SUMMARY OF THE STATEWIDE SHRIMP WORKSHOP HELD IN ANCHORAGE DURING OCTOBER 24-26, 1988

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INTRODUCTION

This report summarizes a shrimp workshop held in Anchorage at the regional office of Alaska Department of Fish and Game (ADF&G) during October 24-26, 1988. The objectives of the meeting were to: (1) provide a forum for ADF&G staff discussions on shrimp biology and life history, key management issues, and direction of the state's monitoring and management programs for shrimp; (2) increase staff's level of expertise in determining the sex of shrimp; and (3) critique the Central Region's Kachemak Bay trawl shrimp program.

The meeting was attended by department staff with shrimp management/research responsibilities, including Cathy Botelho and Tim Koeneman of Region I; Wayne Donaldson, Rich Gustafson, Lee Hammarstrom, John Hilsinger, Al Kimker, Chuck Meacham, and Charlie Trowbridge of Region II; Dave Jackson of Region IV; and Gordon Kruse and Peggy Murphy of headquarters. We were also very fortunate to have Jim Boutillier of the Department of Fisheries and Oceans (DFO), Nanaimo, British Columbia, in attendance. The meeting was organized by Gordon Kruse (chairman), Lee Hammarstrom, and Tim Koeneman.

Discussions focused on five species of shrimp: pink or northern shrimp *(Pandalus borealis)*, spot shrimp or prawn *(Pandalus platyceros)*, humpy shrimp *(Pandalus goniurus)*, coonstripe or humpback shrimp *(Pandalus hypsinotus)*, and sidestripe shrimp *(Pandalopsis dispar)*.

AGENDA

A draft agenda was discussed and modified slightly. The meeting closely followed this revised agenda:

October 24 (Monday)

Morning Session (10:30 - 12:00)

A. Preliminaries

1. Introductions and Announcements
2. Purpose of Meeting
3. Review of Agenda

B. Review of Regional Shrimp Fisheries and Management

1. General Comments
2. Southeast Alaska and Yakutat
3. Prince William Sound
4. Cook Inlet
5. Kodiak, Aleutian Islands, and Alaska Peninsula
6. British Columbia

Afternoon Session (13:30 - 17:00)

C. Review of Biology and Life History of Shrimps

1. Spot Shrimp

a. Life Cycle
b. Age and Growth
c. Fecundity
d. Migration

2. Other Shrimp Species

a. Major Information Needs

October 25 (Tuesday)

Morning Session (8:00 - 12:00)

D. Determination of Sex in Shrimp

1. Review of Methodology
2. Hands-on Workshop

E. Tagging Methods for Shrimp

1. Prince William Sound Shrimp Tagging Studies
2. Recommendations for Future Studies

F. Microcomputer Applications

1. Length Frequency Modal Analysis
2. Electronic Calipers and Microcomputer Interfaces

Afternoon Session (13:30 - 17:00)

G. Management of Shrimp Fisheries

1. Statewide Policy on Shrimp Management

a. Need for Such a Policy
b. Management Goals

2. Nuts and Bolts of Fishery Management

a. Exploitation Rates
b. Estimating Threshold
c. Mesh Size Regulations
d. Management Problems

3. Factors Affecting Stability in Shrimp Fisheries
4. Recommended Survey Methods

October 26 (Wednesday)

Morning Session (8:00 - 12:00)

H. Fishery Monitoring Programs

1. Southeast Alaska and Yakutat
2. Prince William Sound
3. Cook Inlet
4. Kodiak, Aleutian Islands, and Alaska Peninsula
5. British Columbia

I. Data Collection Forms

1. General Comments
2. Southeast Alaska, Yakutat, Kodiak, Aleutian Islands, and Alaska Peninsula
3. Cook Inlet and Prince William Sound
4. British Columbia

Afternoon Session (13:30 - 17:00)

J. Review of Kachemak Bay Shrimp Program

1. Brief Review of History of Shrimp Program
2. Survey Design
3. Management and Analysis of Survey Data
4. Recommendations

REVIEW OF REGIONAL SHRIMP FISHERIES AND MANAGEMENT

General Comments

Peggy Murphy summarized the species composition of trawl and pot fisheries for 1987. She provided a summary table of these data (Appendix A). Peggy also summarized management regulations for trawl and pot fisheries (Appendix B).

Southeast Alaska and Yakutat

Trawl Fishery

Southeast Alaska. Tim Koeneman described the beam trawl fishery that has operated in Southeast Alaska since 1915. Twenty-three vessels (<58 ft length) participated in this fishery during 1987. Trawling occurs in estuarine waters less than 420 ft, and most catches are taken from 90-210 ft. A guideline harvest range is established for each major district separately based on historic catches. Recent catches have been approximately 1.4 million lbs which is down from a peak harvest of 7.6 million lbs in 1958. Catches are comprised primarily of pink shrimp with some sidestripe shrimp taken.

Yakutat. Tim also presented a brief overview of the small otter trawl fishery that occurs near Yakutat. Recent population estimates of pink and sidestripe shrimp were 2-6 million lbs, and annual catches have averaged about 190,000 lbs. Sporadic operation of shoreside processing facilities and inclement weather have limited this fishery. A guideline harvest level of 30,000 pounds per each month of open season has been implemented for this fishery.

Pot Fishery

Southeast Alaska. The pot shrimp fishery in Southeast Alaska targets upon the spot shrimp. Effort has been increasing rapidly. At present, approximately 100 vessels participate in the fishery which is dominated by vessels from the local area. The annual catch is about 300,000 lbs and is regulated by guideline harvest ranges in major districts. Most of the pot shrimp catch is taken from the Ketchikan area, with additional catches from the Petersburg/Wrangell area. Both catcher/processor and catcher/seller vessels handle the pot shrimp catch.

Yakutat. A very small pot fishery harvests a few thousand pounds of shrimp in Yakutat Bay.

Prince William Sound

Trawl Fishery

Wayne Donaldson presented an overview of the trawl fishery for shrimp in Prince William Sound (Appendix C). In past years the catch has been dominated by pink shrimp but in 1987 the catch was comprised primarily of sidestripe shrimp. Currently an otter trawl fishery is conducted along the north western side of Prince William Sound in 900-1,200 ft of water and along the south western side at a depth between 600 and 900 ft. Recent fisheries have harvested approximately 100,000 lbs worth about $150,000 in exvessel value. Some landings have been shipped live to Japanese markets. The fishery is regulated by season and area closures. The Icy Strait Disrict also has a guideline harvest range for pink shrimp. The December to April period is closed to fishing to protect egg-bearing females: December - February for sidestripe shrimp and March - April for pink shrimp. The eastern side of the sound is closed to protect king and tanner crabs.

Pot Fishery

An overview of the pot fishery for shrimp in Prince William Sound was also presented by Wayne (Appendix D). Three management districts or areas have been defined for the Prince William Sound pot fishery. The pot fishery in the traditional harvest area targets on spot shrimp in the outer reaches of Valdez arm and fjords along the west and north sides of the sound. The area has yielded approximately 225,000 lbs annually with an exvessel value of $735,000 in 1987. The harvest is taken by approximately 80 vessels, most of which are catcher/sellers. The traditional harvest area is regulated by a guideline harvest range and a season closure from December to March for the peak egg bearing period. The fishery is also closed from June 30 through August 15.

Montague Strait had been established as an experimental harvest area that is open to fishing year-round. Catches in the area have dropped from approximately 50,000 lbs in 1985-86 to about 2,000 lbs in 1988. The Eastern district is characterized by low production yielding approximately 5,000 lbs each year.

