

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ABSTRACT

This report extends the existing 1968-1981 series of annual reports by the Alaska Pandalid Shrimp Research Program through the 1982 season. The history, development, and trends of the shrimp fishery as well as those of the shrimp research program are discussed in detail. While emphasis is given to fishery and stock condition trends during the last two seasons, the entire data bases on total catch, catch-per-unit-effort (C/E), age composition, and stock abundance indices are reviewed in light of recent changes in stock condition. Included also is the existing shrimp management strategy. This strategy is based on past and ongoing studies by the shrimp research program with primary emphasis on shrimp stock abundance indices.

Trends in C/E, age composition, and stock abundance for major Westward Region stocks coincide with trends in total catch and fleet success. The radical abundance declines seen during the last four seasons in most stocks are reflected in age composition trends. The abundance of all age cohorts is seen to decline simultaneously and at relatively equal rates, suggesting influence by a non size-specific mortality factor. While several potential non size-selective mortality factors exist, the most plausible at present is fish predation. This is because the shrimp decline coincides with sharply increasing abundance of fish species, several of which are known shrimp predators. A major predator is the Pacific cod *(Gadus macrocephalus)* which has been shown to feed on shrimp in a non size-selective manner.

INTRODUCTION

This report constitutes the first of a series designed to annually document the status of the Westward Region shrimp fishery and activities of the Alaska Pandalid Shrimp Research Program by the Alaska Department of Fish and Game (ADF&G). This series is designed to serve two purposes: first, to document and evaluate the performance of each season's fishery relative to the existing data base; and second, to evaluate any relationships seen between fishery performance and biological indicators of stock condition. Initiation of this series stems from the termination of Federal Aid reporting requirements under which the Kodiak District shrimp fishery had been documented seasonally since 1968. Elimination of these requirements is a result of a reallocation to other projects of the Federal funds used since 1968 to partially support this program under PL 88-309 "Commercial Fisheries Research and Development Act". Although Kodiak District shrimp research and fishery development had been documented annually in federal reports from 1968 through 1981, only part of the program carried out in the Chignik, South Peninsula, and Aleutian Island Districts were included in them as work in these districts was solely supported by State of Alaska funding. This current report is intended to succeed the last report under Federal funding (Jackson 1981) and bring together under one cover all fishery performance evaluations and stock assessment research carried out by the Westward Shrimp Research Program including discussion of management techniques. Discussions of fishery performance and catches in this report, unless stated otherwise, will be based on the "biological year" (May-April) rather than on an annual or fiscal year basis. Fishery performance trends on the basis of fishing seasons are more meaningful as they coincide with egg hatch and recruitment cycles. Catches based on the biological year in this report shall be referred to as seasonal catches and must not be compared with those based on the calendar or fiscal year.

The last federal report (Jackson 1981) concentrated on evaluating shrimp stock conditions in the 1980-81 season; therefore, the present report will concentrate on stock conditions in the 1981-82 and 1982-83 seasons. Since most previous reports contained no information on shrimp fisheries and research programs in Chignik, South Peninsula, and Aleutian Island shrimp districts, the historical catch, effort, and stock abundance data for these districts are included to facilitate discussion and future reference.

Description of the Area

The Westward Region shrimp fishery includes all Pacific Ocean waters south of the latitude of Cape Douglas (58°52' N. lat), west of the longitude of Cape Fairfield (148°58' W. long.) east of 172° E. long. and seaward to the 300 F contour, and all Bering Sea waters east of 172° E. long. (Figure 1). This area, referred to as Statistical Area J, is divided into five fishing districts delineated as follows:

1) Kodiak District - all waters of Statistical Area J east of a line extending south from Kilokak Rocks.

2) Chignik District - all waters west of a line extending south from Kilokak Rocks, east of a line from Kupreanof Point to the easternmost point of Castle Rock, and east of a line extending 135° southeast from the easternmost point of Castle Rock.

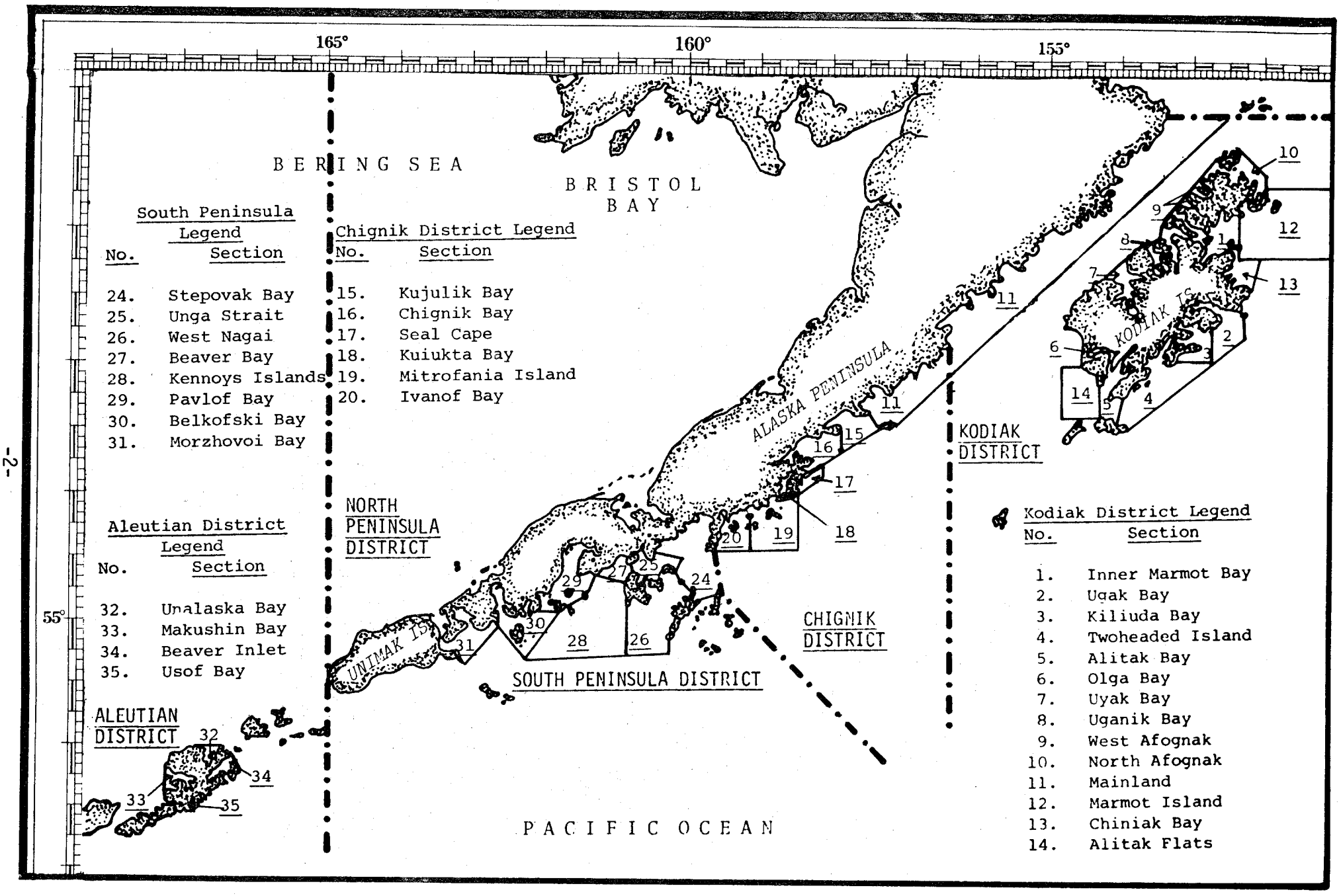

Figure 1. Shrimp fishing districts and sections of the Westward Region (Statistical Area J) shrimp fishery.

3) South Peninsula District - all waters west of a line from Kupreanof Point to the easternmost point of Castle Rock, and west of a line extending 135° southeast from the easternmost point of Castle Rock and Pacific Ocean waters east of the longitude of Cape Sarichef.

4) North Peninsula District - all Bering Sea waters east of the longitude of Cape Sarichef.

5) Aleutian District - all Pacific Ocean and Bering Sea waters west of the longitude of Cape Sarichef.

All districts except the North Peninsula District are comprised of several "fishing sections" within which the majority of shrimp trawling occurs. Harvest levels are regulated for most sections, and each section is considered to contain discrete stocks which generally do not migrate to adjacent sections. All references to shrimp districts and sections throughout this report will be based on delineation of these geographical units shown in Figure 1.

Development of the Fishery

The Westward Region shrimp fishery was initiated at Kodiak in 1957 with exploratory tows by local vessels in nearby Marmot and Chiniak Bays. The first shrimp peeling machines were installed during calendar year 1958, with 1959 marking the first year of commercial production with an annual catch of 2.9 million lb (1,318 mt). Subsequent annual catches progressively increased to 36.7 million lb (16,682 mt) in 1967, peaked in 1976 at 119.3 million lb (54,227 mt), then declined rather abruptly to 21.7 million lb (9,864 mt) in 1981 (Figure 2).

The shrimp fishery prior to 1967 operated entirely within the Kodiak District. Beginning in 1967 and 1968, however, development of small localized fisheries began in the South Peninsula and Chignik Districts (Figure 1). Development of the South Peninsula fishery centered initially in Unga Strait and Stepovak Bay, while that in the Chignik District centered around Ivanof Bay and Mitrofania Island. A third small fishery was initiated during 1972 in the Aleutian District near Unalaska Island. Fishing effort here quickly expanded to include Makushin Bay, Beaver Inlet, and several small bays on the Pacific Ocean side of Unalaska Island. Seasonal catches from the Aleutian District have remained small, with a high of 4.9 million lb (2,225 mt) in 1978-79, and a subsequent low of 0.34 million lb (154 mt) in 1982-83 (Table 1). While the seasonal catches from the Chignik, South Peninsula, and Aleutian District seasonal catches comprised only a small proportion (2-13%) of annual regional catches through 1971. Their contribution increased markedly to 25.5% in 1972, peaked in 1977 at 71% (78.9 million lb or 35,864 mt), and subsequently declined to 11.6 and 3.2% in 1981-82 and 1982-83, respectively. This resulted in the Kodiak District once again becoming the major contributor to regional catches. It must be recognized, however, that while dependence upon Kodiak District catches increased during 1981 and 1982, actual catch magnitude was declining, although less rapidly than in the other districts.

Evaluating stock condition requires an understanding of the evolution of vessel and gear types used. During the initial years of this fishery from the early through late 1960's the primary vessel type was the 50 to 70 ft (15.2-21.3 m) herring seiner rigged to fish a single West Coast style trawl with a 60 to 90 ft

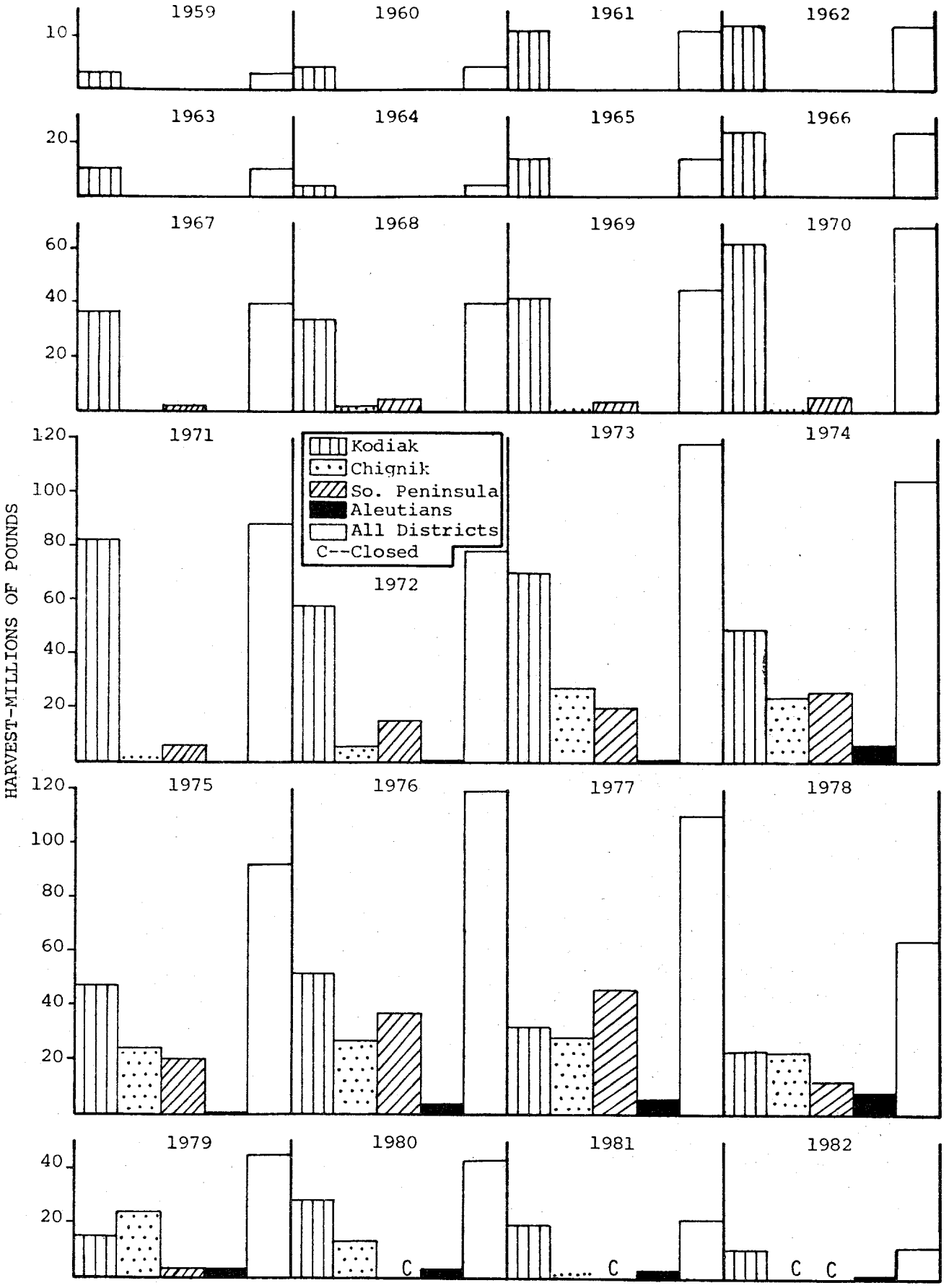

Figure 2. Annual shrimp harvests of the Westward Region, 1969-1982.

Table 1. Westward Region seasonal trawl-caught shrimp harvests in millions of pounds by fishing section, 1973-74 through 1982-83 seasons[1].

Fishing District/Section	Fishing Season									
	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83
KODIAK DISTRICT										
Marmot Bay	3.36	2.84	3.05	2.71	1.48	.47	0	0	1.96	[2]
Marmot Island	15.86	20.21	16.05	14.15	3.30	0	0	0	.09	[2]
Chiniak Bay	1.40	2.89	.76	1.01	.03	[3]	[3]	[3]	[3]	[3]
Kalsin Bay	-	-	1.28	1.51	1.81	1.16[3]	.92[3]	.14[3]	2.60[3]	1.38[3]
Kiliuda Bay	5.93	8.75	6.61	6.69	6.06	0	0	0	0	[2]
Twoheaded Island	12.74	12.73	12.81	11.89	4.04	.002	0	2.14	3.04	[2]
Alitak Bay	8.99	4.19	4.25	4.90	4.42	3.49	3.54	4.72	4.14	3.58
Alitak Flats	-	-	-	-	-	-	-	-	1.73	.05
Olga Bay	-	-	-	-	-	1.79	2.26	1.16	.76	.94
Ugak Bay	.02	.06	0	0	0	0	.53	1.05	.10	[2]
Uyak Bay	1.48	.72	.33	.48	1.31	1.00	0	.43	0	[2]
Uganik Bay	1.94	1.60	.84	.91	1.48	.37	0	0	0	[2]
West Afognak	.84	.66	.83	.99	.26	.88	.48	1.18	.23	.001
Northern	1.42	3.09	1.03	1.07	.05	1.15	1.43	2.20	.75	1.21
S. Mainland	.07	0	.12	.21	.27	-	-	-	-	-
Kukak	2.15	.48	1.02	.22	.78	.59	.53	1.17	.55	1.71
Wide Bay	-	-	-	-	-	-	1.18	.98	.93	.85
Puale Bay	-	-	-	-	-	-	1.84	.66	1.60	.66
Non-Section	0	0	0	0	0	9.60[4]	.14	11.28[5]	.64	.01
SUB-TOTAL	56.20	58.22	49.08	46.74	25.29	20.50	12.85	27.11	19.12	10.391
CHIGNIK DISTRICT										
Kujulik Bay	2.80	1.70	3.50	6.64	5.79	6.03	11.05	3.37	[2]	[2]
Chignik Bay	4.90	2.70	7.00	4.81	5.45	8.83	5.83	5.37	[2]	[2]
Kuiukta Bay	.60	2.60	3.00	1.84	1.23	1.74	.09	.01	[2]	[2]
Mitrofania Is.	9.80	19.30	6.00	9.69	8.22	4.05	2.69	[2]	[2]	[2]
Ivanof Bay	.40	.30	.20	1.75	3.31	2.17	[2]	[2]	[2]	[2]
Sutwik Is.	1.00	.90	.50	.31	1.40	.31	4.06	4.07	.07	[2]
Seal Cape	2.20	.50	4.10	2.10	1.10	.13	0	[2]	[2]	[2]
SUB-TOTAL	21.70	28.00	24.30	27.14	26.50	23.26	23.72	12.82	.07	[2]

-Continued-

Table 1. Westward Region seasonal trawl-caught shrimp harvests in millions of pounds by fishing section, 1973-74 through 1982-83 seasons[1] (continued).

Fishing District/Section	Fishing Season									
	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83
SOUTH PENINSULA										
Stepovak Bay	4.00	6.40	7.30	11.99	10.35	.09	[2]	[2]	[2]	[2]
Unga Strait	2.10	3.70	4.30	3.69	0	0	[2]	[2]	[2]	[2]
West Nagai	8.20	7.80	4.60	1.64	.46	1.01	.30	[2]	[2]	[2]
Beaver Bay	1.80	2.00	.30	.59	0	0	[2]	[2]	[2]	[2]
Kennoys Is.	-	-	-	-	-	-	0	[2]	[2]	[2]
Pavlof Bay	2.80	4.90	3.40	17.29	25.68	8.25	2.82	[2]	[2]	[2]
Belkofski Bay	-	-	-	-	1.46	.005	.003	[2]	[2]	[2]
SUB-TOTAL	18.90	24.80	19.90	35.20	44.87	9.43	3.13	[2]	[2]	[2]
ALEUTIAN DISTRICT										
Unalaska Bay	-	-	.37	1.00	.93	1.23	.24	0	0	0
Makushin Bay	-	-	.52	2.26	3.16	1.53	1.67	1.54	1.95	.34
Beaver Inlet	-	-	0	.11	.16	1.38	.71	.54	.19	0
Skan Bay	-	-	0	.31	.20	[6]	[6]	[6]	[6]	[6]
Usof Bay	-	-	-	-	.15	.76	.67	.38	.05	0
SUB-TOTAL	-	-	.89	3.68	4.60	4.90	3.29	2.46	2.19	.34
GRAND TOTAL	96.80	111.02	94.17	112.76	101.26	58.09	42.99	42.39	21.38	10.73

[1]Sections with no catch indicated by zero. Dashes indicate no section existed that year.

[2]Closed to commercial trawling.

[3]Catches from Kalsin and Chiniak Bays combined under Kalsin Bay.

[4]Catch made from Wide and Puale Bays.

[5]Catch made from Alitak Flats.

[6]Skan Bay catch incorporated with the Makushin Bay catch since 1978.

(18.3 - 27.4 m) headrope. The first Gulf of Mexico style double-rigged vessels equipped to fish two trawls simultaneously appeared in 1970. A rapid influx of this type of vessel and gear followed and by 1973 at least one-half of the fleet was composed of double-rigged vessels ranging from 70 to 100 ft (21.3 - 30.5 m) in length. The trawls and rigging used originally by these vessels were lighter, somewhat narrower, and tended bottom less closely than West Coast style single-rigged trawls. These differences proved to produce consistently higher and somewhat cleaner shrimp catches. Because pink shrimp distributions characteristically occur slightly above bottom and because of the need to reduce incidental bottomfish contamination, fishermen and government agencies began experimenting with high opening trawls. These new trawls became the standard and were fished (or flown) up to several feet above bottom and achieving up to 12 ft (3.7 m) vertical opening. High opening trawls continue to utilize the traditional tickler chain which tends bottom immediately in front of the footrope.

The evolution to new gear types has been accompanied by increased use of sophisticated electronic fish finding and depth sounding equipment, especially during the last 5 years. Use of these hydroacoustic sounders has enabled more precise location of shrimp schools and has increased the ability to fish areas previously considered untrawlable. In the Westward Region shrimp fishery, as in most fisheries, the evolution of trawl gear as well as electronic aids to fishing and fish finding is a never ending process aimed at increased efficiency.

The introduction of double-rigged vessels into the fleet occurred simultaneously with an abrupt increase in the number of vessels involved. This increase, coupled with the fact that the majority of the new vessels were double-rigged, greatly increased overall fishing power. The number of vessels fishing annually increased from 6 to 26 between 1960 and 1970 and ranged from 49 to 75 between 1971 and 1981. Fleet size during the 1978-1981 seasons leveled off at approximately 60 vessels, and declined to approximately 60 vessels in the 1982 season. The majority of vessels fishing shrimp during the last five seasons have been double-rigged.

Development of the Westward Region shrimp fishery including the dramatic increase in seasonal catches in the mid-1970's and subsequent decline through the 1981-82 season was discussed earlier in this report. This decline has, unfortunately, continued with the 1982-83 season catch of 10.73 million lb (4,871 mt) being only 50.2% of that in the 1981-82 season and the lowest seasonal catch since 1964 (Table 1).

It must be recognized in evaluating fishery performance, that the decline in total catch is due, at least in part, to the increasing number of fishing sections which have remained closed because of continued low abundance. These closures have resulted in a complete absence of effort in the Alaska Peninsula District and only minimal effort in established sections in the Chignik District (Table 2). In addition, several once productive fishing sections in the Kodiak District have remained closed for the last several seasons; the most notable of these are the Twoheaded Island, Kiliuda Bay, Marmot Bay, and Ugak sections. These closures were made in accordance with the shrimp management strategy to be discussed in detail later in this report, and were in response to continuing extremely low abundance. Had these closed areas been open to commercial fishing, catches from them would probably have been minimal.

Table 2. 1981-82 and 1982-83 seasonal trawl-caught shrimp catches by month and fishing district in the Westward Region.

Month	Fishing District - Season							
	Kodiak		Chignik		Alaska Peninsula		Aleutian Islands	
	1981-82	1982-83	1981-82	1982-83	1981-82	1982-83	1981-82	1982-83
March	[1]	[1]	[1]	[1]	[1]	[1]	155,810	[3]
April	[1]	[1]	[1]	[1]	[1]	[1]	428,793	[3]
May	[1]	[1]	[1]	[1]	[1]	[1]	849,779	189,048
June	24,950	3,692,623	70,948[2]	[1]	[1]	[1]	495,103	152,503
July	8,000	4,699,058	[1]	[1]	[1]	[1]	[3]	[3]
August	11,893,498	1,500,547	[1]	[1]	[1]	[1]	[3]	[3]
September	3,952,137	326,908	[1]	[1]	[1]	[1]	[3]	[3]
October	2,156,418	67,489	[1]	[1]	[1]	[1]	[3]	[3]
November	194,277	19,368	[1]	[1]	[1]	[1]	55,080	[3]
December	342,323	11,488	[1]	[1]	[1]	[1]	200,761	[1]
January	312,516	40,575	[1]	[1]	[1]	[1]	[3]	[1]
February	227,540	33,151	[1]	[1]	[1]	[1]	[3]	[1]
March	[1]	[1]	[1]	[1]	[1]	[1]	[3]	[1]
TOTAL	19,111,659	10,391,207	70,948	0	0	0	2,185,326	341,551

[1] Season closed to fishing.

[2] Catch from Chiganagak Bay Section only.

[3] Not fished in spite of the season being open.

THE SHRIMP RESEARCH PROGRAM

Program Development

The Westward Region shrimp research program was initiated in late 1967 with initial efforts directed at characterizing the biology of the stocks involved and the nature of the fishery. This involved defining the life history parameters of the various species utilized and initiating a study to monitor catch-per-unit-effort (C/E) of the commercial fleet. Objectives of these initial studies were to establish baseline data on relative stock abundance and to define basic life history parameters such as mating, egg hatch, age at sexual maturity, and molting periods for the primary species involved. Results of these studies served to justify closure of certain inshore waters throughout the egg hatch period.

The sharply increased utilization of Westward Region shrimp stocks between 1970 and 1978 resulted in an additional research effort directed at monitoring stock strength and condition. A concerted analytical effort was initiated to standardize the existing C/E data base. This study was initiated in response to suspicion that the simultaneous increases seen in both total catches and C/E was merely a function of increased gear efficiency masking a decline in stock size. Subjection of the existing data base to a computerized C/E standardization routine developed by Miller and Gaffney (1979) confirmed this suspicion and ultimately led to the more conservative pandalid shrimp management strategy presently in effect. Detailed discussions and evaluations of this C/E standardization routine are presented in Jackson (1980, 1981). Another major research effort initiated since 1970 was the development and utilization of shrimp stock assessment surveys. These surveys presently comprise a major study component and the primary data source upon which the shrimp management strategy is based. Discussions of the gear, sampling techniques utilized, interpretation of results, and historical abundance indices from these surveys are found in Jackson (1981). These surveys provide two primary data types for each fishing section surveyed: first, a series of stock abundance indices which are directly comparable and used to monitor stock strength; and second, size composition profiles which are used to monitor recruitment, growth, and the effects of fishing on overall age structure.

It becomes obvious, therefore, that studies by the Alaska Pandalid Shrimp Research Program have necessarily been closely aligned with fishery management needs. This has been especially true since 1979, at which time trawl survey techniques were refined and a shrimp management strategy was developed which directly utilized survey results as a primary data source for harvest level determination.

The shrimp research staff has also been instrumental in the development, implementation, and evaluation of the existing shrimp management strategy. It must be stressed here, however, that this development and evaluation is by no means complete. In light of the complex and changing nature of the shrimp fishery, final development of this strategy will be a long term process, with the final strategy possibly different from that presently in effect.

Present Program Objectives

The primary responsibility of shrimp research has typically been to design and conduct studies to evaluate the abundance and condition of commercially utilized shrimp stocks. In light of the rapid expansion of the shrimp fishery and subsequent downward abundance trends discussed earlier, research efforts in the mid-1970's concentrated on assessment of stock condition at various harvest rates. A major project goal since 1979 has been the development, implementation, and evaluation of a comprehensive shrimp management strategy. This effort led to the formal adoption of the existing management strategy described later in this report, which represents a concerted effort by research and management personnel as well as by interested public and industry representatives. It is important to note here that the primary criteria of this strategy, those which define stock condition categories and constitute the basis for calculating harvest levels are obtained from studies conducted by the shrimp research staff.

Analyses of stock condition are dependent upon three long term historical data bases: C/E, indexing of stock abundance, and size/age composition analyses of commercial and research catches. These three data bases, although obtained independently, are closely related and interdependent indicators of stock condition.

Data on C/E are obtained from the commercial fleet through a voluntary trawl logbook program and are designed to monitor density of major stocks over time in terms of pounds caught per hour trawled. The stock density parameters provided by these data, while standardized and directly comparable, are not intended to represent total stock magnitude as are stock abundance, indices; rather, they provide a convenient and long term monitor of fleet success on commercially utilized stocks. In view of certain density dependent factors, however, direct interpretation of C/E data must be approached with caution. These considerations are discussed by Jackson (1980). Nevertheless, the existing C/E data base available by time and area since 1967 provide an excellent indicator of stock condition and an in-season management tool.

The most recently initiated aspect of the shrimp research program is the assessment of stock abundance through resource surveys using trawls. As opposed to C/E data which provide indices of stock density, stock assessment surveys provide continuing indices of total abundance which can be directly compared between seasons and areas. The data base on stock assessment is available since 1971, although that obtained since 1975 incorporates improved methodologies and procedures. In addition to monitoring total abundance, these surveys yield data on size composition, an essential parameter for analyzing stock condition. Analyses of size composition data provides insight into the mechanisms responsible for fluctuations seen in total abundance which may in turn suggest the optimum management approaches to best maintain or improve stock condition.

The fluctuations and interrelationships seen in these three data sources, especially during the last three seasons, warrants their detailed discussion. The objective of this discussion is twofold: first to attempt an explanation of the mechanism behind the pronounced declines in shrimp stock abundance throughout the Westward Region; and second, to present and discuss shrimp research findings and results during the last two seasons. This discussion considers each data type separately and discusses overall similarities and differences between districts

and individual fishing sections. While emphasis will be placed on the last two fishing seasons, the entire data bases for the Chignik, Alaska Peninsula, and Aleutian Districts will be presented to facilitate discussion as they have not previously been reported.

Catch-Per-Effort Study

The ongoing C/E study was initiated in 1968 and is the shrimp research program's most long standing facet of work. The data base derived from this study consists of a series of directly comparable stock density indices based on commercial fishing effort, and should not be confused with the stock abundance indices from trawl survys which are more directly related to total standing stock. The C/E data derived from the commercial fleet via trawl logbooks include location, depth, and duration as well as gear type and size for each tow made. These data are entered directly from the edited fishermen's log into the permanent data file. The time-intensive aspect of this study is soliciting fisherman participation as well as obtaining and editing completed logbooks. As mentioned earlier in this report, the need for and subsequent development of standardization of raw C/E data stemmed from the evolution to larger, more efficient vessels and gear types in the early 1970's. This change in gear type and vessel efficiency precluded the ability to directly compare unstandardized C/E data between seasons and areas. Detailed discussions and evaluations of the logbook program and the data standardization procedures are discussed by Jackson (1980, 1981) and Miller and Gaffney (1979).