Cook Inlet

Trawl Fishery

Lee Hammarstrom presented an overview of the trawl shrimp fishery and management program in Cook Inlet (Appendix E). An otter trawl fishery targets on pink shrimp. Due to interannual variation, sidestripe shrimp can comprise up to 20% and humpy shrimp up to 50% of the total catch in some years. Coonstripe shrimp are less than 5% of the catch. In 1981-82 about 5 million lbs were caught by 22 vessels. In recent years effort has moved in response to change in shrimp abundance from west of the Homer spit to east of the spit. Most harvest was taken from 240-540 ft west of the spit and between 210-300 ft east of the spit. Trawl shrimp surveys have been conducted by ADF&G since 1971 to assess stock condition and determine if the fishery will be opened. The fishery has been closed since 1986-87 due to low stock size. Historically, primary management measures are guideline harvest range, subseasons, fishing periods, and closed waters. The upper portion of Kachemak Bay was closed to trawling to protect small shrimp. Tutka Bay and Sadie Cove were closed to prevent overexploitation in the small available area.

Lee indicated two pot shrimp fishery areas have been designated in Cook Inlet. The area H pot fishery harvested up to 800,000 lbs of coonstripe shrimp annually during the 1970's. Catches since the 1982-83 season have been less than 75,000 lbs per year. The fishery has been closed during parts of the 1983-84 and 1987-88 seasons and nearly all of the 1988-89 season. The area G pot fishery operates at great distance from the port of Seward on a small shrimp resource. The fishery targets spot shrimp with an annual harvest of less than 20,000 lbs.

Kodiak, Aleutian Islands, and Alaska Peninsula

Trawl Fishery

Dave Jackson described the trawl shrimp fisheries in the Westward Region. A beam trawl shrimp fishery developed in Kodiak in the late 1950's and early 1960's for pink shrimp. In the mid-1970's effort shifted to the South Peninsula and Chignik areas, otter trawlers entered the fishery and the region-wide catch peaked at about 110 million lbs. Since then, catches have dropped dramatically. A management plan was implemented in 1982 and provides for exploitation rates of 0-40% based upon stock assessment data. A representative biomass index (RBI) was estimated as the stock abundance after initial development of the fishery. A minimum acceptable biomass index (MABI) was defined as 40% of the RBI. Stocks are classified as healthy (>RBI), recovering (>MABI and <RBI), and severely depressed (<MABI). Harvest rates are based upon these classifications. An

experimental management area consisting of the mainland section of the Kodiak district and the eastward sections of the Chignik district was also established in 1982. This area can be closed only for limited reasons independent of stock abundance. Since the closure of major production areas, the Aleutian Islands and Alaska Peninsula, to shrimp harvest in 1983, the experimental management area has been the only area contributing to shrimp harvests in the Westward Region. Shrimp abundance surveys by ADF&G are restricted to the Alaska Peninsula area and select bays on Kodiak Island.

Pot Fishery

Dave mentioned that a very small pot shrimp fishery operates around Afognak Island. Only a few vessels participate in this fishery. Catches are composed mostly of spot shrimp, and total catches do not exceed 18,000 lbs per year.

British Columbia

General

Jim Boutillier presented the following information about fisheries for shrimp in British Columbia. Six species of shrimp are fished in British Columbia: pink or northern shrimp *(Pandalus borealis)*, ocean or smooth pink shrimp *(Pandalus jordani)*, dock shrimp or coonstripe shrimp *(Pandalus danae)*, spot shrimp or prawn *(Pandalus platyceros)*, coonstripe shrimp or humpback *(Pandalus hypsinotus)*, and sidestripe shrimp *(Pandalopsis dispar)*. British Columbia is the northern end of the range for *P. jordani* and the southern end of the range for *P. borealis*.

Trawl Fishery

An otter trawl fishery for inshore and offshore populations of smooth pink shrimp (*P. jordani*) occurs off Vancouver Island. Catches have ranged up to 12 million lbs annually. Success of this fishery appears related to advection of shrimp larvae from other areas. Beam trawl fisheries occur for northern shrimp (*P. borealis*).

Pot Fishery

Pot fisheries occur primarily for spot shrimp or prawn (*P. platyceros*). Prior to 1979, all spot shrimp fisheries occurred along the south coast of British Columbia. Increases in effort since then have prompted increased regulation of this fishery. The fishery is managed in part by a spawner index based upon proportion of the population breeding in the spring, summer and fall. In addition, experimental management areas have been developed to evaluate the response of shrimp populations to different fishing rates. Pot designs have been evaluated to increase the catch of large shrimp and decrease the catch of small shrimp. These studies also examined pot volume to provide for effort standardization used in analyses of fishery data.

REVIEW OF BIOLOGY AND LIFE HISTORY OF SHRIMPS

Spot Shrimp

The biology and life history of spot shrimp were reviewed by Wayne Donaldson. Spot shrimp occur throughout the North Pacific to depths of 600-750 ft. Juveniles tend to occur in shallow subtidal environments and adults prefer rocky bottom and steep slopes. Newly hatched spot shrimp are pelagic for 2 months prior to settling into the demersal phase as a juvenile for 1-2 yrs. Spot shrimp remain as males until age 3-5, become transitionals at age 6-7, and die as females between age 7-9 in Prince William Sound. Spot shrimp of size 30-40 mm carapace length (CL) molt twice per year and grow approximately 1.5 mm CL per molt. Larger shrimp molt once per year with a growth increment of about 3 mm CL. Mating occurs in the fall with internal fertilization of eggs. Females carry eggs 5-6 months, eggs hatch in March and April, and larvae settle in late summer. Jim Boutillier noted that most spot shrimp live approximately four years and produce one egg clutch prior to death in British Columbia. Multiple egg clutches have been documented in Prince William Sound tagging studies. Jim also noted that diel migrations have been observed in Howe Sound; shrimp move inshore at dusk and occur offshore during the remainder of the day.

Other Shrimp Species

The biology and life history of other shrimp species were discussed briefly. Gordon Kruse provided one-page outlines for these species (Appendix F). It became quite apparent that there were many gaps in our understanding of the biology of these species. Specific areas of discussion included: 1) variability in spawning time and hatching period; 2) causes of egg loss and infertility; 3) skip of transitional stage and resulting effects on fecundity; 4) predation; 5) gear effects; 6) need for additional measurements of physical characteristics; 7) interpretation of female length frequency histrograms; and 8) enforcement. Lack of detail about growth and mortality are most consequential to fishery management.

DETERMINATION OF SEX IN SHRIMP

Jim Boutillier presented an overview of procedures to determine the sex of shrimp. Jim showed slides of photographs, and Gordon provided some overheads and photocopies of diagrams (Appendix G) to distinguish the sexes. The first or second pleopod is used to sex shrimp. The first pleopod is most useful for pink shrimp, and the second pleopod is most informative for prawns and sidestripe shrimp. Males can be identified by the presence of setae on the first pleopod. The setae begins to disappear on transitional shrimp, and has completely disappeared on females. Immature and transitional shrimp are difficult to distinguish. Using characteristics of the pleopods, Jim categorizes shrimp into immature (0), male (1), transitional (2), non-berried female (3), berried female

(4), and spent female (5). Distinguishing between a male and a transitional shrimp can be aided by using size in conjunction with sexing techniques. A hands-on workshop provided excellent opportunity to compare sexing techniques for spot and pink shrimp.

TAGGING METHODS FOR SHRIMP

Al Kimker gave a presentation on a tagging project for spot shrimp in Prince William Sound. Approximately 10,000 spot shrimp were tagged with a streamer tag between the first and second segment. Data valuable to management were obtained, largely due to the fact that tags were retained through the molting process. For example, this study found that mortality of mature females is less than previously thought, because some females bore more than one egg clutch; lower mortality rates imply that lower harvest rates may be best. Good growth data were also obtained. Shrimp molted up to twice per year, and the growth increment averaged 3.0 mm CL for shrimp of size 28-42 mm CL. These slow rates of growth imply a maximum age of 9 yr. This maximum age is older than previously thought, and may imply that lower exploitation rates are appropriate. Movement of shrimp was not significant. Therefore, area-specific management is necessary to prevent recruitment overfishing of localized stocks. Details of this study were reported in Kimker and Donaldson (1987). Suggestions for future tagging studies included: 1) request return of entire shrimp to ensure accurate measurement of CL; 2) include a control group to test tag retention; 3) make measurements to the nearest 0.10 mm; 4) avoid fresh water circulation in the holding tank and at the release site; and 5) take precautions against effects of light known to cause columbar disintegration.