Data on C/E were obtained from 1,166 and 2,406 individual tows during the 1981-82 and 1982-83 seasons, respectively. This sample represents 2,813 and 5,963 trawl hours of fishing in each of these respective seasons. The approximately 6.1 million lb (2,773 mt) total catch recorded in trawl logbooks during the 1982-83 season (Table 3) represents 57% of the 10.7 million lb (4,864 mt) regional catch (Table 1). The proportion of the 1982-83 seasonal catch from the region logged (57%) is nearly double the 31% logged in the 1981-82 season. The 1982-83 seasonal C/E values for all districts combined of 1,016 lb (461 kg) per trawl hour (Table 3) is 42% and 43% of the seasonal C/E rates in 1980-81 and 1981-82 seasons, respectively.

The highest district-wide C/E rates during the 1981-82 and 1982-83 seasons were in Kodiak at 2,379 and 1,039 lb (1,079 and 471 kg) per hour, respectively (Table 3). These 1981-82 and 1982-83 C/E rates were followed by those in the Aleutian District at 2,074 and 759 lb (941 and 344 kg) per hour, and the Chignik District at 200 and 60 lb (91 and 27 kg) per hour, respectively. As the Alaska Peninsula District has been closed to commercial shrimp trawling during the last three seasons because of continued low abundance levels, C/E data for this district during these seasons do not exist. Sections open to trawling in the Chignik District during the last two seasons were limited to the Chiginagak, Nakalilok, and Aniakchak Bay grounds where effort was minimal and largely unsuccessful. Effort in the Aleutian District has been by only two vessels and confined primarily to Makushin Bay (Table 3).

The highest 1982-83 seasonal C/E rate is the Westward Region was in the Chiniak Bay section at 2,637 lb (1,196 kg) per hour (Table 3). The Chiniak Bay fishery during the last two seasons has been characterized by intense effort in an approximate 5 square mile fishing area. The 1982-83 Chiniak Bay fishery occurred in June,

Table 3. Seasonal unstandardized C/E rates by shrimp fishing section in the Westward Region for the 1980-81 through 1982-83 seasons. Catch-per-unit-effort rates shown in pounds per trawl hour.

	Fishing Season											
	1980-81				1981-82				1982-83			
Fishing Section	Tows	Lbs	Hrs	C/E	Tows	Lbs	Hrs	C/E	Tows	Lbs	Hrs	C/E
North Afognak[1]	252	866,492	517	1,676	36	97,371	93	1,047	368	697,077	1,061	657
Chiniak Bay	12	47,796	28	1,707	131	959,700	210	4,570	58	255,789	97	2,637
Ugak Bay	60	464,184	216	2,149			CL				CL	
Twoheaded Island	154	554,264	316	1,754	242	1,407,089	761	1,849			CL	
Olga Bay	152	471,366	258	1,827	39	120,387	101	1,678	149	360,917	233	1,547
Alitak Bay	366	2,680,900	830	3,230	228	1,555,965	639	2,435	977	2,564,470	2,390	1,073
Alitak Flats	516	2,327,904	1,644	1,416	50	241,056	186	1,296			CL	
Uyak Bay	47	153,699	91	1,689			CL				CL	
West Afognak[3]	142	466,918	314	1,487	9	954	3	318	1	400	1.7	235
Kukak Bay	159	531,706	233	2,282	24	94,855	61	1,555	289	765,765	765	1,001
North Shelikof[1]	63	185,610	115	1,614			NL		3	-	-	0
South Shelikof[2]	18	58,072	34	1,708	57	460,530	90	5,117	205	442,628	478	926
Wide Bay[4]	34	449,637	67	6,711	41	325,656	72	4,523	177	600,762	446	1,347
Uganik Bay	-	-	-	CL	5	500	5	100			CL	
Viekoda Bay	-	-	-	CL	2	1,200	1	1,200			CL	
Inner Marmot	-	-	-	CL	205	945,199	409	2,311			CL	
Subtotals	1,975	9,258,548	4,663	1,986	1,069	6,260,462	2,631	2,379	2,227	5,687,808	5,471.7	1,039
Kujulik Bay	219	2,212,816	464	4,769			CL				CL	
Chignik Bay	359	1,990,667	763	2,609			CL[5]				CL	
Kuiukta Bay	2	11,550	3	3,850			CL				CL	
Sutwik Island[6]	22	87,110	72	1,405	1		-	0	2	-	-	0
Port Wrangell	149	1,364,794	293	4,658	1	200	1	200	5	150	2.5	60
Subtotals	751	5,666,937	1,585	3,575	2	200	1	200	7	150	2.5	60
Usof Bay	86	323,628	181	1,788	5	12,648	8	1,581	1	-	-	0
Makushin Bay	384	1,957,340	682	2,870	80	337,783	149	2,267	167	369,889	481	769
Unalaska Bay	90	333,394	178	1,873	10	24,936	24	1,039	4	1,432	8	179
Subtotals	560	2,614,362	1,041	2,511	95	375,367	181	2,074	172	371,321	489	759
GRAND TOTALS	3,286	17,539,847	7,289	2,406	1,166	6,636,029	2,813	2,359	2,406	6,059,279	5,963	1,016

-Continued-

Table 3. Seasonal unstandardized C/E rates by shrimp fishing section in the Westward Region for the 1980-81 through 1982-83 seasons. Catch-per-unit-effort rates shown in pounds per trawl hour (continued).

NL - No logs

CL - Closed

[1] Northern Shelikof Strait area, not including mainland shoreline, but including west shoreline of Afognak Island. Not an established shrimp fishing section.

[2] Central offshore Shelikof Strait area. Not an established shrimp fishing section.

[3] Currently open - totals include up to 11/82 for the 1982-83 season.

[4] Currently closed pending test fishery - totals include up to 11/82 for the 1982-83 season.

[5] Offshore Chignik District opened 28 July - 14 February.

[6] Sutwik section divided into three new sections - Chiginagak, Nakalilok, and Aniakchak Bays, April, 1981.

lasted only 5 days, was commonly utilized by as many as 12 vessels simultaneously, and yielded 1.38 million lb (627 mt). The second highest 1982-83 seasonal C/E rate was in Olga Bay of 1,547 lb (703 kg) per hour. This fishery was utilized by 10 vessels and was characterized by highly variable C/E rates ranging from 700 to 2,100 lb (317 to 952 kg) per hour, and closed after a harvest of 0.94 million lb (427 mt) was obtained. The third and fourth highest C/E rates during the 1982-83 season were in Wide and Alitak Bays, respectively. The Wide Bay fishery was characterized by high incidences (80% - 90%) of 1-year-old shrimp and was closed early for this reason. Alitak Bay, on the other hand, performed more poorly than expected based on the pre-season survey. In spite of the continuing low C/E rates, the season remained open from 15 June through 31 July at which time the 3.7 million lb (1,682 mt) harvest level was obtained.

The changing nature of the Westward Region fishery resulting from the declines in overall shrimp abundance appears to have affected the comparability of C/E data. This change is due largely to the limited number of areas being opened to fishing and their relatively modest harvest levels. The resulting intense competition and fishing pressure during these openings have resulted in a "pulse" fishing situation. It is doubtful that either standardized or unstandardized C/E generated from this type of fishery are valid or directly comparable with those in earlier more stable periods. Although the logbook program has and will continue, the C/E data generated during the last two seasons is considered to have limited value. It appears that these data are most valuable as a management tool to answer in-season questions and to provide a vehicle for maintaining contact and public relations with the commercial fleet.

Shrimp Stock Assessment Surveys

The primary objective of stock assessment surveys is to provide a continuing base of directly comparable seasonal abundance indices for major stocks. These indices provide one of the three primary data sources from which stock condition is determined. The present rationale and methodologies for this stock assessment remain essentially unchanged from those described by Gaffney (1978), and Jackson (1975), the only exception being that certain on-board procedures have been modified for increased efficiency. Survey approach is based on the premise that the shrimp concentrations found on the various major grounds (e.g., Twoheaded Island, Chignik Bay) are independent stocks which remain intact between seasons and do not migrate between grounds. The total area inhabited seasonally by all portions of each stock (as determined from prior studies of distribution and size composition) is defined, then overlayed with a standardized sampling grid to permit unbiased station selection. Sampling consists of a series of straight line 1-mile (1.6 km) tows in each fishing section selected on a random-systematic basis. Standardized gear and towing procedures are used to insure constant fishing power and comparability of results. Abundance indices are calculated using an area-swept technique. Minimum sampling intensity is one tow per four square nautical miles (6.4 km^2) as this level usually results in percentage errors around estimated means no greater than the desired ± 25% at the 80% confidence interval. It is essential in evaluating these estimates to recognize that they are indices rather than absolute measures of total abundance. This is due to two primary reasons. First, the fact that indices are calculated on a trawl efficiency factor of 1.0 results in their being less than the actual stock abundance. This is because some shrimp, especially smaller individuals, escape through the meshes and because at times the vertical height of some shrimp off the bottom is greater

than that of the trawl. Unfortunately, the true efficiency factor, whatever it is, is not constant, thus creating an inherent error source. Second, the fact that surveys can only cover those portions of the area which are trawlable, results in estimates being biased downward. This is because the mean catch rates are not expanded into these untrawlable areas when calculating abundance indices. Studies directed at determining the precise magnitude that stock assessment surveys underestimate actual stock size are presently underway. So long as survey approach and methodology remain constant, however, the fact that these estimates are actually indices of the absolute abundance should make little difference in evaluating stock condition so long as they are recognized as indices and interpreted accordingly.

Shrimp stock assessment surveys in the Westward Region have constituted a major program function since their institution in 1971. Since that time this work has comprised a major financial expenditure and, especially during the last two seasons, has been the program's most controversial function. This controversy is due largely to the fact that abundance indices (trawl surveys) are used directly to determine harvest levels. The techniques and procedures utilized to generate abundance indices were initiated and developed in the Kodiak District, then expanded to major grounds of the Chignik District in 1974. In addition, the National Marine Fisheries Service (NMFS) through cooperative agreement, has conducted comparable trawl surveys of major Alaska Peninsula District grounds from 1971 through 1980.

Intensity of stock assessment effort in most areas consists of pre- and post-season surveys conducted in the 15 May - 15 June and 15 August - 15 September periods, respectively. This schedule enables assessment of recruitment, carry-over of post-recruit age classes, and the effects of fishing as well as growth rate and mortality. Survey intensity prior to 1979 in the Kodiak District was higher because of better vessel availability. Tabulation of all Westward Region stock assessment surveys by month, year, and fishing section through 1981 is shown in the Westward Region Shellfish Report to the Board of Fisheries, March 1982 (ADF&G 1982).

Shrimp stock assessment effort in 1981-82 and 1982-83 seasons consisted of 962 individual tows in 32 fishing sections (Appendix Table 1). The total survey effort in 1982-83 (435 tows) was 17% less than the 527 tows made in 1981-82. This decline is a result of partial assessment of the Chignik and Alaska Peninsula Districts in the fall of 1982 because of the unavailability of the state vessel (Appendix Table 1).

Between-season comparisons of successive spring and fall abundance indices in major fishing sections from spring 1975 through fall 1982 show the decline in overall stock abundance in all sections surveyed to have continued through 1982. As in post-seasons, the between-season comparisons are made independently for spring and fall survey periods because of characteristic abundance differences. With the minor exception of Chignik Bay, the indices obtained in 1982 were among the lowest in survey history. The fall 1982 Chignik Bay abundance index of 1.15 million lb (522 mt) exceeds only slightly the historical low of 0.96 million lb (436 mt) set in the fall of 1981. An unusual result of the 1982-83 season surveys is the fact that spring abundance indices in all sections fished exceeded those in the fall (Figure 3). It is of interest to note, however, that the fall 1982

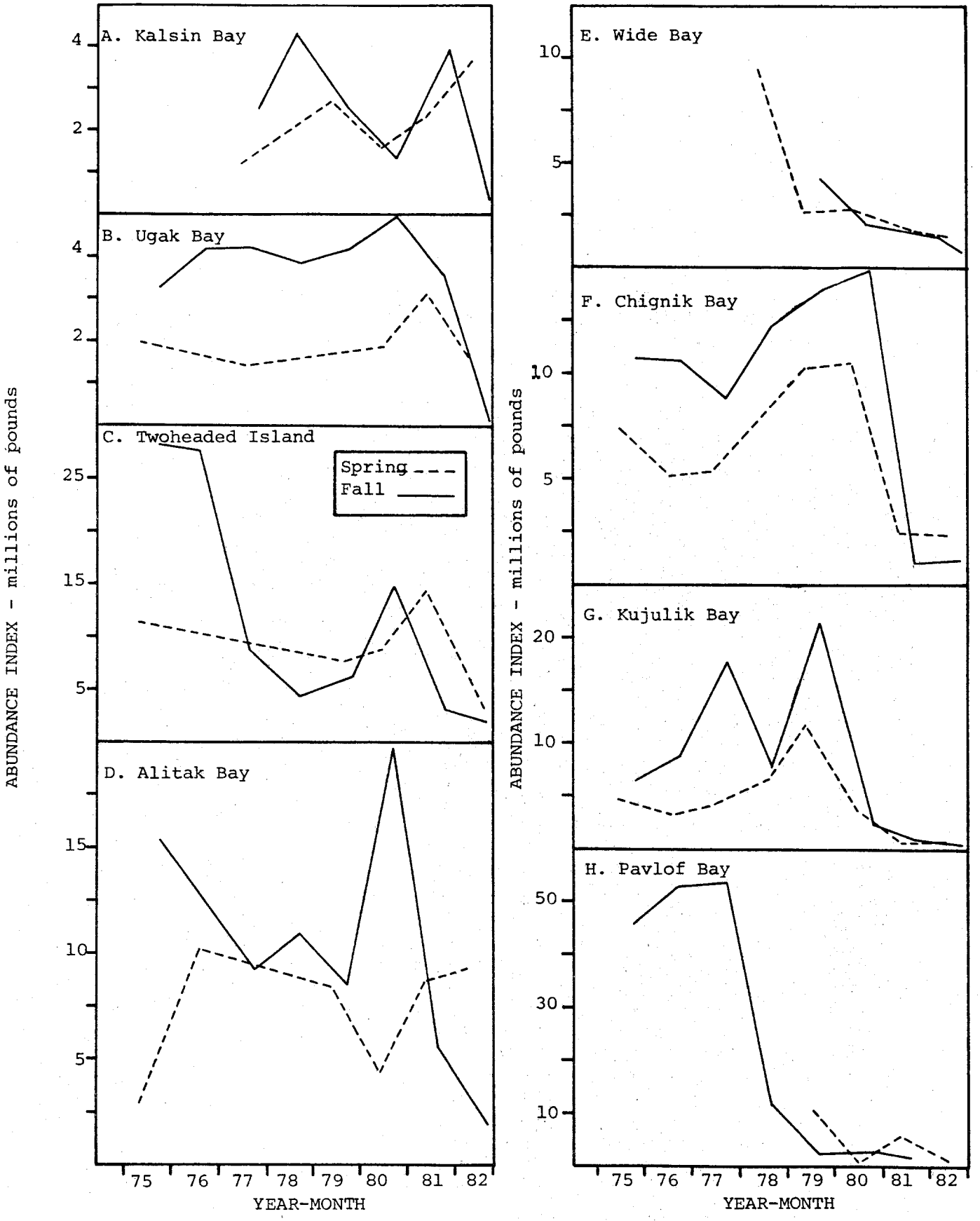

Figure 3. Spring and fall shrimp stock abundance indices from major fishing sections of the Westward Region, 1975-1982.

abundance indices in approximately one-half of the minor production areas surveyed and were closed to fishing, exceeded those in the spring (Appendix Table 1).

The fact that spring 1982 abundance indices in all major sections fished uniformly exceeded those in the fall is unusual from two standpoints. First, review of historical abundance indices from major areas shows fall indices are normally greater than those in the spring. Only in 1982 have spring indices in a significant number of sections exceeded those in the fall. Second, higher indices in the fall would normally be expected as the shrimp at this time are generally larger because of the summer period of rapid growth. This results in the younger (primarily 1-year-old) age groups in the fall being larger and more vulnerable to trawls than in the spring. Moreover, the abundance of all age groups appears to be normally greater in the fall, due probably to seasonal distribution cycles which are poorly understood at this time. Because fall indices exceed those in the spring, the stock condition categories and seasonal harvest levels, described later in this report under the shrimp management strategy, are based on them. The staff has also proposed for the last 2 years that the Alaska Board of Fisheries (BOF) adopt a shrimp season opening of 1 September rather than 15 June (ADF&G 1982).

A second data source derived from shrimp stock assessment surveys is the composite size (age) frequency distributions from each stock surveyed. These data are used to determine year class success as well as mortality and recruitment rates. Evaluation of fluctuations in the abundance of successive age groups is essential in managing shrimp stocks as it provides insight into the mechanisms influencing abundance. As maintenance of a reasonably balanced age structure is probably essential for stock stability, continuous monitoring of these parameters is an integral part of stock assessment and the existing management strategy. A problem initially encountered with utilizing these data, however, was development of a sampling plan which would produce representative samples from the necessarily large volume of data in a rapid and efficient manner. In view of the labor and time intensive nature of shrimp sampling, achievement of these goals required considerable planning and experimentation.

Several methods of obtaining complete and valid composite catch samples were tried during the early 1970's, but most proved to be cumbersome in light of the required high number of observations and degree of data organization required. Presently two complimentary procedures are used simultaneously. The first procedure prescribes physically combining a constant proportion of each haul's catch into a composite. A subsample of this composite is then extracted for laboratory determination of length and sex frequency. Additionally, a fixed number of shrimp (300) are randomly measured from each tow aboard the vessel. Through the use of a computer routine, the size frequency distribution from the individual tows made within each stock are mathematically weighted by catch weight and distance into an overall average distribution. This provides a high volume unsexed sample, permitting better age group definition yet preserves the integrity of the individual tow parameters. The resulting distributions are printed out as part of the routine computer output and have proven to be instrumental in facilitating size frequency analyses.

Stock condition is evaluated by comparing abundance trends of individual age groups within and between fishing seasons over the desired time spans. This is

normally done by comparing abundance of each age group between fishing seasons, or between season comparisons of the proportion of the total abundance comprised by each age group. As with stock abundance indices, between year comparisons of age group abundance are normally made between similar months so as to avoid the influence of characteristic spring-fall abundance differences. All age composition data obtained from stock assessment surveys conducted since 1974 have been composited in this manner.

The technique described above for mathematically combining and summarizing size frequency data has three distinct advantages. First, it yields the necessary large volume sample size for construction of accurate length frequency profiles. Second, it presents the data in a manner which permits determination of age composition on absolute (number of shrimp per mile trawled) as well as relative (percentage) bases. This permits direct between-survey comparisons of abundance indices. The third advantage is the rapidity in which size composition analyses can be prepared following surveys; this is often essential in order to facilitate management decisions. A detailed discussion of this sampling procedure is included in Jackson (1980).

Age group delineations are based primarily on the size ranges occupied by each cohort seen in plotted length frequency distributions. Delineation of age groups often requires inspection of the individual tow frequencies as certain age group boundaries may be indistinct within overall average distributions. Determination of sexual state is also of assistance when available. Availability of the sexual state as well as length parameters considerably increases the precision with which the size ranges occupied by individual age groups can be determined. A computer routine is presently being perfected through which the frequencies from the lower volume but highly labor-intensive size-sex distributions can be mathematically integrated with the high volume unsexed samples on a routine basis. Perfection of this program should significantly increase the efficiency and precision with which age analyses can be made.

Age group determinations are based on the abundance (shrimp per mile trawled) of shrimp falling into the following approximate size/age groupings: 0+ (less than 9 mm carapace length); 1+ (9 mm through 10 mm carapace length); 2+ (11 mm through 14 mm carapace length); 3+ and older (15 mm and larger). The size ranges given for each age group are approximate, and are determined independently from each composite length frequency profile analyzed. The actual age ranges associated with these age group designations are: 0+ (less than 12 months of age); 1+ (12 months through 23 months of age); 2+ (24 through 35 months of age); and 3+ and older (greater than 35 months of age).

While comparisons between consecutive spring and fall size/age composition profiles show several minor trends, the most obvious is the simultaneous and pronounced declines in the abundance of all size groups in 1981 and 1982 (Table 4, Figure 4). While declines of similar magnitude were not uncommon for isolated age groups prior to 1980, they are usually accompanied by more substantial abundances of other age groups. These isolated declines in earlier years, in most cases, probably resulted from fluctuating recruitment levels. Only in the last two seasons have the simultaneous abundance declines of all age groups been so apparent.

Table 4. Abundance of major size (age) groups of pink shrimp *(Pandalus borealis)* in major fishing sections of the Westward Region as determined by catch samples obtained during stock assessment surveys from spring 1974 through fall 1982.

Fishing Section	Year	Season (Mo.-Day)	Age Group 0+ %	0+ Shr./mi.	1+ %	1+ Shr./mi.	2+ %	2+ Shr./mi.	3+** %	3+** Shr./mi
Kalsin Bay	1979	Fall (10-11)	-	0	74.3	53,373	9.4	6,766	16.3	11,749
	1980	Spring (5-2)	-	0	2.1	1,775	85.5	73,465	12.4	10,659
	1980	Fall (9-2)	-	0	6.0	5,009	36.4	30,202	57.6	47,842
	1981	Spring (5-9)	-	0	6.5	7,068	27.0	29,167	66.5	71,988
	1981	Fall (9-3)	1.0	2,206	30.8	65,778	29.8	63,794	38.4	82,085
	1982	Spring (5-11)	-	0	28.5	40,893	37.9	54,384	33.6	48,297
	1982	Fall (9-6)	1.0	124	28.9	3,781	41.5	5,422	28.6	3,740
Ugak Bay	1974	Fall (8-6)	-	0	5.9	3,162	28.3	15,114	65.8	35,152
	1975	Fall (8-6)	-	0	17.8	5,576	52.3	16,418	29.9	9,397
	1976	Fall (9-3)	-	0	66.6	28,461	19.5	8,315	13.9	5,974
	1977	Fall (8-30)	-	0	16.3	11,055	51.3	34,885	32.4	21,972
	1978	Fall (9-4)	-	0	58.4	40,663	18.3	12,757	23.3	16,211
	1979	Fall (10-26)	-	0	55.0	36,069	11.1	7,291	33.8	22,167
	1980	Spring (5-3)	0.1	16	0.6	395	57.6	36,218	41.8	26,264
	1980	Fall (8-22)	-	0	6.1	2,123	49.1	17,011	44.8	15,543
	1981	Spring (5-10)	-	0	25.6	25,007	8.1	7,880	66.3	64,702
	1981	Fall (9-5)	-	0	45.0	18,550	12.9	5,306	42.1	17,335
	1982	Spring (5-82)	-	0	18.1	762	30.5	1,288	51.4	2,168
	1982	Fall (9-82)	-	0	-	0	-	0	-	0
Twoheaded Is.	1976	Spring (7-1)	0.2	341	14.3	24,478	48.2	82,565	37.3	63,900
	1977	Fall (8-28)	-	0	47.7	43,345	28.7	26,028	23.6	21,402
	1978	Fall (8-2)	-	0	27.9	8,552	27.9	8,573	44.2	13,579
	1979	Spring (7-29)	-	0	64.3	45,488	9.9	7,034	25.8	18,220
	1979	Fall (9-8)	-	0	71.0	43,159	10.3	6,239	18.7	11,374
	1980	Spring (5-8)	-	0	6.5	3,554	25.2	13,903	68.3	37,542
	1980	Fall (8-27)	-	0	2.6	2,215	3.6	3,070	93.8	79,327
	1981	Spring (5-14)	-	0	28.2	40,570	23.8	34,159	48.0	69,030
	1981	Fall (9-8)	0.2	149	56.7	19,698	14.7	5,139	28.4	9,913
	1982	Spring (5-18)	-	0	24.6	5,594	11.4	2,597	64.0	14,526
	1982	Fall (9-1)	-	0	-	0	-	0	-	0
Alitak Bay	1974	Spring (5-10)	-	0	1.0	1,620	52.5	85,225	46.5	75,503
	1975	Fall (8-3)	-	0	2.8	1,961	6.9	4,900	90.3	64,028
	1976	Spring (6-30)	-	0	3.4	2,198	24.8	16,104	71.8	46,642
	1977	Fall (8-29)	-	0	9.2	2,772	22.8	6,905	68.0	20,556
	1978	Fall (8-28)	0.1	61	4.8	2,683	50.2	27,966	44.9	25,041
	1979	Spring (5-15)	1.3	847	11.3	7,097	9.3	5,879	78.1	49,252
	1979	Fall (9-7)	-	0	41.2	18,134	13.0	5,727	45.8	20,161
	1980	Spring (5-12)	-	0	1.0	312	37.4	12,038	61.6	19,873
	1980	Fall (8-30)	-	0	18.3	8,183	43.1	19,318	38.6	17,310
	1981	Spring (5-18)	-	0	2.9	1,318	28.9	13,003	68.2	30,625
	1981	Fall (9-12)	-	0	12.2	4,563	34.3	12,859	53.5	20,061
	1982	Spring (6-5)	-	0	3.1	2,389	23.2	18,127	73.7	57,582
	1982	Fall (8-28)	0.1	16	21.1	3,243	12.1	1,855	66.7	10,237

-Continued-

Table 4. Abundance of major size (age) groups of pink shrimp *(Pandalus borealis)* in major fishing sections of the Westward Region as determined by catch samples obtained during stock assessment surveys from spring 1974 through fall 1982 (continued).

Fishing Section	Year	Season (Mo.-Day)	Age Group 0+ %	0+ Shr./mi	1+ %	1+ Shr./mi.	2+ %	2+ Shr./mi.	3+** %	3+** Shr./mi.
Wide Bay	1979	Spring (5-19)	1.7	923	40.7	21,854	35.0	18,803	22.6	12,135
	1979	Fall (8-31)			74.7	50,401	8.3	5,629	17.0	11,453
	1980	Spring (6-12)	0.1	73	28.4	13,375	47.8	22,515	23.7	11,177
	1980	Fall (9-15)			59.0	27,006	28.3	12,951	12.7	5,784
	1981	Spring (5-26)			11.1	9,832	71.2	63,115	17.1	15,669
	1981	Fall (9-18)			21.0	10,506	61.5	30,718	17.4	8,711
	1982	Spring (6-7)			43.3	26,873	40.6	25,130	16.1	9,991
	1982	Fall (9-21)	1.1	319	60.6	17,514	21.6	6,236	16.7	4,842
Kujulik Bay	1974	Spring (5-28)	1.1	1,840	39.5	67,629	24.0	41,166	35.4	60,646
	1975	Spring (7-4)	2.9	13,992	19.6	92,562	31.7	149,609	45.8	216,341
	1976	Spring (6-3)			7.6	8,238	40.2	43,541	52.2	56,485
	1977	Spring (5-24)	1.7	1,903	40.0	44,507	29.7	33,080	28.6	31,896
	1978	Fall (8-20)			10.4	22,831	51.2	112,323	38.4	84,015
	1979	Spring (5-23)			13.0	63,312	41.4	202,209	45.6	222,423
	1979	Fall (8-29)			36.5	133,721	46.7	171,174	16.8	61,558
	1980	Spring (5-28)			6.7	10,883	52.8	85,375	40.5	65,501
	1980	Fall (9-9)			11.7	8,922	58.6	44,906	29.7	22,748
	1981	Spring (5-30)			1.5	216	32.2	4,538	66.3	9,336
	1981	Fall (9-14)			33.9	7,171	23.0	4,879	43.1	9,114
	1982	Spring (5-14)			12.9	1,861	67.1	9,656	20.0	2,877
	1982	Fall (9-19)			46.6	3,015	4.9	316	48.6	3,145
Chignik Bay	1974	Spring (6-1)			6.5	7,651	24.9	29,194	68.6	80,212
	1975	Spring (7-5)	6.8	16,182	15.4	36,274	32.1	75,715	45.7	107,704
	1976	Spring (6-4)	5.8	2,191	20.0	7,472	29.2	10,909	45.0	16,815
	1977	Spring (5-26)			5.8	3,860	42.4	28,247	51.8	34,439
	1978	Fall (8-20)			55.5	26,213	37.3	17,625	7.2	3,390
	1979	Spring (5-25)			12.8	17,428	53.1	72,121	34.1	46,258
	1979	Fall (8-27)			28.0	60,110	38.4	82,581	33.6	72,033
	1980	Spring (5-27)	5.5	8,575	35.8	56,283	39.1	61,586	19.6	30,903
	1980	Fall (9-7)			6.6	14,580	54.9	120,321	38.5	84,373
	1981	Spring (6-1)			0.9	382	23.6	10,009	75.5	32,037
	1981	Fall (9-12)			15.3	1,879	37.6	4,615	47.1	5,777
	1982	Spring (5-30)			15.2	3,950	47.1	12,235	37.7	9,785
	1982	Fall (9-14)			18.8	2,590	15.6	2,151	65.6	9,037
Stepovak Bay	1980	Spring (6-80)			1.5	90	56.5	3,440	42.0	2,560
	1981	Spring (5-31)			16.7	3,420	42.1	8,628	41.2	8,441
	1981	Fall (9-7)			17.0	314	21.2	391	61.8	1,141
	1982	Spring (5-23)			9.8	983	21.8	2,190	68.4	6,982
Balboa-Unga	1980	Fall (8-25)			12.1	137	6.0	69	81.9	931
	1981	Fall (9-10)			64.4	2,739	4.3	182	31.3	1,330
	1982	Spring (5-21)			31.7	2,284	10.3	742	58.0	4,176

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Table 4. Abundance of major size (age) groups of pink shrimp *(Pandalus borealis)* in major fishing sections of the Westward Region as determined by catch samples obtained during stock assessment surveys from spring 1974 through fall 1982 (continued).