MICROCOMPUTER APPLICATIONS

Jim Boutillier briefly described a program for analysis of length frequency modes developed by Fournier (1988). He provided copies of a demonstration program (MULTIFAN) to handle length frequency data. Jim emphasized exclusion of berried females from length frequency data analysis, because they no longer grow. Demonstration copies of this program are available from Gordon Kruse. Rich Gustafson described (Appendix H) and demonstrated laboratory procedures and data analyses of samples collected from the trawl shrimp survey in Kachemak Bay. Rich described the use of electronic calipers connected to a microcomputer that was driven by software written by Limnotera. Jim pointed out that staff of DFO use electronic calipers with other personalized software.

MANAGEMENT OF SHRIMP FISHERIES

Statewide Policy on Shrimp Management

The need for a statewide policy on shrimp management was discussed. Staff were very supportive of the idea to develop a policy statement on shrimp management, including a statement of goals and objectives, description of area-specific regulations, and a discussion of how these regulations achieve the goals. However, it was recommended that it would be wisest to seek approval for the draft king and Tanner crab policy prior to initiating work on a new statement for shrimp. John Hilsinger distributed the draft policy statement for king and Tanner crabs, and sought comments.

Nuts and Bolts of Fishery Management

Management goals, objectives, and strategies were discussed. We discussed broad goals for maximizing and stabilizing yield, social and economic benefits. Sporadic recruitment of shrimp was accepted as a given. Management would not eliminate this fact. However, it was agreed that high exploitation rates can increase the magnitude of the fluctuations. The use of a threshold for females to insure reproductive potential was discussed. In British Columbia a minimum relative abundance of egg bearing females must occur before the fishery is opened. Consensus was reached that more information is needed on exploitation rates and environmental variables. It was pointed out that exploitation rates for herring are 0-20%. Given that maximum age of herring (9-13 yr) and spot shrimp (7-9 yr) are similar, merits of similar exploitation rates were discussed. Possible relationships between target exploitation rate and size structure were postulated. Also, it was recognized that mesh restrictions alone are insufficient to prevent overfishing; mesh restrictions can be used to prevent growth overfishing, but cannot prevent recruitment overfishing.

Stability Factors in Shrimp Fisheries

Factors contributing to stable shrimp fisheries in Southeast Alaska were discussed. Shrimp fisheries in Duncan Canal and Stikine Flats may be excellent stocks for study. These areas have had the longest continuous shrimp fisheries in Alaska. Perhaps consistent recruitment and low exploitation rates in these fisheries are conducive to stable fisheries in general. Unfortunately, lack of stock assessment surveys prohibit estimation of population size and exploitation rates. The fisheries are targeted by beam trawls, and these vessels tend to be less efficient than most vessels in other fisheries with more sophisticated electronics. Each of these factors may promote stability. Alternatively, beam trawls may impact shrimp habitat to a lesser degree than otter trawls. The possibility of harmful effects on shrimp by hydrogen sulfide released from otter trawling was mentioned. It was also noted that the incidence of crab is high in shrimp otter trawls.

Recommended Survey Methods

Establishment of a survey or fishery monitoring area could be useful for pot fishery management in Prince William Sound. Multiple surveys for biological data coordinated with a log book program would be ideal. Data collection activities could promote the development of regulations to avoid catches of small shrimp, avoid egg-bearing periods, and lower exploitation rates to promote fishery stability. Opportunities to conduct surveys before and after each season as opposed to dockside sampling would provide better data on catch and discard mortality. A spawner index could be developed and a threshold implemented. Size structured data could be obtained to aid development of regulations to minimize catches of small shrimp.

FISHERY MONITORING PROGRAMS

Southeast Alaska and Yakutat

Tim Koeneman mentioned that no surveys or logbook programs are conducted in Southeast Alaska or Yakutat for shrimp. Dockside samples are collected in Petersburg from the beam trawl fishery for pink shrimp. Approximately 300 shrimp are sampled per delivery. Vessels deliver every day but each vessel is sampled once a week. Size frequency data are available for each fishing district and statistical week. Incidental landings of sidestripe and coonstripe shrimp are also sampled, but these size frequency data are biased, because the large shrimp are sold to processors. Fisherman interviews are conducted when vessels are sampled. These interviews are coupled with the size frequency data to gauge fishery performance in relation to the guideline harvest range. Data for all landings are available from fish tickets. No interviews are conducted for the pot shrimp fishery. Occasionally, samples are purchased from fishermen to obtain data on count per pound and length frequencies.

Prince William Sound

Wayne Donaldson mentioned that data on shrimp fisheries of Prince William Sound are quite limited. Fish tickets are collected and edited after phone conversations with fishermen. Logbooks are available for both pot and trawl shrimp fisheries, and these provide data on pounds landed per hour. Limited data on size frequency are collected from measurement of heads saved by some pot shrimp fishermen. Historically, catches of Prince William Sound shrimp landed in Kodiak were sampled occasionally. Difficulties with accuracy and delayed receipt of fish ticket information have complicated inseason management of Prince William Sound shrimp fisheries.

Cook Inlet

Lee Hammarstrom described fishery monitoring programs for Cook Inlet. Aside from statistical area G, random samples of commercial shrimp catches are collected from the trawl shrimp fishery in Kachemak Bay. Data are obtained on shrimp length frequency, sex, count per pound, and percent composition of shrimp and fish in the catch. Some fishermen provide subsamples they have taken of their own catch for percent species composition of shrimp and fish. Radio reports of catches and fish ticket data are obtained inseason. Logbooks are obtained weekly and reviewed, but not computerized. Sporadic observer data are available.

There is no survey for the trawl fishery in statistical area G. Information on the fishery comes primarily from fish ticket data. Occasionally catch samples and log books are collected, and skipper interviews conducted when catches are landed in Kodiak.

Prior to 1986 a pot shrimp index program was conducted in Cook Inlet. This program provided data on the sex ratio and length frequency of coonstripe shrimp. After elimination of this program a logbook program was initiated to collect CPUE data, however, fishermen participation has diminished. Fish ticket data are available, but these data are not received in time for inseason management. The small pot fishery in statistical area G targets on spot shrimp. One logbook is obtained annually for this area and fish tickets from catcher/processors are available.

Kodiak, Aleutian Islands, and Alaska Peninsula

Dave Jackson described data collection programs for shrimp in Westward Region. A trawl survey is used to estimate population size for shrimp populations in the this region. In the mid-1970's to early 1980's the survey was conducted over 120 d. In 1989 a survey of 30 d duration is planned. Area swept methods are used to calculate the population estimates. Approximately 200 shrimp are sampled each tow for length frequency. A composite sample for a given area is analyzed in the laboratory for sex and length. Currently, only a small commercial fishery occurs on shrimp stocks in the Westward Region. Historically, a major logbook program was used to collect fishery performance data. At present, logbooks are required from fishermen fishing in the experimental management area. Historically, an interview program was also conducted, but this was terminated when the fishery collapsed. A computerized data base of commercial catch samples is available. No data, other than fish tickets, are collected for the pot shrimp fishery.