Fishing Section	Year	Season (Mo.-Day)	Age Group 0+ %	0+ Shr./mi.	1+ %	1+ Shr./mi.	2+ %	2+ Shr./mi.	3+** %	3+** Shr./mi
Pavlof Bay	1980	Spring (6-4)			1.9	30	69.0	1,070	22.0	452
	1980	Fall (8-24)	27.9	5,023	19.9	3,580	19.1	3,434	33.1	5,953
	1981	Spring (5-24)			18.7	5,648	14.8	4,462	66.5	20,061
	1982	Spring (5-19)			37.6	1,225	32.5	1,059	29.9	972

** Includes the 3+ and older age groups.

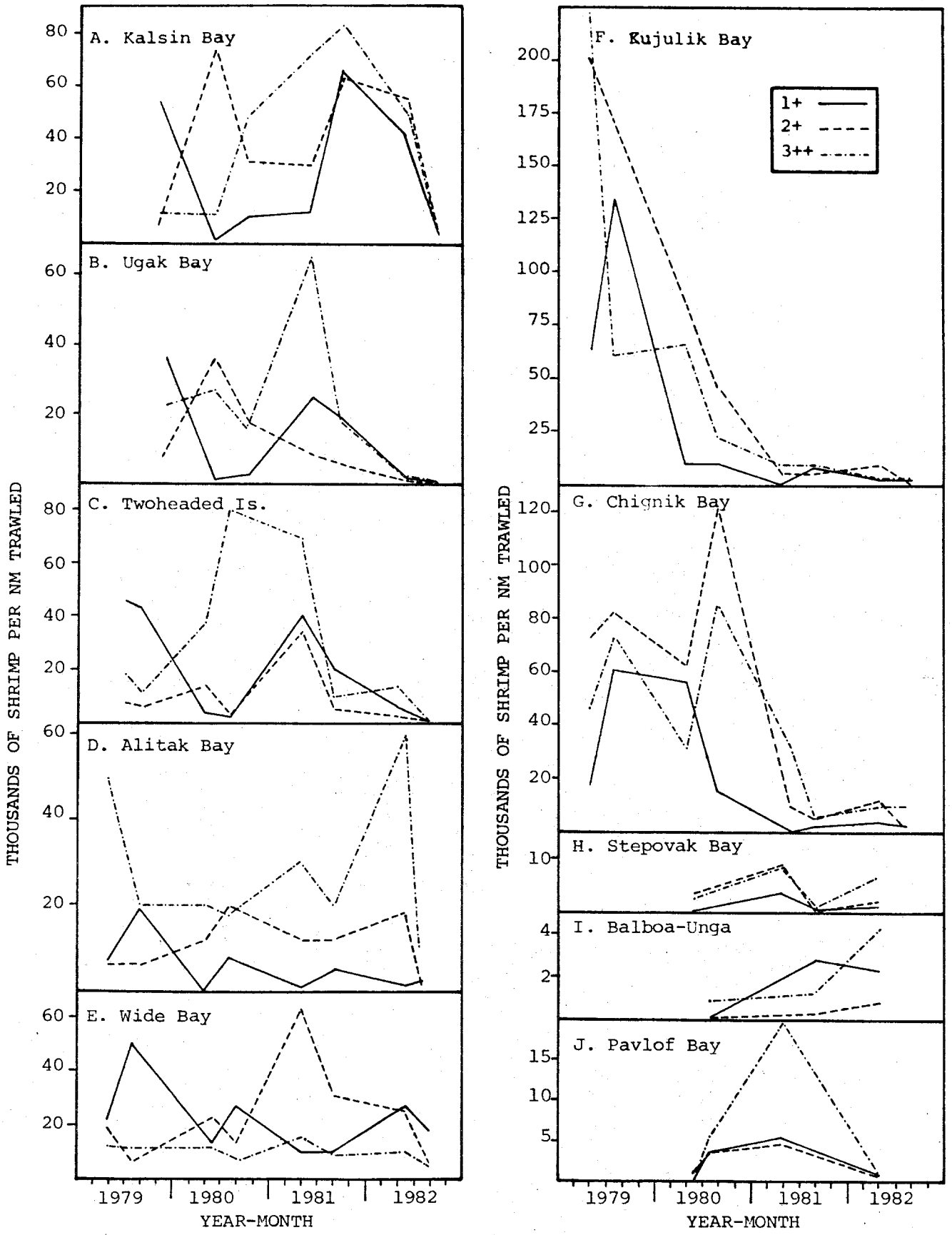

Figure 4. Successive abundance of major age groups of pink shrimp *(Pandalus borealis)* by month and year in major fishing sections of the Westward Region as determined from shrimp stock assessment surveys from spring 1979 through fall 1982.

The declines in abundance of all age groups is typified in the Chignik and Kujulik Bay sections, and best seen through between-year comparisons of their individual strengths. Visual inspection of the successive spring and fall size frequency profiles in Chignik and Kujulik Bays (Figures 5 and 6) shows three distinct size cohorts. Evaluation of the strength of similar size cohorts in these sections in successive years between 1979 and 1982 (in terms of number of shrimp per mile trawled) shows to significant trends. First, the strength of individual cohorts is seen to decrease progressively and generally most marked between 1980 and 1981. Based on fall surveys, the catch per mile for all cohorts combined in Chignik Bay declined from 219,264 in 1980 to 12,271 in 1981, a decline of 94% (Table 5). This was accompanied by a similar decline (74%) in Kujulik Bay (Table 5). The second significant trend is that these declines occurred simultaneously in all cohorts with no radical fluctuations seen in the percentage contributions of a given cohort in successive year's distributions. The proportion of successive distributions occupied by each cohort is also seen to differ between spring and fall because of characteristic seasonal differences in catchability and abundance (Figures 5 and 6).

The simultaneous declines seen in the abundance of each cohort coupled with the relatively consistent proportion of successive distributions occupied by each, suggests a mortality factor which is not size-selective. This contrasts with a size selective mortality factor which affects only individual age groups rather than all age groups simultaneously. Increased mortality of only the larval or juvenile portion of the stock, for example, would result initially in reduced recruitment, and the affected year class would remain weak as it passed through the fishery. Over-exploitation, on the other hand, would tend to have the greatest effect on the abundance of the older age cohorts initially as they are more susceptible to trawls because of their larger size. Neither of these mortality sources would be expected to affect the abundance of all size cohorts relatively equally as appears to be the case here.

The simultaneous abundance declines of all size cohorts of shrimp has coincided with an increasing abundance of Pacific cod *(Gadus macrocephalus)* and walleye pollock *(Theragra chalcogramma)* as determined from stock assessment survey catches. This increased incidental fish catch and the corresponding decline in shrimp abundance can be seen in Figure 7. Even cursory inspection of these data show three important consistencies between the eight major stocks.

First, catch rates for shrimp since 1980 have bcome progressively smaller while catches for incidental fish have progressively increased. Second, the 1982 catch rates for incidental fish groups in all major stocks except Wide Bay exceed those for shrimp. Although the 1982 catch rates for shrimp in Wide Bay slightly exceed those of a progressive 3-year decline (Figure 7). The third consistency is that the catch rates for shrimp in 1982 were consistently the lowest in the history of the shrimp stock assessment program.

Shrimp Management Strategy

The existing strategy for surveyed stocks is based on two thresholds of abundance which are established individually for each. Harvest rates are based on the relationship of abundance indices to these two abundance thresholds. The first of these, referred to as the "Representative Biomass Index" (RBI), is the mean

Table 5. Abundance and proportion comprised by each age cohort of pink shrimp *(Pandalus borealis)* in composite catch samples from successive spring and fall shrimp stock assessment surveys of Chignik and Kujulik Bays, 1979-1982.

Fishing Section	Age Cohort[1]	YEAR 1979 Spring No.	%	1979 Fall No.	%	1980 Spring No.	%	1980 Fall No.	%	1981 Spring No.	%	1981 Fall No.	%	1982 Spring No.	%	1982 Fall No.	%
Chignik	1	18,144	14.6	60,101	28.0	8,573	5.4	14,580	6.7	382	0.9	1,497	12.2	3,948	15.2	2,590	18.8
	2	67,376	54.4	87,163	40.6	59,721	38.0	125,237	57.1	10,010	23.6	4,997	40.7	3,223	12.4	2,150	15.6
	3	38,430	31.0	67,568	31.4	89,054	56.6	79,447	36.2	32,036	75.5	5,777	47.1	18,799	72.4	9,038	65.6
Totals		123,950	100.0	214,832	100.0	157,348	100.0	219,264	100.0	42,428	100.0	12,271	100.0	25,970	100.0	13,778	100.0
Kujulik	1	63,312	13.0	133,721	36.5	10,883	6.7	8,922	11.7	216	1.5	7,171	33.9	1,861	12.9	3,015	46.5
	2	202,209	41.5	177,465	48.4	89,298	55.2	44,906	58.6	4,538	32.2	5,326	25.1	9,656	67.1	316	4.9
	3	221,972	45.5	55,266	15.1	61,578	38.1	22,746	29.7	9,336	66.3	8,697	41.0	2,878	20.0	3,147	48.6
Totals		487,493	100.0	366,452	100.0	161,759	100.0	76,574	100.0	14,090	100.0	21,194	100.0	14,395	100.0	6,478	100.0

[1] Designation of age cohorts

1. Predominantly the 1+ age group
2. The 2+ and a portion of the 3+ age group
3. 3+ and all older age groups

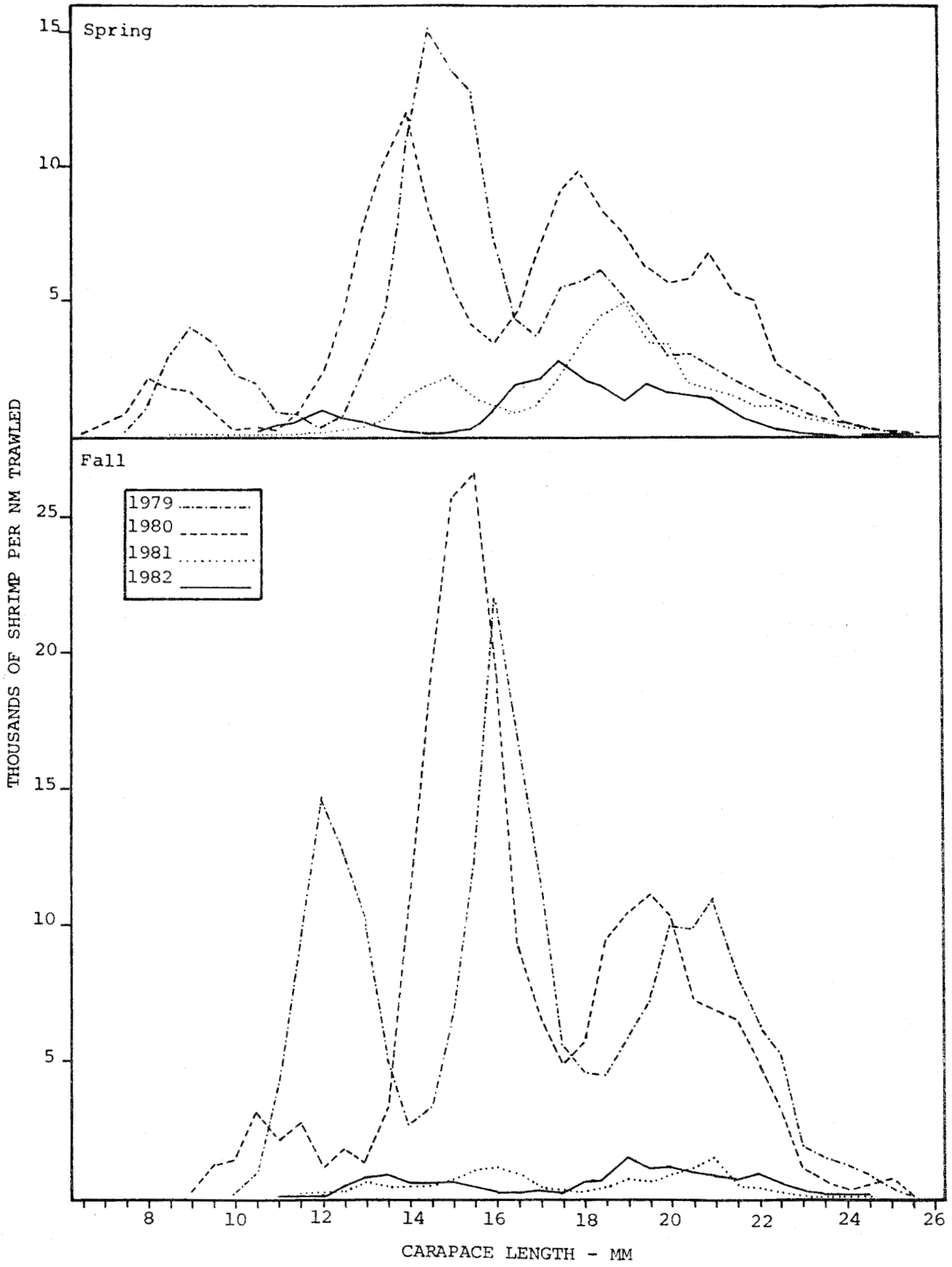

Figure 5. Seasonal size abundance profiles of pink shrimp *(P. borealis)* in Chignik Bay in 1979, 1980, 1981, and 1982 as determined from trawl survey results.