British Columbia

Jim Boutillier described data collection programs for shrimp in British Columbia. The trawl fishery is a limited entry fishery. Shrimp stocks harvested by the trawl fleet are monitored with a trawl survey by methods similar to the one

conducted by the Kodiak office of ADF&G. Logbooks are collected, and there are occasional observer data. Sales slips are collected, and data from sales slips are useful for cross-checking the logbook data. However, CPUE data from the sales slips are dubious and not used. Fishery officers also maintain fishing activity logbooks in which they report time/area/activity observations of commercial vessels. These logbooks are useful for validating abundance indices computed from surveys.

Logbooks are also mandatory in the pot fishery. Samples are collected from the commercial pot fishery for sex and length frequency data. A pot survey is conducted on board commercial vessels. Pot survey data is used in conjunction with logbook data to compute an abundance index and to estimate the spawner index upon which fishery openings and closures are based.

DATA COLLECTION FORMS

General Comments

Copies of shrimp data forms used by ADF&G and DFO were distributed and discussed. Copies can be obtained from ADF&G regional offices or headquarters. Similarities and differences among the forms were noted. There was agreement that advantages would accrue from standardizing forms for data collected on shrimp trawl surveys. Peggy Murphy agreed to draft some forms for review by regional staff. It is hoped that a consensus about form design can be achieved.

Southeast Alaska, Kodiak, Aleutian Islands, and Alaska Peninsula

In general, the Southeast and Westward Regions use the same primary data forms. There is a skipper trawl record for each survey tow. Detailed data on location, time, depth, weather and gear are recorded. A station catch record form is completed for each tow. Percent composition and weight of each species of shrimp and fish are estimated and recorded. Species codes are taken from the National Oceanic and Atmospheric Administration NODC Taxonomic Code (1981). The skipper and station catch record forms are identical for both shrimp and crabs. Similar forms are used for length frequency samples from both commercial and survey catches. Subsamples from survey and commercial catches examined for size, sex and ovigerity are summarized on the composite survey tally record before transfer to a form for key punching. A summary data form is kept aboard the vessel to expedite radio reports to the area office regarding shrimp catches, species composition, and relative abundance estimates. Various other data summaries can be obtained from computer-generated print outs.

Cook Inlet and Prince William Sound

Central Regional staff discussed data forms that they use. A skipper trawl log form is completed for surveys. The form includes data such as deployment time, starting and ending depths, loran readings, and compass heading. A field form is completed aboard the survey vessel for each tow. Percentages of shrimp and fish are estimated, and subsamples are collected for species composition and length frequencies. Prior to development of electronic calipers, another form was used to record length frequency data from both survey and commercial catch samples. Since the development of electronic calipers, data are entered directly into a microcomputer and a print out of length frequency data is generated. Summary sheets of species composition, sex, and catch are also generated from these data. Commercial catch samples are recorded on forms. Number, weight, and percent species composition of subsamples are recorded for each landing.

British Columbia

A standard form is used to record data from the shrimp trap fishery in British Columbia. Data include trap type, bait used, time set and hauled, location, depth, and catch by species. Collection of data on bait may be discontinued, because it is difficult to standardize. Description of each type of trap is facilitated by distribution of forms that allow detailed explanation of trap design. A single code book is used for all data collection by DFO.

SPECIAL TOPIC: REVIEW OF KACHEMAK BAY SHRIMP ASSESSMENT PROGRAM

Lee Hammarstrom presented a thorough overview of the trawl shrimp survey for Kachemak Bay (Appendix E). The purpose of this session was to seek suggestions about survey design, survey methods, and data analyses.

The Kachemak Bay trawl shrimp survey was started in 1971 by the National Marine Fisheries Service (NMFS). ADF&G assumed responsibility for this survey in 1975 and implemented surveys both in spring and autumn. The survey is conducted with a NMFS-design otter trawl with a 61 ft opening. Prior to 1983, stations were randomly selected annually. Since 1983, the station location pattern has been fixed at the 1983 design. Most tows are 1 nm long; west of Homer spit some tows are 0.5 nm long in areas of zero catches. Area swept methods are used to calculate an index of abundance. Abundance estimates for fall and spring surveys differ, due to recruitment, growth, commercial catches and changes in shrimp distribution.

Survey methods in Kachemak Bay appear to be good. Analyses could be conducted on historical data to estimate appropriate sample sizes for length frequency analyses. Off hand, Jim Boutillier estimated that 1,000 samples per population per month was a reasonable size.

It was recommended that consideration be given to randomness in survey design. Analysis of historical data could provide insight about design considerations. Surveys could be conducted to locate concentrations of shrimp, and then a systematic station pattern could be implemented to delimit the geographic distribution of the concentration. Computerized graphical methods could be used to generate maps of shrimp abundance, and total absolute abundance could be estimated from them. Jackknife methods could be used to determine the importance of each tow in the survey design, define geographic patterns of abundance and estimate variances.

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Appendix A

1987 Shrimp Species Rank in Terms of Commercial Importance by Area and Gear Type
by Peggy Murphy

		Species				
Area[1]	Gear	Pink	Spot	Humpy	Coonstripe	Sidestripe
WESTW	Pot					
	Trawl	#1		#2		#3
PWS	Pot	#3	#1		#2	
	Trawl	#3	#2			#1
COOK	Pot	#3	#2	#4	#1	
	Trawl	#1		#2/3	#4	#2/3
YAKUT	Pot		#1			
SE	Otter	#1				
	Beam	#1	#5	#4	#3	#2
BC	Pot		#1			
	Otter	#1 (*P. jordani*)				
	Trawl	#1 (*P. borealis*)				

[1]Statistical Areas: WESTW - Westward Area J, PWS - Prince William Sound Area E, COOKH - Cook Inlet Area H, COOKG - Outer Cook Inlet Area G, YAKUT -Yakutat Area D, SE -Southeastern Alaska Area A, BC - British Columbia

Appendix B

1987 Management Regulations by Area and Gear Type[1]
by Peggy Murphy

Management Regulations	Statistical Areas[2]																			
	WESTW		PWS		COOKH		COOKG		YAKUT		SE				BC	
	P	T	P	T	P	T	P	T	P	T	P	T_o	T_b		P	T
Fishing Season	X	X	X[4]	X	X	X	–	X	X	X	X	X	X		–	–
Fishing Sub-seasons					X	X										
Closed Area(s)		X		X		X				X		X	X			
Gear Restrictions			X	X					X		X	X	X		X	
GHL		X			X	X				X						
Sub-season/weekly GHL					X	X										
GH Range			X[4]	X						X	X	X	X			
Pot Limit									X		X					
Mandatory Logbook		X[3]	X[5]												X	X
Species Composition		X		X												
Exclusive Registration						X										
Permit Required			X													
Fishery Performance		X													X	X
No Management Strategy							X									
Exp. Management Area		X	X												X	
Limited Entry															X	X

[1]Gear Types: P - Pot, T - Trawl, T_o - Otter Trawl, T_b - Beam Trawl
[2]Statistical Areas: WESTW - Westward Area J, PWS - Prince William Sound Area E, COOKH - Cook Inlet Area H, COOKG - Outer Cook Inlet Area G, YAKUT -Yakutat Area D, SE -Southeastern Alaska Area A, BC - British Columbia
[3]Applies only to areas covered by the Mainland Shrimp Management Plan
[4]Applies only to traditional harvest area.
[5]Applies only to Montague Strait experimental harvest area.

Prince William Sound
by Wayne Donaldson

Trawl Shrimp

Trawl shrimp fishery began in 1972. Harvest and effort were minor until the late 1970's when large Kodiak based otter trawl vessels targeted on pink shrimp (Pandalus borealis) in southwestern Prince William Sound. The peak harvest occurred in 1984 when 1.3 million lbs. was taken. No vessels have targeted on pink shrimp during the previous two seasons due to marginal catch rates, fish bycatch and low ex-vessel value. Recent emphasis has shifted from pink shrimp to sidestripe shrimp (Pandalopsis dispar). The sidestripe fishery is characterized by a few small vessels targeting their effort in the northwest corner of the Sound. Initial catches were from the southwestern Sound. Indications from catch rates suggest that this stock is small. The product is marketed in Anchorage and Japan with an ex-vessel value of $1.25/lb for whole shrimp.

Commercial catch sampling of the pink shrimp fishery has been conducted by Leslie Watson of the Kodiak staff. Current monitoring of the sidestripe fishery includes logbook and fish ticket information.

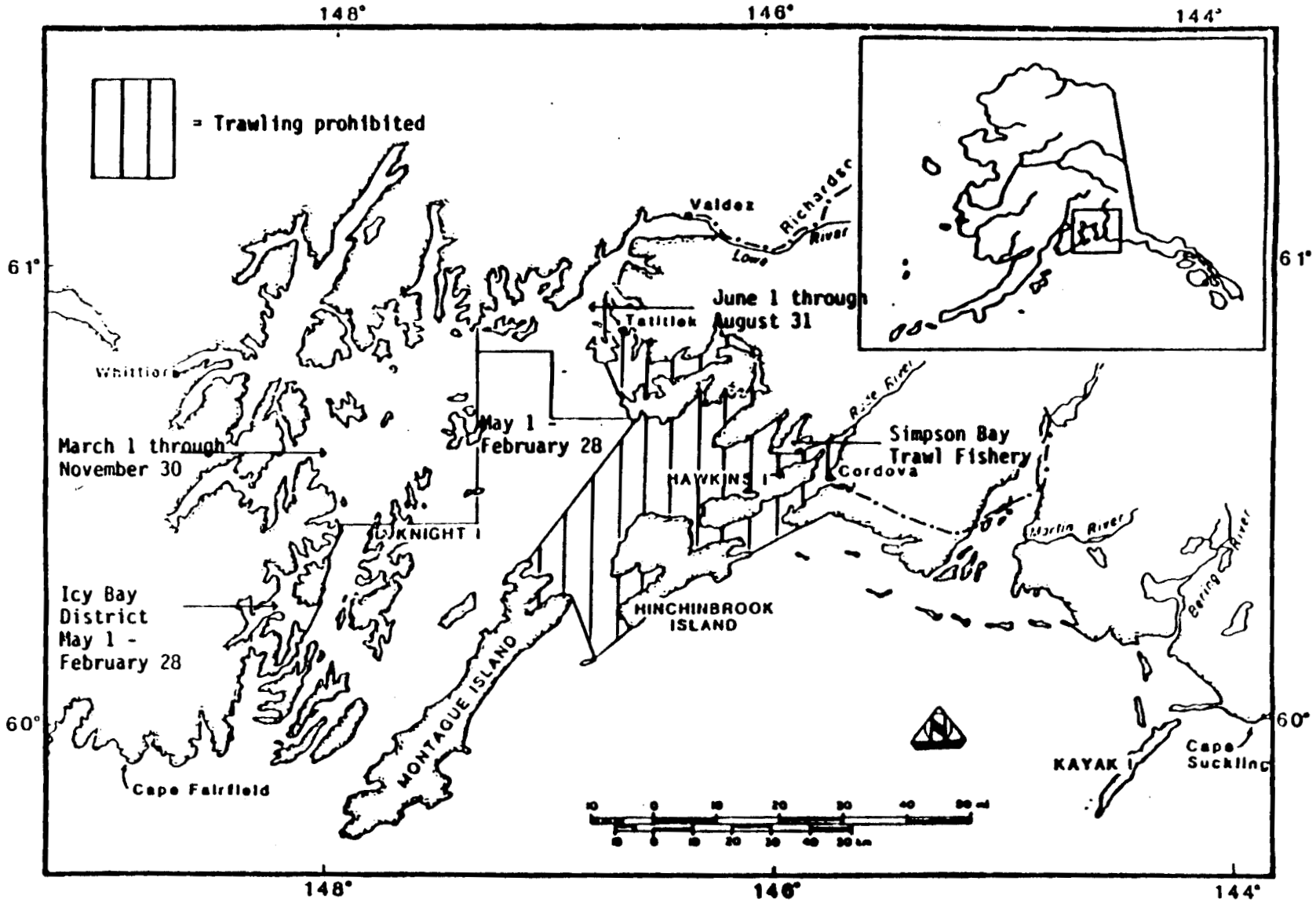
Management Measures

1) The pink fishery is closed March and April for the peak egg release period.
2) The sidestripe fishery is closed from December thru February for the peak egg release period.
3) Cod end mesh restriction of 1 5/8" minimum and hung square during March and April to minimize the catch of pinks.
4) The eastern Sound is closed to trawling to protect crab stocks.

Appendix C.1 Trawl shrimp harvest, Prince William Sound management area.

Year	Vessels	Pounds
1972		5,153
1973		4,243
1974		1,345
1975		26,961
1976		134,115
1977		170,757
1978	8	440,684
1979	4	634,518
1980	6	557,328
1981	4	70,560
1982	9	346,517

Year	Vessels	Landings	Pink	Sidestripes	Other	Total
1983	13	46	420,275	1,058	2,345	423,678
1984	14	55	1,292,643	8,842	1,155	1,302,640
1985	6	44	432,514	15,696	440	448,650
1986	3	44	218,156	27,701	13	245,870
1987	2	109	275	95,043	400	95,718



Appendix C.2 Prince William Sound management area, trawl shrimp seasons and trawl closures.

Shrimp Workshop
Prince William Sound

by Wayne Donaldson

Pot Shrimp (95% Pandalus platyceros, 5% Pandalus hypsinotus)

Pot shrimp fishery began around 1960. Fishery was minor to other shellfish fisheries in the area during the 60's and early 70's (1,000 to 20,000 lbs.)

From 1978, catch and effort began a dramatic increase until 1982 when ADF&G instituted a closure from December thru March based on the peak egg bearing period. A guideline harvest range of 75,000 - 145,000 pounds was also instituted to allow the department to evaluate the stock during the rapid expansion.

The Alaska Board of Fisheries increased the guideline harvest range in 1985 to 150,000 - 200,000 lbs. for the western portion of the Sound only. The western Sound quota was divided equally between a spring and fall season. Two other areas were established to test the effects of continuous fishing on shrimp stocks by having unrestricted year around fishing.

Fishing still occurs during the egg release and egg bearing period. Catch has decreased in the most productive of the open all year area. Catch for the fall 1988 season in the western Sound decreased over preseason expectations.