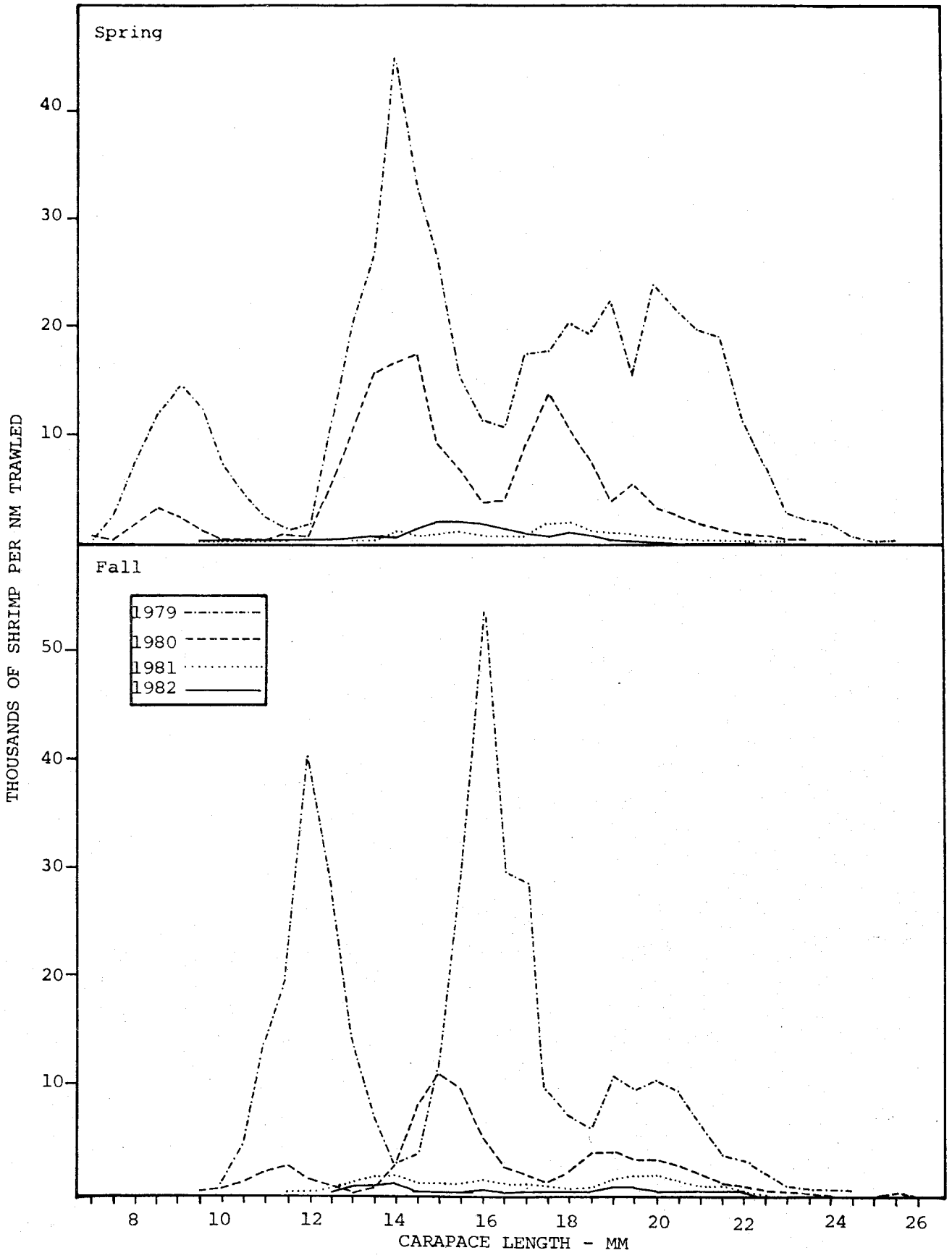

Figure 6. Seasonal size abundance profiles of pink shrimp *(P. borealis)* in Kujulik Bay in 1979, 1980, 1981, and 1982 as determined from trawl survey results.

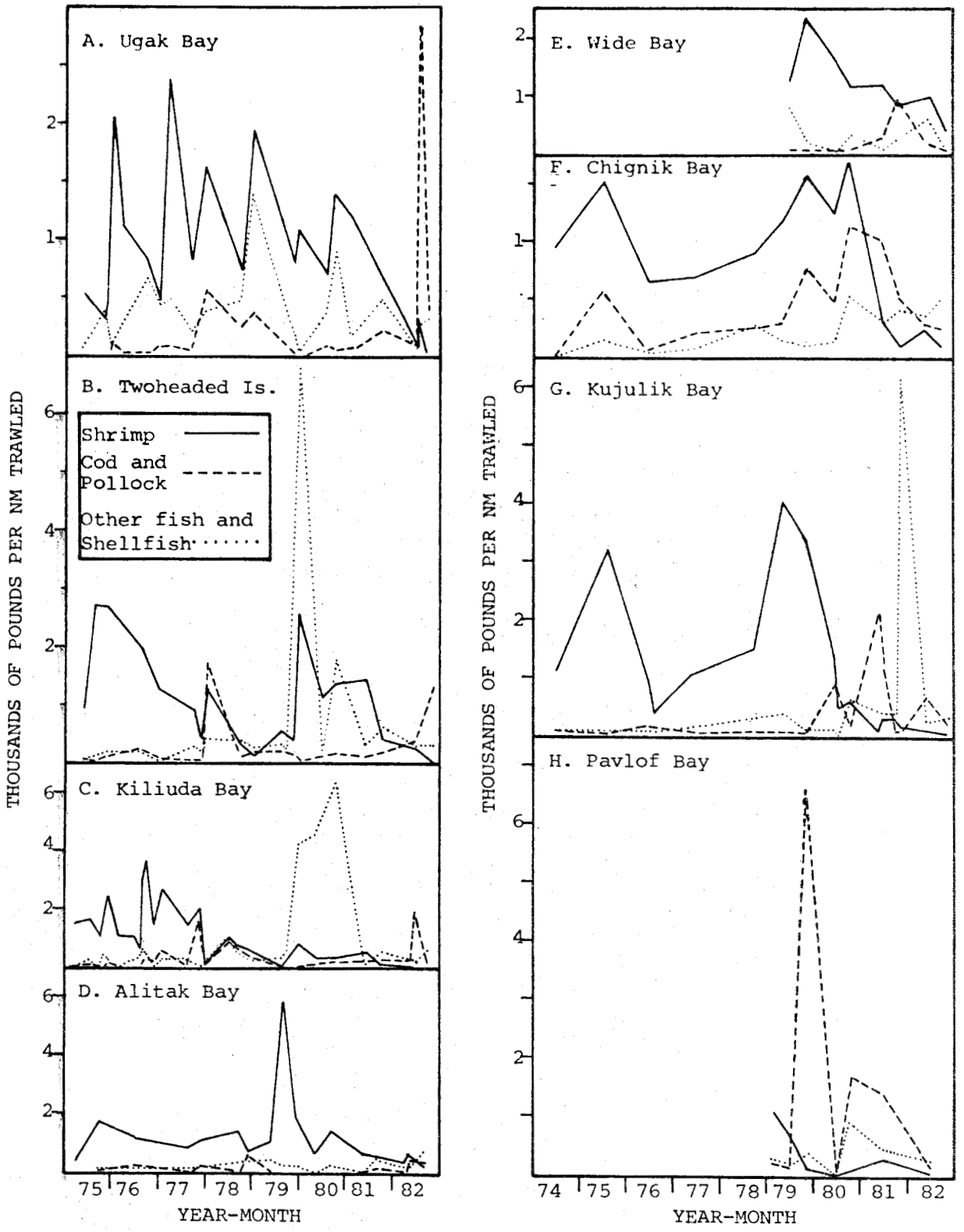

Figure 7. Catch rate of shrimp (all species) as opposed to cod and pollock and other incidentally caught fish and shellfish species during shrimp stock assessment surveys in the Westward Region, 1974-1982.

of individual fall abundance indices obtained from each stock following the initial commercial developmental period but prior to any significant decline. In other words, the RBI is a threshold point at which abundance should reasonably be expected to be maintained. The second of these threshold levels, called the "minimum acceptable biomass index" (MABI), is simply 40% of the RBI. Past experience indicates that stocks reduced below this point are slower to recover. This framework of RBI and MABI levels is used as a basis for classifying each major stock into one of three condition categories. These categories are "healthy", "recovering", and "severely depressed". A healthy stock is one where the most recent abundance index is at or above the RBI. A recovering stock is characterized by the most recent abundance index being less than the RBI, but at, or above the MABI. Severely depressed stocks are those with abundance indices below the MABI.

The objectives of this strategy are achieved by regulating harvest rates on healthy stocks in a manner that their abundance remains constant or increases only modestly, with all surplus production being harvestable. In order to promote rebuilding, harvest rates on recovering stocks are reduced, while severely depressed stocks remain closed. Based on past experience with stock response to varying biostatistical exploitation rates, optimum harvest rates presently appear to be zero percent for severely depressed stocks, 20% to 30% for recovering stocks, and 40% for healthy stocks. The foregoing rates assume a normally balanced age composition. In the event of a severe age class imbalance, the strategy stipulates that harvest rates for healthy and recovering stocks be decreased.

Due to the wide abundance range encompassed by recovering stocks, harvest rates on stocks within this category increase as abundance increases from the MABI to the RBI level. As stated earlier, the harvest rate for recovery stocks increases from 20% to 30% as the stock recovers from 40% to 100% of the MABI level. In order to promote the desired incremental harvest rate increases, the strategy stipulates that stocks with an abundance index of at least 40% but less than 70% of the RBI level with balanced age structure be harvested at 20%; stocks with an abundance index of at least 70% but less than 100% of the RBI level and balanced age structure be harvested at 30% of the abundance index. In the event age imbalance occurs, harvest rates on stocks with abundance indices between 40% and 70% of the RBI level are lowered to 15%, and those between 70% and 100% of the RBI are harvested at 20%. When stocks recover to 100% of RBI they move into the "healthy" category where they are harvested at 40% or 25%, depending on age structure.

Following below is a formal outline detailing stipulations and specifications of the existing shrimp management strategy presently in effect for both surveyed and unsurveyed shrimp stocks of the Westward Region.

I. Surveyed Stocks

A. Objectives

Manage pandalid shrimp stocks in a manner so as to obtain optimum yields from each. This is accomplished by harvesting healthy stocks at a higher rate than those in need of rebuilding. The overall goal will be to achieve maximum harvest without affecting reproductive potential.

B. Definitions

1. Representative biomass index (RBI): The mean of fall abundance indices, unless otherwise specified, obtained from each stock following the initial exploratory phase, but prior to any pronounced decline. The RBI is an index of the biomass level judged optimum for each stock. These values are derived by examining the fishery and survey history, and choosing a series of fall index values obtained after the initial period of high production, but before any pronounced decline. The RBI is the mean of the index values chosen. An alternative method is used for stocks which were not surveyed during the representative period. This approach entails expanding the mean RBI densities from areas where they are firmly established into the area encompassed by the stock in question.

2. Minimum acceptable biomass index (MABI): 40% of the RBI as defined in I.B.1. above.

3. Harvest rates: The proportion of an abundance index harvested in a given fishing period. These rates are based on abundance indices obtained from surveys immediately preceding the fishing period in question. For example, the harvest rate for a fishing section with a pre-season abundance index of 5.0 million lb (2,273 mt) and commercial catch during the subsequent fishing period of 2.0 million lb (909 mt) would be 2.0 divided by 5.0, or .40.

4. Harvest goal: The commercial catch allocated during a single fishing period.

5. Fishing period: The time period during which the harvest level (as defined in I.B.4.) based on a single abundance index is obtained by the commercial fishery.

6. Biological year: 1 April of one year through 31 March of the next.

7. Seasonal catch: The combined catch from a fishing section made in all fishing periods within a single biological year.

8. Fishing section: Defined stock boundaries of Statistical Area J as described in 5 AAC 31.505 of the 1982 Alaska Commercial Shellfish Regulations.

C. Strategy Criteria

1. Basic to this strategy is an optimum level of stock abundance referred to as the Representative Biomass Index (RBI). This level is defined in Section I.B.1. of this strategy. The RBI's for certain areas may be too high or too low and are subject to reevaluation in light of recovery rates and fishery performance indicators.

2. A second abundance index level, based on the RBI as defined above, is used to define the lower abundance level at which fishing can be allowed. This level, referred to as the Minimum Acceptable Biomass Index (MABI), is 40% of the RBI. This represents the minimal level at which a fishery will be conducted.

3. Establishment of the RBI and MABI levels provides a framework within which three categories of stock strength can be described.

   a. Healthy: stocks in which abundances are at or above the RBI.

   b. Recovering: stocks where abundance indices are below the RBI, but at or above the MABI.

   c. Severely depressed: stocks where abundance indices are below the MABI.

4. Fishing Periods.

   a. No more than two fishing periods will normally be permitted within any biological year as described in I.B.6. of this strategy. More than two fishing periods may be allowed but only on the basis of underharvests.

   b. Second fishing periods for any stock will be permitted only when the fall abundance index exceeds that in the spring, or is greater than 125% of the RBI.

   c. Second fishing periods will be conducted only when the calculated harvest goal for a stock is 500,000 lb (227 mt) or greater.

   d. Harvest rates for stocks shown by pre-season surveys to have pronounced imbalances of age class composition can be lowered to the following:

      (1) Healthy stocks: 25%

      (2) Recoverying stocks:

         (a) 15% - Those with abundance indices at or above 40%, but less than 70% of the RBI.

         (b) 20% - Those with abundance indices at or above 70%, but less than 100% of the RBI.

5. Harvest Rates:

   a. Fishing is not permitted on stocks categorized as severely depressed.

   b. First fishing periods:

      (1) Healthy stocks: 40% of the abundance index obtained by the trawl survey immediately prior to the fishing period in question.

(2) Recovering stocks:

(a) 20% - Those with abundance indices at or above 40%, but less than 70% of the RBI.

(b) 30% - Those with abundance indices at or above 70%, but less than 100% of the RBI.

c. Second fishing periods: Harvest criteria for second fishing periods are described in Section I.C.6.c. below.

6. Harvest Goals:

a. Harvest goals are obtained by applying the appropriate harvest rate to the abundance index as determined by this strategy rounding to the nearest 100,000 lb (45.4 mt).

b. In fishing sections where more than a single species is encountered, harvest goals will be based on the abundance of the primary species as determined by the abundance index for that species and stipulations of this management strategy. Harvest goals in such sections are determined by first calculating the desired primary species catch. This is accomplished by utilizing RBI and pre-season abundance index values for that species. The harvest goal (total catch for all species) is then determined by dividing the desired primary species catch by the percentage of the primary species in the pre-season trawl survey catch. The species composition of commercial catches will be closely monitored to insure it remains consistent with that determined by the survey. If significant change is noted, the harvest goal will be adjusted accordingly to insure attainment of the desired primary species catch.

c. Harvest goals for second fishing periods will be computed as follows:

(1) Second fishing period harvest goals for stocks with fall abundance indices at or above MABI but less than 70% of the RBI will be computed by multiplying the fall survey index by 20% and subtracting the first period catch.

(2) The second period harvest goals for stocks where both spring and fall abundance indices are greater than 125% of RBI, will be determined by applying a 40% harvest rate to the fall abundance index. If an age imbalance exists, the harvest rate may be lowered to 25%.

(3) Second fishing period harvest goals for stocks not falling into categories a or b above will be computed by adding 56% of the first fishing period catch to the fall survey abundance index. This gives an estimate of what the fall survey would have been had the first period catch not been taken. Multiplying this number by the appropriate harvest

rate from Section I.C.6.c. above and subtracting the first fishing period catch gives the harvest goal for the second fishing period.

(4) Criteria for second fishing period harvests are summarized in Figure 8.

D. Example Applications

1. Single species, normal age composition.

Assume a hypothetical case involving an established fishing section with an RBI and MABI of 6.5 and 2.6 million lb (2,955 and 1,182 mt), respectively. Assume also an abundance index of 4.2 million lb (1,909 mt), of which 100% were *P. borealis*, was obtained in late May, and that the season was scheduled to open 15 June. Assume also that the composite size composition sample from this section indicated normal age composition.

The fact that this index is 65% of the RBI level and no size composition problem is apparent dictates a 20% harvest rate. This would result in a harvest of 840,000 lb (382 mt) (.20 x 4.2) from the 4.2 million lb (1,909 mt) abundance index.

2. Mixed species, normal age composition.

Assume a hypothetical case involving an established fishing section where a pre-season survey yielded a primary species abundance index of 5.0 million lb (2,273 mt). The RBI for that species was 4.0 million lb (1,818 mt), and the primary species comprised 45% of the pre-season survey catch. The fact that the index exceeds the RBI indicates a healthy stock and, therefore, a 40% harvest rate. Application of this 40% harvest rate to the 5.0 million lb (2,273 mt), primary species index would result in a 2.0 million lb (909 mt) primary species catch. As this species comprised only 45% of the total survey catch, however, the harvest goal for all species would be 2.0 ÷ .45, or 4.4 million lb (2,000 mt).

3. Mixed species, age imbalance.

Assume a hypothetical case involving an established fishing section with an RBI and MABI for the primary species, *P. borealis*, of 4.2 and 1.7 million lb (1,909 and 773 mt), respectively. Assume also that the season is scheduled to open 15 June and that a May survey showed a combined index for all species of 12.3 million lb (5,591 mt) with 3.8 million lb (1,727 mt) or 30.9% attributed to *P. borealis* and the remainder to a secondary species. Assume also that size composition analyses for *P. borealis* showed 75% 1-year-olds, and, therefore, was not considered normal. First, the fact that the 3.8 million lb (1,727 mt) index for *P. borealis* is between the RBI and MABI levels classified this stock as recovering. As this index exceeds 70% of the RBI and age composition is not considered normal,

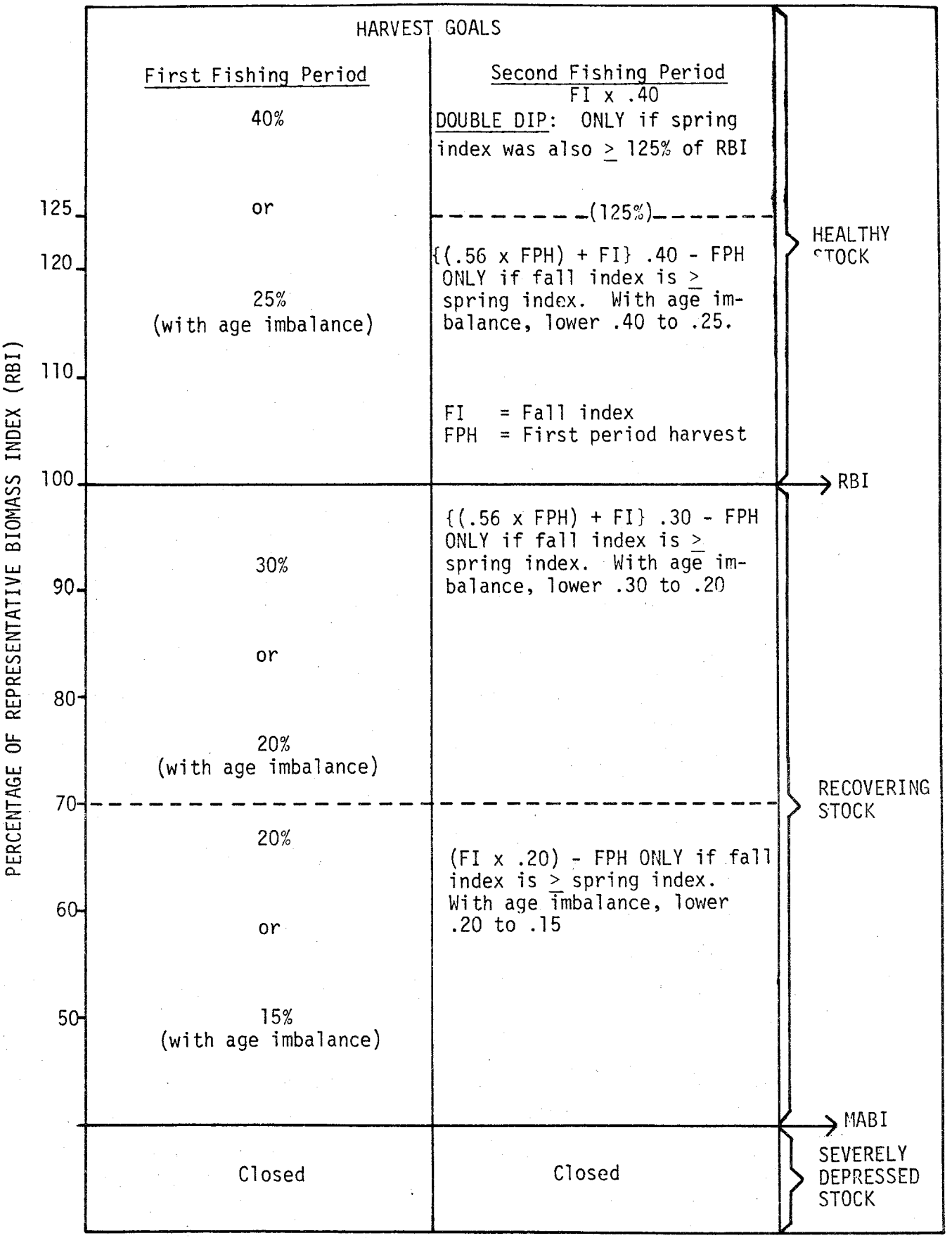

Figure 8. Criteria for determining harvest goals for first and second fishing periods for Westward Region shrimp fisheries.

the strategy permits a 20% harvest rate. This would result in a harvest of 760,000 lb or 345 mt (0.2 x 3.8) of *P. borealis*. Division of this amount by the composition of *P. borealis* in the survey catch yields a harvest goal of 2.5 million lb (1,136 mt).

4. Second fishing periods:

   a. Assume RBI is 10.0 million lb (4,545 mt) with spring and fall abundance indices of 4.2 million lb (190 mt) and 6.9 million lb (3,136 mt), respectively. The fact that the spring index exceeds MABI but is less than 70% of RBI dictates a harvest rate of 20%. This would permit a spring harvest goal of 840,000 lb or 382 mt (.20 x 4.2). The fall index of 6.9 million lb (3,136 mt) is also above MABI but below 70% of RBI, again permitting a 20% harvest rate. The fall harvest goal in this case would be 540,000 lb (245 mt) and be computed as follows: .20 x 6.9 - .84 = .54.

   b. Assume RBI is 10.0 million lb (4,545 mt) with spring and fall abundance indices of 12.5 and 16.0 million lb (5,682 and 7,273 mt), respectively. The fact that the spring index exceeds RBI dictates a harvest rate of 40%, permitting a spring harvest of 5.0 million lb or 2.273 mt (.40 x 12.5). Since both the fall and spring indices exceed 125% of RBI, the fall harvest goal is 40% of the fall index, or 6.4 million lb (2,909 mt).

   c. Assume RBI is 10.0 million lb (4,545 mt) with spring and fall abundance indices of 8.0 and 12.0 million lb (3,636 and 5,455 mt), respectively. The fact that the spring index is between 70% and 100% of RBI dictates a 30% harvest rate and a spring harvest goal of 2.4 million lb or 1,091 mt (.20 x 8.0). The fact that the fall index is between 70% and 125% of RBI dictates a 40% harvest rate and a 2.9 million lb (1,318 mt) harvest goal computes as follows: .40 (12.0 + .56 [2.41]) - 2.4 = 2.9.

E. Use of Fisheries Performance Data

While the above criteria constitute the basis for determining pre-season harvest goals, their appropriateness will be further confirmed by fleet performance factors. These include C/E and age composition. Due to the nature of these factors, their use in evaluating harvest goals is necessarily subjective. If these factors are judged to represent true changes in stock abundance, harvest goals may be modified accordingly. Use of this approach is dependent upon the availability and quality of the performance data received from the fleet.

The present status of stocks demands a conservative approach. Therefore, fishing performance will be utilized to evaluate harvest goals only on stocks in which abundance indices fall within or above the upper level of the recovering range. Harvest goals for stocks with abundance indices below this level will be modified solely on the basis of additional survey results.

II. Unsurveyed Stocks

Four types of unsurveyed areas exist which should be considered separately. The first includes those typically low production areas such as the North and West Afognak sections in Kodiak, which, because of priorities of vessel time and funding, are not surveyed. These areas, as discussed earlier in this report are managed on a historic harvest basis, i.e., seasonal catches are not allowed to exceed the mean historical harvests. As mentioned earlier relative to these areas, they are normally utilized only after closure of major production areas, and in only one instance have they been closed by emergency order prior to the normal season closure.

The second type of unsurveyed areas include those which have been fished on a very limited basis by the fleet in past years and where surveys are conducted on a sporadic and time available basis. These areas include Kuiukta Bay and Seal Cape in the Chignik District and the Sealion Rocks - West Nagai Strait, Kennoys Island, and Sanak Island areas in the South Peninsula District. Due to the fact that stock abundance in these areas has remained at a very low level for some time and that they have never been utilized extensively by the fleet, they are not surveyed as regularly as the major grounds. There are no present plans to survey these stocks more frequently until abundance increases are observed in adjacent inshore areas during regularly scheduled surveys.

The third type of unsurveyed area includes the vast offshore expanses lying outside of the established fishing sections. These waters, which comprise conservatively 90% of the Kodiak, Chignik, and South Peninsula Districts, have, for all intents and purposes never been utilized commercially. While shrimp are known to inhabit these areas, they have never supported a domestic fishery. These areas are presently not surveyed nor subjected to any active management activities. In response to this lack of assessment information and to the fleet's need for additional grounds, the ADF&G is proposing opening the offshore grounds of the Chignik and South Peninsula Districts and certain sporadically surveyed sections where stock status is uncertain. Since opening these largely offshore areas would present a potential enforcement problem, documented illegal fishing in adjacent closed waters could result in closure by emergency order. The offshore grounds outside of the established fishing sections in the Kodiak District will continue to remain open throughout the established seasonal fishing period if no enforcement problems occur. These offshore areas would be managed on a fisheries performance basis if significant concentrations were located.

The fourth type of unsurveyed areas are regularly surveyed stocks which, for either logistical or budgetary reasons, may not be surveyed. As such omissions should not preclude consideration of an opening, initial harvest goals for such stocks shall be based on prior survey results and past fisheries performance. In the event such an opening is made, fishery performance will be closely monitored to determine the appropriateness of the harvest goal.

It must be recognized that the shrimp management strategy shown here does not directly consider all factors affecting stock condition such as natural

and fishing mortality, recruitment, predation, and mating success. These factors are indirectly addressed by the strategy by responding to abundance changes regardless of their cause. In other words, this strategy acts on stocks in their existing condition after all such factors have affected them, and manages them on that basis. The primary objective of this strategy is to maximize the potential yield by harvesting available surpluses, while maintaining sufficient stocks to insure a high level of sustained production. This is accomplished by instituting differential harvest rates on stocks of various conditions. Under this strategy healthy stocks are harvested at a higher rate than those in need of rebuilding.

Conclusions on Stock Condition

The question now arises as to the reason for the pronounced decline seen in shrimp abundance in all major Westward Region shrimp stocks. The progressive decline seen in the abundance of all size cohorts suggest that, by themselves, juvenile mortality and overexploitation are not the only contributors as they would not be expected to affect all size groups simultaneously. The decline appears to result, at least partially, from a non size-selective mortality factor. Three potential mortality causes exist which would be expected to manifest themselves in this manner. The first would be an environmental change affecting survival or food supply. This could result in either high mortality in all segments of each stock or their progressive migration to more favorable grounds. The second would be occurrence of a disease which causes progressive mortality to all portions of each stock simultaneously. The third would be immigration of a predator that affects stocks in a non size-selective manner.

Based on available knowledge of Gulf of Alaska shrimp resources by the ADF&G as well as by NMFS, the most plausible explanation for the declining shrimp abundance at present appears to be non size-selective predation. While this by no means rules out the other two potential mortality sources, research data are not available to support them. Studies on the Westward Region shrimp stocks by this agency as well as NMFS, on the other hand, give considerable support to non-selective predation being at least one of the major causes of the shrimp decline.

Two factors lend evidence for fish predation being a contributor to the shrimp abundance decline; first, the simultaneous decline seen in all shrimp size cohorts suggests influence of a mortality factor which is not size-selective; and second, the coincidence in timing between the decrease in shrimp abundance and the increased abundance of cod and pollock in catches made during shrimp stock assessment surveys.

Evidence for non size-selective feeding on shrimp by Pacific cod comes from ongoing feeding habit studies by NMFS which compares the size distribution of shrimp taken from cod stomachs to that of shrimp in simultaneous shrimp trawl catches in Pavlof Bay. This comparison shows no statistical difference between those portions of these size distributions greater than 16.5 mm carapace length. Assuming that trawls fish non size-selectively on shrimp 16.5 mm and greater in carapace length, the portion of the trawl caught shrimp distribution at or above this size can be assumed to represent that in the actual stock. The differences seen between size distributions below 16.5 mm probably reflects the size selectivity

of shrimp trawl catches, with the distribution of shrimp from cod stomachs probably being more reflective of that in the actual stock.

A relationship appears to exist between the abundance of predators and the rate shrimp stocks have declined. Where commercial fishing has been prohibited, stocks have generally continued to decline, but at a slower rate where predator fish abundance is lowest.

Although considerable evidence exists for predation being one of the primary factors responsible for the decline seen in shrimp abundance, this evidence is at present wholly circumstantial. While other potential mortality factors do exist, they have unfortunately not been investigated nor do indications exist that they have influenced stock condition.

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APPENDICES

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum.

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM^2 Considered	Pop. Est. x 10^6(lb)	Pop. Est. per NM x 10^6(lb)	Percent Error[2]
Marmot Island	81-1	2	5-81	5	23.70	2.060	.042	48.0
	81-5[3]	2	9-81	6	23.70	2.540	.107	60.12
	81-7[3]	3		35	433.37	4.130	.009	-
		T		41	457.07	6.670	.015	
	82-1	2	5-82	6	23.7	0.15	.006	1.06
		3[4]		6	-	-	-	114.00
		T		12	23.7	-	-	
	82-4	2	9-82	4	23.7	0.59	.079	109.18
Marmot Bay	81-1	2	5-81	5	30.96	4.660	.151	55.0[5]
		3		2	1.46	1.080	.740	-
		4		3	10.75	1.440	.134	-
		T		10	43.17	7.180	.166	
	81-5	2	9-81	5	30.96	1.662	.054	
		3		2	1.48	.645	.436	31.95
		4		2	10.75	.576	.044	12.78
		T		9	43.19	2.883	.064	45.20
	82-1	2	5-82	7	30.96	.01	.0003	86.00
		3		2	1.48	.10	.07	55.00
		4		1	10.75	.84	.004	-
		T		10	43.19	.95	.002	
	82-4	2	9-82	6	30.96	.65	.02	58.32
		3		2	1.48	.89	.60	25.00
		T		8	32.44	1.54	.048	
Kalsin Bay	81-1	1	5-81	5	9.00	2.310	.257	23.5
	81-5	2	9-81	6	12.10	3.172	.262	-
		3		4	1.90	.725	.382	-
		T		10	14.00	3.897	.278	
	82-1[5]	2	5-82	6	3.05	1.81	.59	79.6
		3		3	5.98	1.54	.26	90.8
		4		2	2.05	.33	.16	110.1
		5		1	4.03	.02	.005	-
		T		12	15.11	3.70	.307	
	82-3[7]	2	6-82	3	3.05	.65	.21	127.0
		3		4	5.98	.22	.04	70.0
		4		2	2.05	.13	.06	130.0
		5		1	4.03	.43	.11	-
		T		10	15.11	1.43	.095	

-Continued-

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum (continued).