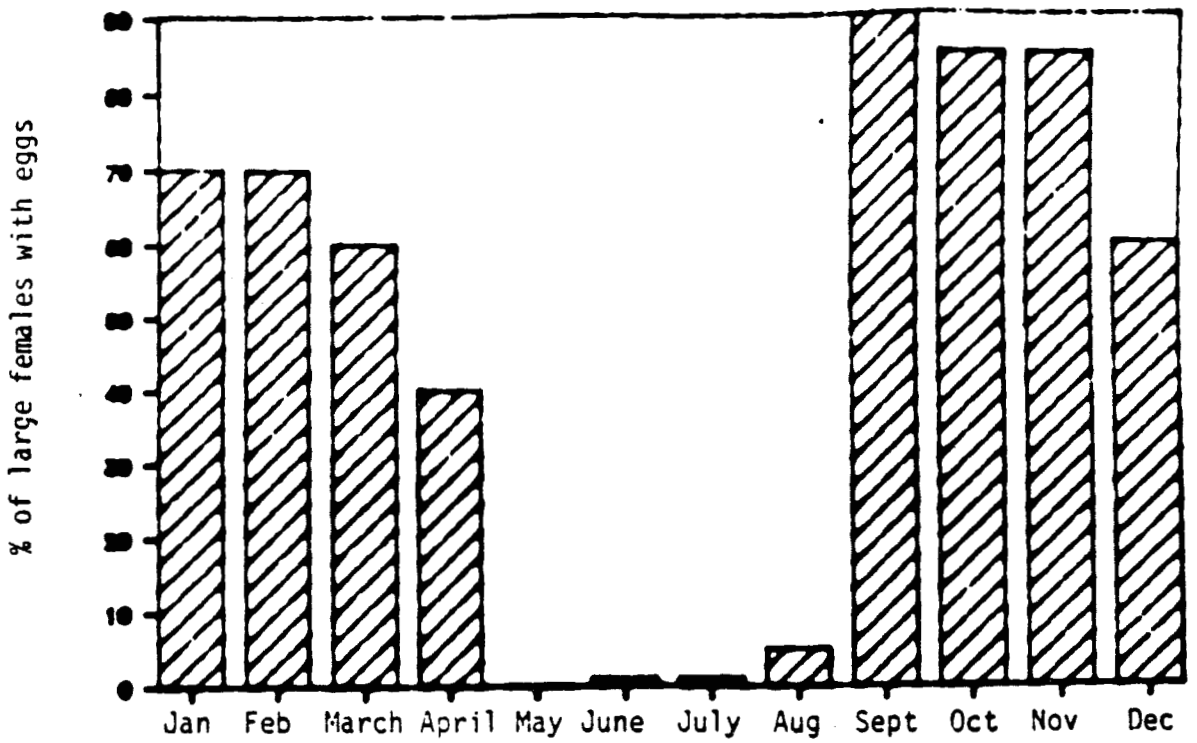
The total catch in 1988 is expected to decrease to approximately 160,000 lbs. which is a 60,000 to 80,000 lb. decrease from recent harvests.

Issues

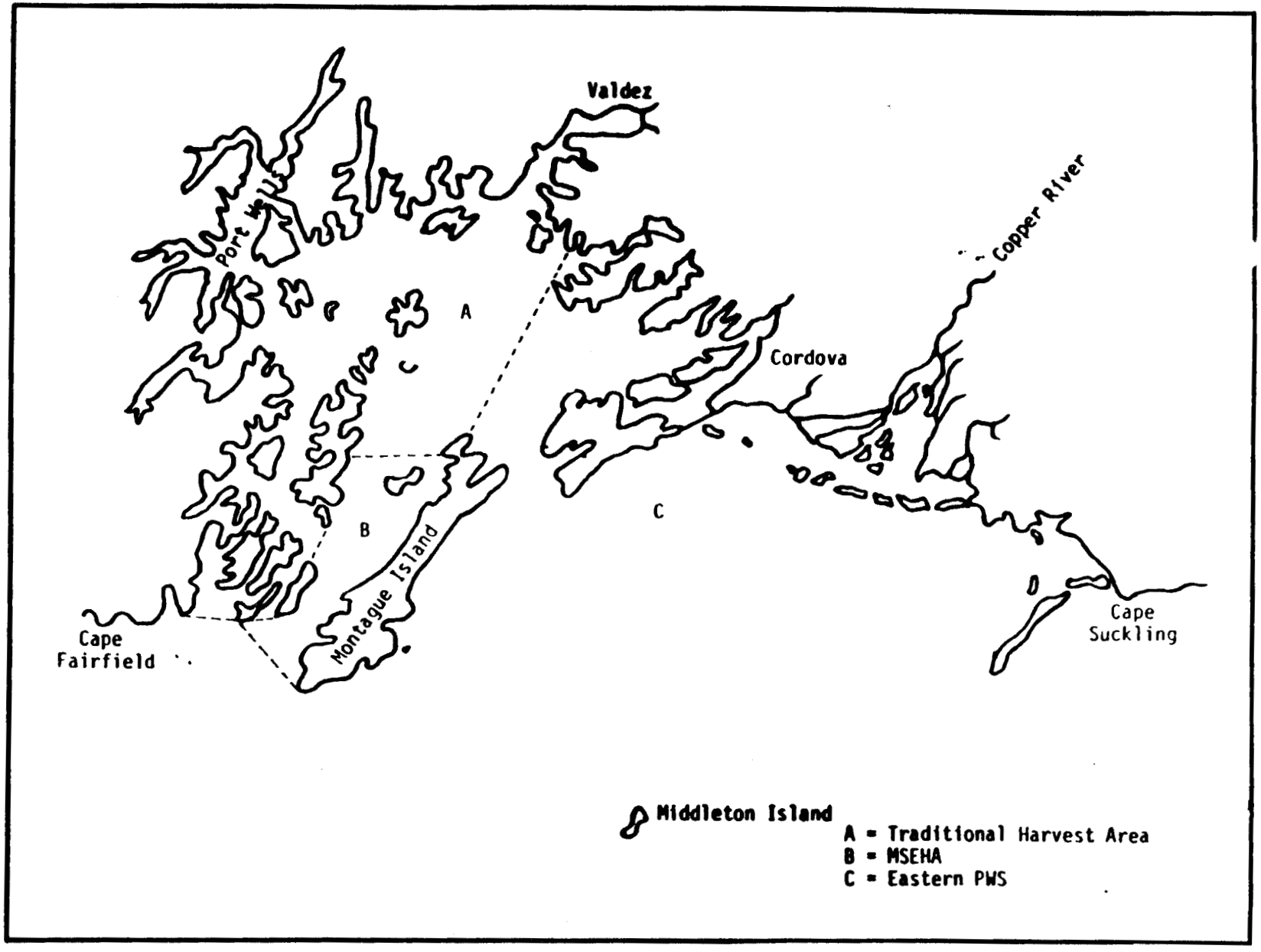
1) Complete field testing and analysis of proposal to institute escape panel. (hard mesh, 1 3/4 in)
2) Shift seasons away from egg bearing and release periods. (obtain maximum larval production, avoid disruption of egg extrusion)
3) Define life history of juvenile spot shrimp (< 25 mm).
4) Monitor the size of egg bearing females over time to detect changes in fecundity and population structure.
5) Collect annual stock data to adjust the present guidelin harvest level. May be easier said than done based on th wide variety of locations to be sampled. Sampling shoul avoid molting periods.

Appendix D.1 Pot shrimp harvest, Prince William Sound management area.

Year	Vessels	Landings	Pounds (Whole Weight)
1960			4,165
1961			---
1962			2,986
1963			919
1964			3,547
1965			3,637
1966			---
1967			625
1968			5,733
1969			4,297
1970			16,513
1971			10,916
1972			5,802
1973			5,319
1974			20,857
1975			3,465
1976			2,012
1977			6,276
1978	9	17	12,914
1979	17	98	43,594
1980	23	155	75,173
1981	51	509	144,903
1982	57	397	178,507
1983	71	646	178,206
1984	79	513	173,079
1985	78	528	231,050
1986	80	540	242,678
1987	86	498	225,160



Appendix D.2 Percentage of large females with eggs by month, Montague Strait experimental harvest area, 1986.



Appendix D.3 Prince William Sound management area pot shrimp fishing districts.

Appendix E

Shrimp Workshop, Anchorage October 24-26, 1988

COOK INLET TRAWL SHRIMP: REVIEW OF FISHERY, MANAGEMENT, AND STUDIES

by

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Abstract - Cook Inlet is located in the north central Gulf of Alaska and is bounded on the south by the Kodiak management area at the latitude of Cape Douglas and on the east by the Prince William Sound management area at the longitude of Cape Fairfield. The major trawl shrimp fishery of Cook Inlet occurs in the Southern District (Kachemak Bay) and targets on pink shrimp (*Pandalus borealis*). Small and intermittent catches in the 1950's and early 1960's did not accurately reflect sizes of the stocks. Commercial catches reached the 5.0 million pound level annually in the late 1960's and remained near that level through the early 1980's. Vessel effort ranged from a low of one in 1968 to a high of 22 in 1981. Guideline harvest levels were established in the early 1970's but were more a reflection of local processing capacity than biological factors. The Kachemak Bay Trawl Shrimp Management Plan was adopted by the Alaska Board of Fisheries in 1979, which spread the harvest out evenly during a time period of July 1 through March 31 each year. The fishery was closed for a portion of the 1983-84 fishing year and again during the 1986-87 year, remaining closed since the latter closure until the present time, due to declines in stock abundance.

The Kachemak Bay trawl shrimp index program dates back to 1971, and two trawl shrimp index of abundance surveys have been conducted annually by ADF&G in Kachemak Bay since 1976. From 1978 to 1986, the mid-point estimates from these surveys steadily declined, and although the estimates have risen slightly during the past two years, the majority of pink shrimp captured during the recent surveys have been small in size, suggesting juveniles or males, and the areas of occurrence have diminished significantly since the late 1970's and early 1980's. In an attempt to refine the index of abundance estimates, the number of stations sampled in the survey was expanded in the area of highest shrimp abundance (east of the Homer Spit) beginning with the spring survey of 1988.

Biology and Life History of Pink Shrimp

Pandalus borealis

A. Life Cycle

spawning in Nov-Dec; hatching in Mar-Apr in BC; six larval stages lasting 45-100 d, depending on temperature; juvenile stage lasts 1 yr; at 18 mo 50:50 sex ratio of mature males:females; males begin sex change at 2 yr and are transitional for 4-5 mo.

B. Age and Growth

size related to age and geographic region

maximum age is 3 (UK), 4 (BC), 5-6 (Kachemak Bay), 7 (western Gulf of AK and Bering Sea)

maximum size is 20 mm CL or 121 mm TL for males and 37 mm CL or 182 mm TL for females

C. Fecundity

egg count ranges from 600-4900, depending upon size of female and geographic area

D. Natural Mortality

natural mortality inversely related to time spent as male and maximum age; larval and juvenile mortality is higher at warmer temperatures over the range 4-10 C; annual estimates are M=.2-1.0 (A=18-68%)

E. Predator-Prey Relationships

Prey: macro algae, copepods, crustaceans, bivalves, diatoms, foraminifera, polychaetes, echinoderms, nematodes, foraminifera, gastropods, detritus, etc.

Predators: fish such as dogfish, cod, turbot, hake, and parasites such as rhizocephalan *(Sylon hippolytes)*, bopyrid isopod *(Bopyroides hippolytes)*, and microsporidia

F. Major Information Needs

Biology and Life History of Spot Shrimp or Prawn

Pandalus platyceros

A. Life Cycle

spawning completed by end of Oct; ovigerous for 5 mo; hatching in Mar-Apr in BC; 4 true larval stages (5th is postlarval); some males begin sex change at 18 mo and by 3 yr all prawns have become transitionals or females

B. Age and Growth

21 mm CL at 1 yr

maximum size is 48 mm CL or 230 mm TL for males and 61 mm CL or 253 mm TL for females

C. Fecundity

mean counts between 2000 (BC) - 3900 (AK)

D. Natural Mortality

E. Predator-Prey Relationships

Prey: polychaetes, crustaceans

Predators: Octopus, yelloweye rockfish, and parasite *(Sylon hippolytes)*

F. Major Information Needs

Biology and Life History of Humpy Shrimp

Pandalus goniurus

A. Life Cycle

larvae hatch in spring; 2-2.5 mo larval period; at least seven larval stages; some females and most males mature in 1st year; change to female in 2nd summer; most females die after eggs hatch at 2 yr

B. Age and Growth

maximum age is 3

maximum size is 13 mm CL or 62 mm TL for males and 16.5 mm or 78 mm TL for females

C. Fecundity

mean of about 2000 eggs (AK)

D. Natural Mortality

mortality is high after 2 yr

E. Predator-Prey Relationships

Prey:

Predators: sand sole

F. Major Information Needs

Biology and Life History Sidestripe Shrimp

Pandalus dispar

A. Life Cycle

eggs are extruded in late Oct; eggs hatch in Mar or Apr (BC) or Apr (SE AK); 5-6 pelagic larval stages; males begin to mature at 18 mo; sex change begins at 2 yr with 4-5 transition stages

B. Age and Growth

maximum size is 31 mm CL or 182 mm TL for males and 36 mm CL or 208 mm TL for females

maximum age is 4

C. Fecundity

mean is 903 (WA), 1129 (BC) and 4150 (AK)

D. Natural Mortality

mortality is high after 3 yr

E. Predator-Prey Relationships

Prey:

Predators: parasite *(Bopyroides hippolytes)* and Metacercaria

F. Major Information Needs

Biology and Life History of Humpback or Coonstripe Shrimp

Pandalus hypsinotus

A. Life Cycle

egg bearing begins in late Nov or early Dec; larvae hatch in late Mar-Apr; 6 zoeal and 3 postzoeal stages; larval period lasts 2-2.5 mo; mature as males (and some females) at 1.5 -2 yr; after 4-5 molts transition to female is complete; survival to 4 yr is low

B. Age and Growth

maximum age is 4

maximum size is 29 mm CL or 151 mm for males and 40 mm or 192 mm TL for females

C. Fecundity

mean is 2257 (BC), 4000 (AK), and 264-3000 (Japan)