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM² Considered	Pop. Est. x 10^6(lb)	Pop. Est. per NM x 10^6(lb)	Percent Error[2]
Kalsin Bay (continued)	82-4	2	9-82	3	3.05	.04	.01	90.0
		3		3	5.98	.15	.02	122.0
		4		2	2.05	.04	.02	130.4
		5		1	4.03	.07	.02	-
		T		9	15.11	.30	.02	
Ugak Bay	81-1	1	5-81	6	12.04	3.120	.259	51.0
	81-5	2	9-81	6	12.04	3.060	.254	18.5
		3		5	15.79	.474	.030	60.0
		4		1	1.23	.060	.049	-
		T		12	29.06	3.594	.124	
	82-1[6]	2	5-82	6	12.04	.30	.02	49.0
		3		3	15.29	.08	.005	125.3
		T		9	27.33	.38	.014	
	82-3[7]	2	6-82	6	12.04	1.12	.09	52.0
		3		3	15.29	1.28	.08	49.0
		T		9	27.33	2.40	.088	
	82-4	2	9-82	6	12.04	.02	.002	68.9
		3		4	15.29	.04	.003	83.6
		T		10	27.33	.06	.002	
Kiliuda Bay	81-1	2	5-81	3	3.99	0.380	.095	65.0
		3		5	21.91	2.160	.099	40.0
		T		8	25.90	2.540	.098	
	81-5	2	9-81	3	3.99	0.660	.165	-
		3		5	21.01	0.501	.024	29.3
		4		3	21.60	0.386	.018	47.0
		T		11	46.60	1.547	.033	
	82-1[6]	2	5-82	3	3.99	.003	.0007	94.0
		3		6	21.01	.58	.28	60.0
		4		5	21.60	.05	.003	85.0
		T		14	46.60	.633	.014	
	82-3[7]	2	6-82	3	3.99	.00	.00	-
		3		5	21.01	.014	.0007	1.20
		T		8	25.00	.014	.001	
	82-4	2	9-82	2	3.99	.0038	.0009	26.0
		3		7	21.01	.0074	.0003	97.0
		T		9	25.00	.0112	.0001	
Twoheaded Island	81-1	1	5-81	13	52.81	14.138	.268	40.4
	81-5	1	9-81	13	51.73	3.040	.059	23.6
	82-1[6]	1	5-82	13	45.3	1.83	.04	31.0
	82-3[7]	1	6-82	12	45.3	2.65	.06	28.0

-Continued-

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum (continued).

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM² Considered	Pop. Est. x 10^6(lb)	Pop. Est. per NM x 10^6(lb)	Percent Error[2]
Twoheaded Island (continued)	82-4	2	9-82	13	38.28	.164	.004	51.4
		3		3	13.47	.019	.001	130.0
		T		16	51.75	.183	.004	
Alitak Bay[8]	81-1	2	5-81	12	45.27	8.690	.192	25.0
		3		8	78.30	1.640	.021	62.0
		T		20	123.57	10.330	.084	
	81-5	2	9-81	10	45.27	5.440	.110	48.4
		3		18	78.30	5.750	.073	32.7
		T		28	123.57	11.190	.987	
	82-1[6]	2	5-82	12	45.27	4.25	.09	36.5
		3		9	78.30	.96	.01	35.34
		T		21	123.57	5.21	.04	
	82-2[7]	2	6-82	11	45.27	9.31	.21	56.9
		3		13	78.30	0.79	.01	52.2
		T		24	123.57	10.10	.08	
	82-4	2	9-82	12	45.27	1.89	.04	40.09
		3		9	78.30	2.25	.03	23.85
		T		21	123.57	4.14	.03	
Olga Bay	82-1	3	5-82	1	1.61	0.188	.12	-
		4		1	2.69	0.485	.18	-
		5		2	2.57	0.196	.08	23.00
		6		3	5.36	1.046	.20	31.00
		T		7	12.23	1.915	.16	
	82-4	2	9-82	9	10.62	0.87	.08	10.07
		3		2	1.61	0.09	.06	51.90
		T		11	12.23	.96	.07	
Uyak Bay	81-1	3	5-81	4	16.95	.035	.002	59.0
		4		2	1.95	.380	.195	80.5
		5		1	.82	.003	.004	-
		T		7	19.72	.418	.021	
	81-5	2	9-81	2	7.20	.113	.016	-
		3		4	16.95	.386	.023	-
		4		2	1.95	.008	.004	-
		T		8	26.10	.507	.019	
	82-1	2	5-82	1	7.02	.008	.001	-
		3		4	16.95	.03	.002	66.00
		T		5	23.97	.038	.001	

-Continued-

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum (continued).

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM² Considered	Pop. Est. x 10^6(lb)	Pop. Est. per NM x 10^6(lb)	Percent Error[2]
Uyak Bay (continued)	82-4	2	9-82	1	7.02	.09	.01	-
		3		4	16.95	.21	.01	79.00
		4		2	1.95	0	.00	-
		5		1	.82	0	.00	-
		T		8	26.74	.30	.01	
Uganik Bay	81-1	2	5-81	1	.68	.000	0	-
		3		3	20.50	1.783	.087	15.0
		4		1	1.52	.320	.211	-
		5		2	5.67	.382	.067	109.0
		T		7	28.37	2.485	.088	
	81-5	2	9-81	1	.68	0	0	-
		3		3	12.71	1.360	.107	40.0
		4		1	1.54	0	0	-
		5		3	5.67	.446	.079	15.7
		T		8	20.60	1.806	.088	
	82-1	2	5-82	1	.68	0	.00	-
		3		4	12.71	0.33	.03	31.00
		4		1	1.52	0	.00	-
		5		3	5.67	0.51	.09	63.00
		T		9	20.58	0.84	.02	
	82-4	3	9-82	4	20.5	0.72	.03	22.64
		4		1	1.52	0	.00	-
		5		2	5.67	0.24	.04	64.13
		T		7	27.69	.96	.04	
Kukak Bay	81-1	1	6-81	3	6.42	.780	.121	78.0
	81-5	2	10-81	4	6.42	.271	.042	26.02
		3		3	6.19	.020	.003	89.00
		T		7	12.61	.291	.023	
	82-2	2	6-82	5	6.42	1.40	.04	29.20
		3		2	6.19	0.003	.0005	130.52
		T		7	12.61	1.403	.111	
	82-4	2	9-82	5	6.42	0.040	.006	47.24
		3		3	6.19	0.003	.0005	111.26
		T		8	12.61	.043	.003	
Puale Bay	81-1	1	5-81	4	9.40	2.760	.294	41.0
	81-5	1	10-81	2	9.40	---[9]	-	-
	82-2	1	6-82	4	9.40	2.98	.32	59.70
	82-4	1	9-82	3	9.40	0.38	.04	37.12

-Continued-

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum (continued).

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM^2 Considered	Pop. Est. x 10^6(lb)	Pop. Est. per NM x 10^6(lb)	Percent Error[2]
Wide Bay	81-1	1	5-81	6	7.20	1.950	.271	20.0
	81-6	1	9-81	6	8.25	1.404	.170	45.2
	82-2	1	6-82	6	7.20	1.42	.20	31.10
	82-4	2	9-82	5	7.33	0.71	.10	35.68
		3		1	0.92	0.002	.002	-
		T		6	8.25	.712	.086	
Chiginagak Bay	81-2	1	5-81	4	4.74	1.12	.23	70.0
	82-2	1	5-82	4	4.74	0.08	.02	41.90
Nakalilok Bay	81-2	1	6-81	3	5.63	.07	.012	57.90
	82-2	1	5-82	4	5.63	0.05	.009	105.50
Aniakchak Bay	81-4	1	6-81	5	19.84	0	0	-
	82-2	1	5-82	4	19.84	0	0	-
Kujulik Bay	81-2	2	5-81	3	4.3	.045	.010	130.0
		3		4	18.9	.42	.022	129.0
		T		7	23.2	.465	.020	
	81-4	2	6-81	3	4.3	.37	.086	130.01
		3		8	18.9	1.00	.053	32.79
		T		11	23.2	1.37	.059	
	81-6	2[6]	8-81	3	4.3	.29	.067	-
		3		8	18.9	1.19	.063	63.0
		T		11	23.2	1.48	.063	
	81-7	2[7]	8-81	3	4.3	.15	.035	111.96
		3[7]		8	18.9	.62	.033	33.85
		T		11	23.2	.77	.033	
	82-2	2	5-82	2	4.3	0.002	.0005	130.50
		3		8	18.9	0.53	.03	34.30
		T		10	23.2	.532	.023	
	82-4	2	9-82	2	4.3	0.12	.03	130.00
		3		8	18.9	0.22	.01	32.59
		T		10	23.2	.34	.01	

-Continued-

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum (continued).

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM^2 Considered	Pop. Est. x 10^6(lb)	Pop. Est. per NM x 10^6(lb)	Percent Error[2]
Chignik Bay	81-2	2	5-81	8	33.7	2.54	.075	93.0
		3		4	10.5	.025	.002	69.0
		T		12	44.2	2.565	.058	
	81-4	2	6-81	8	33.7	3.00	.089	29.59
		3		4	10.5	0	0	-
		T		12	44.2	3.00	.068	
	81-6	2[6]	9-81	8	33.7	.54	.016	40.49
		3[6]		4	10.5	.19	.018	43.39
		T		12	44.2	.73	.017	
	81-7	2[7]	9-81	8	33.7	.74	.022	40.49
		3[7]		4	10.5	.22	.021	43.39
		T		12	44.2	.96	.022	
	82-2	2	5-82	8	33.7	2.19	.06	18.30
		3		4	10.5	0.09	.009	18.00
		T		12	44.2	2.28	.052	
	82-4	2	9-82	7	33.7	0.91	.03	38.00
		3		4	10.5	0.24	.02	47.00
		T		11	44.2	1.15	.03	
Kuiukta Bay	81-4	1	6-81	4	15.9	1.16	.073	10.64
	81-6	1	9-81	4	15.9	.04	.002	65.60
	82-2	1	5-82	4	15.9	.46	.029	14.6
Mitrofania Is.	81-4	2	6-81	5	17.5	.40	.023	37.2
		3		6	24.2	.01	.0004	-
		4		3	35.0	.013	.0004	-
		5		2	98.0	0	0	-
		T		16	174.7	.423	.002	
	81-6	2	9-81	5	17.5	.13	.007	60.67
		3		6	24.2	.02	.0008	32.87
		4		3	35.0	.02	.0006	130.0
		5		6	98.0	0	0	-
		T		20	174.7	.17	.001	
	82-2	2	5-82	5	17.5	.098	.006	14.30
		3		5	24.6	.008	.0003	203.70
		5		3	78.0	.005	0	133.9
		T		13	120.1	.111	.0009	

-Continued-

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum (continued).

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM^2 Considered	Pop. Est. x 10^6(lb)	Pop. Est. per NM x 10^6(lb)	Percent Error[2]
Ivanof Bay	81-4	2	6-81	4	20.13	0	0	-
		3		3	17.30	0	0	-
		4		4	24.15	0	0	-
		5		3	28.02	0	0	-
		7		6	96.00	0	0	-
		T		20	185.6			
	81-6	2	9-81	4	20.13	.008	.0004	88.01
		3		4	17.3	.052	.003	61.06
		5		3	28.02	.006	.0002	65.20
		T		11	65.45	.066	.001	
	82-2	2	5-82	3	20.13	0.0	0	-
		3		3	17.30	.128	.007	61.0
		4		3	24.75	.066	.003	95.0
		T		9	62.18	.194	.003	
Stepovak Bay	81-3	2	5-81	6	72.0	0	0	-
		3		5	32.0	3.05	.095	27.1
		4		5	60.0	0	0	-
		7	6-81	6	160.0	0	0	-
		T		22	324.0	3.05	.009	
	81-7	2	9-81	6	72	.05	.0007	25.17
		3		4	32	.02	.0006	30.86
		4		5	60	.02	.0003	63.04
		6		2	24	.03	.001	130.13
		7		9	160	.47	.003	34.75
		T		26	348	.59	.002	
	82-2	2	5-82	10	132	2.05	.01	38.00
		3		5	32	1.52	1.52	21.97
		T		15	164	3.57	.02	
Balboa-Unga	81-3	1	5-81	6	53.2	0	0	-
	81-7	1	9-81	6	53.2	.32	.006	100.55
	82-2	1	5-82	5	53.2	0.75	.01	60.80
Beaver Bay	81-3	1	5-81	3	24.00	0	0	-
	81-7	1	9-81	3	24.0	.18	.007	94.21
	82-2	1	5-82	3	24.0	.02	.0008	65.00

-Continued-

Appendix Table 1. Summary of 1981 and 1982 Westward Region shrimp trawl survey results by fishing section, cruise, and stratum (continued).

Fishing Section	Cruise	Strata[1]	Date Mo-Yr	No. Tows	NM^2 Considered	Pop. Est. x 10^6(lb)	Pop Est. per NM x 10^6(lb)	Percent Error[2]
Sealion Rocks	81-3	1	5-81	3	32.00	0	-	-
Acheredin Point	81-3	1	5-81	3	24.00	0	-	-
Kennoys Island	81-3	1	5-81	6	52.00	0	-	-
Popof Strait	81-3	1	5-81	2	1.00	0	-	-
W. Nagai Strait	81-3	1	5-81	3	28.00	0	-	-
Pavlof Bay	81-3	2	5-81	10	84.4	4.99	.059	30.82
		3		1	4.0	.04	.010	-
		T		11	88.4	5.03	.057	
	82-2	2	5-82	7	84.2	0.80	.009	30.50
		3		1	4.0	.02	.005	-
		T		8	88.2	.82	.009	
Belkofski Bay	82-2	1	5-82	3	11.5	.0007	0	130.0
Morzhovoi Bay	81-3	2	5-81	7	77.12	5.54	.072	36.51
		3		2	46.03	0	0	-
		T		9	123.15	5.54	.045	
	82-2	2	5-82	8	77.2	.81	.01	18.7
		T		8	77.2	.81	.01	
Totals	1981-82[10]			527	1478.03			
	1982-83[10]			435	1824.21			

[1]Unstratified, entire area considered as single stratum. The digits 2, 3, 4, 5, etc. represent individual strata designation in sections where multiple strata are considered. T=Total for all strata.

[2]At the 80% confidence level.

[3]Survey conducted by M/V RESOLUTION and M/ALASKA simultaneously.

[4]Tows as specific sites selected by skipper - time not available for a formal survey. Data not valid for use in generating an abundance index.

[5]Percent error for all strata combined.

[6]Problem found with trawl rigging following survey - section resurveyed.

[7]Resurvey.

[8]Strata 2 - Inner Alitak Bay. Strata 3 - Alitak Flats.

[9]Vessel breakdown after first two tows - no estimate made.

[10]Seasonal totals.