D. Natural Mortality

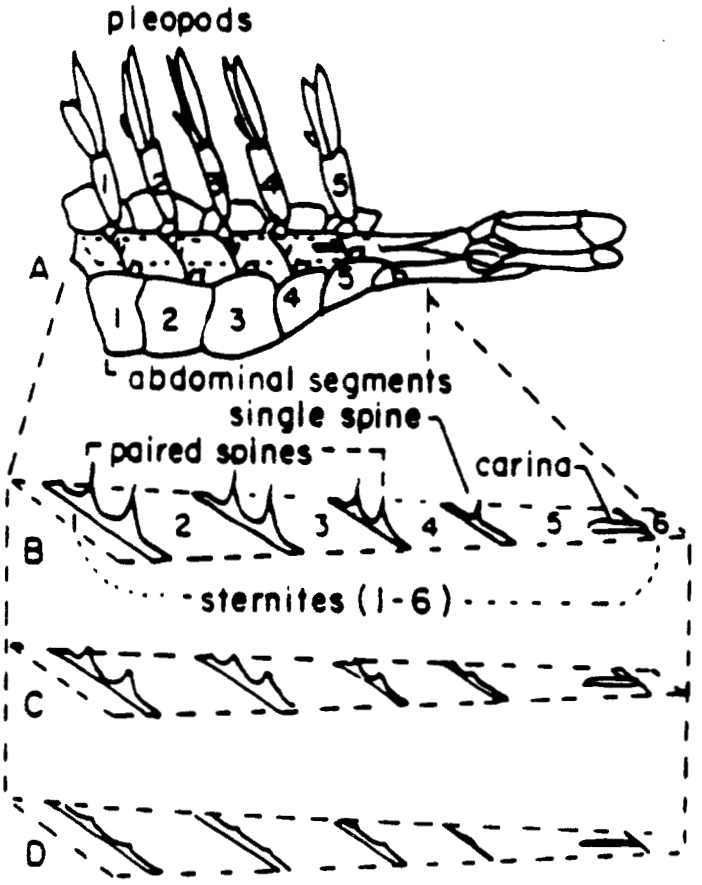
mortality is high after 3 yr

E. Predator-Prey Relationships

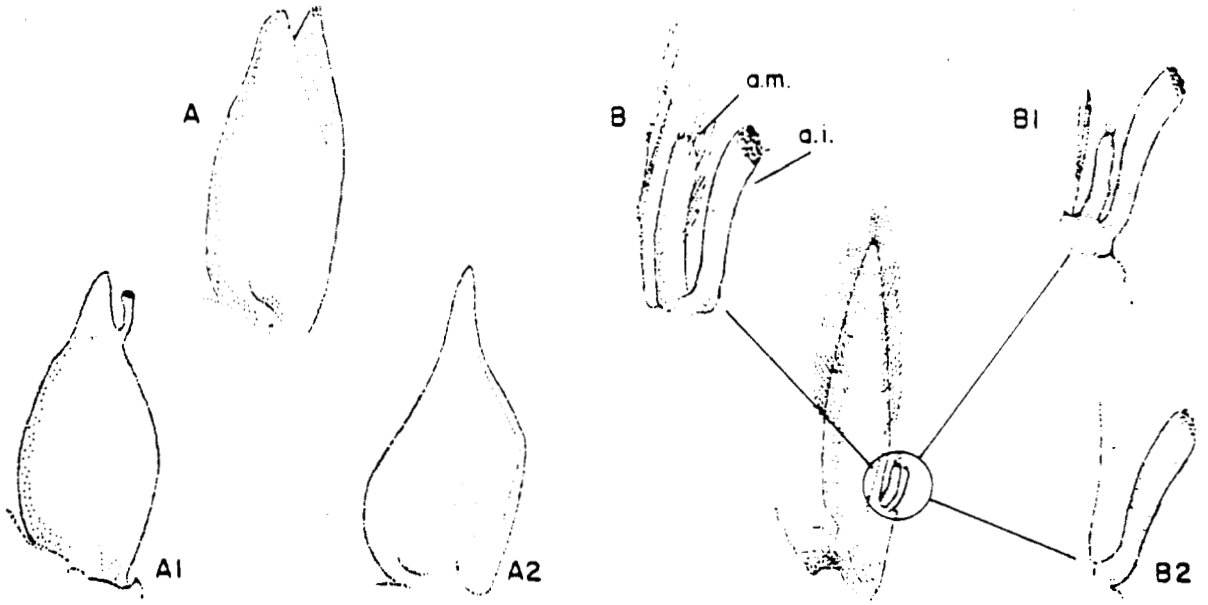
Prey: mysids, crustaceans, and polychaetes

Predators: sand sole

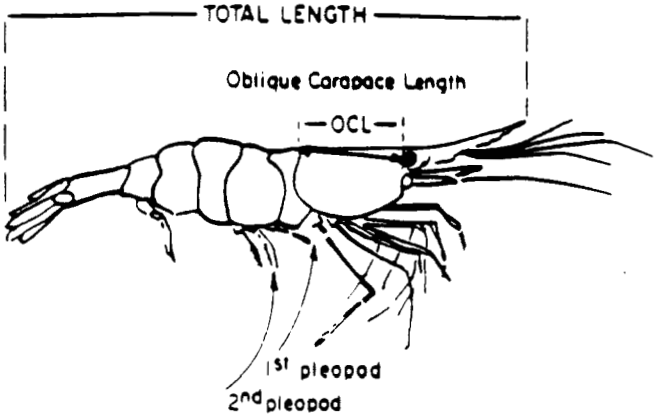
F. Major Information Needs



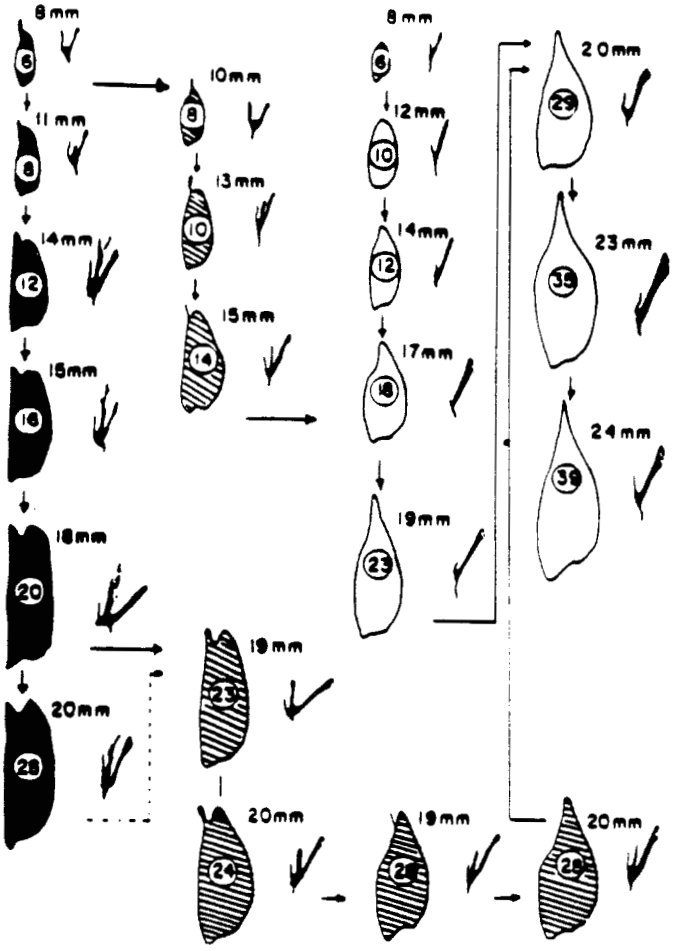
Appendix G.1 A: Diagrammatic ventral view of the abdomen of a pandalid shrimp showing sternal spines. B-D: Expanded ventral views of sternal spines in prominent, reduced, and remnant stages respectively. Taken from Figure 1, McCrary 1971.



Appendix G.2 *Pandalopsis dispar*. Endopod of first pleopod: (A) active male phase. (A_1) transitional phase. (A_2) female phase. Endopod of second pleopod: (B) active male phase. (B_1) transitional phase. (B_2) female phase. a.i., appendix interna; a.m., appendix masculina. Taken from Figure 1, Butler 1980.



Appendix G.3 Method of measuring the carapace of *Pandalus borealis* and location of the first and second pleopods. Taken from Figure 9, Allen 1959.



Appendix G.4 Change in form with increasing age of the endopodite of the first pleopod and corresponding appendix interna and appendix masculina of the second pleopod of *Pandalus borealis* from the Northumberland population. Age in months is given in the ring in each endopodite and the carapace length (mm) above each figure. Male endopodite, black; transitional, cross-hatched; female, outlined. Arrows indicate sequence. Taken from Figure 10, Allen 1959.

Appendix H

1988 Shrimp Workshop, Anchorage October 24-26,

KACHEMAK BAY TRAWL SHRIMP INDEX LABORATORY PROCEDURES AND DATA ANALYSIS

by

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Small samples of pandalid shrimp captured during the annual Kachemak Bay trawl shrimp surveys are frozen at the end of each survey day for later sex and carapace length frequency analysis. After the survey when time allows, samples are thawed and separated by species and sex in the laboratory. Prior to the Fall 1988 index, shrimp were divided into sex categories by the sternal spine method described by McCrary (1971). Sternal spines present or partially present were placed in the "sex undetermined" category. Shrimp with no sternal spines or external eggs present were considered to be "non-ovigerous females". Shrimp with external eggs were considered as "ovigerous females". In the fall 1988 the category "sex undetermined" will be changed in order to further break down that category to include males and transitionals.

Carapace length frequency measurements are next taken from each individual shrimp of the different sex categories to the nearest one-tenth millimeter using the " Limnotera Computer Caliper" modem with a "Compaq Plus" personal computer and "Alaska Basic" software developed by John Plank and Ray Burkholder. The aggregate weight of each species sex category is also recorded into the "Alaska Basic" program. Data from each station is then imported from the "Alaska Basic" into a "Lotus 2" spread sheet developed by John Hilsinger for the Kachemak Bay shrimp program. The length frequencies for each station's catch were then transferred into another "Lotus 2" spread sheet that converted the number of shrimp in each size category into percentage of total measured in the sample. The percentages at each station were weighted by a correction factor, computed as the species weight of each station's catch divided by the total species catch of all stations. Finally all stations' weighted length frequencies were combined into length frequency histograms by area caught for each spring and fall survey.