Informational Leaflet 135

MINUTES OF THE SECOND ALASKAN SHELLFISH CONFERENCE

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October 31, 1969

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ALASKA
Fish & Game

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IN MEMORIAM

The Alaskan fishing industry lost a faithful friend on December 11, 1968, with the passing of U. S. Senator E. L. (Bob) Bartlett. Raised in Fairbanks, Bartlett rose from a humble beginning as a miner and journalist to become Alaska's delegate to Congress during territorial days. With the advent of Statehood in 1959, Bartlett was elected U. S. Senator, the office he held until his death.

Senator Bartlett's name was associated with numerous laws affecting fisheries during his 35 years of public service. As chairman of the Senate Subcommittee on Merchant Marine and Fisheries of the Senate Commerce Committee, he held a post of power for fisheries. Most notable among his many achievements was the Bartlett Bill, Public Law 88-308, which provided the legal framework for the protection of natural resources on the continental shelf of the United States. One of the direct effects of this bill was the authority it conferred to the United States for jurisdiction over the king and tanner crab resources.

It was Senator Bartlett who sensed the significance of the Geneva Continental Shelf treaty and pressed for the legislation that gave the United States control over the king crab fishery of the shelf far outside territorial waters and later extended the three mile limit to 12 miles for fisheries jurisdiction.

Although the United States recognized that the Bering Sea king crab fishery had been under heavy exploitation for years by Japan and the Soviet Union, it was the force of the Bartlett Bill that drew these nations into negotiations with the United States that resulted in restraints on foreign fisheries to ensure conservation of the king crab resource.

Senator Bartlett was a true friend of the fishing industry and fishermen throughout the United States. His passing will be mourned by all those men who go down to the sea in ships.

MINUTES OF THE SECOND ALASKAN SHELLFISH CONFERENCE

ANCHORAGE, ALASKA

FEBRUARY 10-14, 1969

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INTRODUCTION

The Second Alaskan Shellfish Conference was held in Anchorage, Alaska, February 10-14, 1969. Its purpose was similar to that of the first Alaskan Shellfish Conference - to exchange information and provide a forum for discussion between shellfish biologists of the Alaska Department of Fish and Game (ADF&G) and the U. S. Bureau of Commercial Fisheries (BCF) on matters pertaining to the shellfish resources in Alaskan waters. Co-chairmen during the Conference were Dr. David Hoopes, Chief of Shellfish Investigations, U. S. BCF Biological Laboratory at Auke Bay and Mr. Dexter Lall, ADF&G Kodiak Regional Research Supervisor, Division of Commercial Fisheries. The present report summarizes the major talks given by participants during the conference.

Coordinators appointed for the 1970 meeting were Mr. John Karinen, BCF, Mr. Melvan Morris, Wakefield Fisheries, and Mr. Duane Petersen, ADF&G.

INTERNATIONAL AND INTERAGENCY REVIEWS

Role of Federal Government in Shellfish Research -- Dr. William Smoker

To understand the present role of the Federal Government in Alaska's shellfish research we need to keep in mind the Federal role in past years. As with many affairs in Alaska, we can say "In the beginning was the Federal Government... " and I'm sure there will be those willing to add "...and behold it was weighed and found wanting". Be that as it may, the Federal Government was the only agency administering shellfish resources in those times.

As usual with new fisheries, the crab, shrimp, and clam resources in Alaska developed with very little known about them and the responsible Federal agents had to make management decisions by the "seat of their pants". We are all familiar with the often cumbersome system that existed where regulations had to be published from Washington, D.C. and the interplay of various lobbyists that operated there.

After the beginning there occurred the state government. When the new state took over there were, I believe, two separate Bureau studies on king crab, one University of Washington study, one University of Southern California study in addition to ADF&G studies. I'll reminisce a bit and recall for you that about that time in November, 1960 ADF&G called the first ancestral meeting of this gathering to compare notes on all current king crab research. Some of us at this meeting were present at that time and you may recall we ended then with a long list of research problems and needs. While much progress has occurred, most of the questions on reproduction, growth, mortality and movements require further answering and we do have new questions.

Of course, management from the state level has had its own set of difficulties, but, now as then, the need for biological information is critical. A most important (and frequently the only) source of information has been the commercial landing statistics from which we have had to squeeze regulatory decisions.

To continue with the Federal role in Alaska, even with transfer of the management of the resources to the state, the Federal Government through the BCF stays in the act if only because of the appearance of foreign fishing fleets on our Alaskan continental shelf and the complex international problems that result.

More significant is the continuity that perhaps only the Federal Government can provide in research on shellfish. Regardless of Federal inadequacies -

state, university, and industry agencies by themselves seem to have even greater difficulties in providing continuity in resource basic studies. One outcome of seeking solutions to this is the federal aid-to-the-state projects which I believe will prove to be a considerable boom to all of us.

At times the Federal Government finds it necessary to play a plug-the-breach role in shellfish research in Alaska. Events move so swiftly that the usual conservative process of getting research started by the appropriate agency is not adequate. A current case in point is scallops. We've had a chain of cause and effect events in the past year that is forcing the Bureau to get a scallop research program underway for which it really has had no formal appropriation.

Lack of basic information on scallops resulted in a conservative approach to authorizing monies for vessel conversions which caused great criticism of the Bureau and which makes it necessary that the Bureau get on with the business of producing the required research information.

Similar comments may be made about tanner crab. Also, both tanner crab and scallops are involved in international action which must involve the Federal Government.

Before concluding these remarks on the previous Federal research role, budget figures are always interesting and I will emphasize that in the past ten years the Alaska Region annual budget on shellfish biological research has risen from a low of $20,000 increasing steadily to a present budget of $300,000. This is a remarkable accomplishment considering the very austere climate in recent years for Federal non-military natural resource budgets. I must emphasize that these figures do not include Federal aid funds nor exploratory fishing and technology monies.

The Federal role in future Alaska shellfish research is no more clear than the future outcome of most human affairs. I'm certain the needs for continuity will remain with us as well as needs to respond to crises developments and certainly the international involvements will expand rather than decline.

We are aware of the accelerating Alaskan industrialization with its impact on shellfish environment and we anticipate an increasing research involvement here.

We hope to rise above some of the haphazard and disjointed actions that have characterized shellfish research by all agencies in the past. For example, we believe we have finally been able to muster enough vessel support for a realistic attack this year on king crab - tanner crab studies in the

Bering Sea. This in my mind approaches what we should be able to do over the entire Alaskan continental shelf which involves understanding the seasonal physical and biological dynamics of the major ocean gyre, currents and water masses and their involvement in the prosperity or decline of the shellfish stocks which extend over the shelf and into coastal and estuarine environments. We are probably committed to continue our attacks on high priority management crises and gradually fill in the big picture as we can whenever we can.

The budget wasting crises sort of actions will probably not diminish until we finally build up our fund of basic knowledge and I believe the Federal research role has a particular mission in that regard.

Areas of Federal Research in Alaska Shellfish -- Dr. David Hoopes

Federal research on shellfish can be divided into three broad categories:

1. Commitments resulting from international conventions and agreements.

2. Support to Bureau branches and other agencies within the Federal government.

3. Cooperation with state agencies and assistance to all segments of the commercial fishing industry.

The first category encompasses all obligations of an international nature that, by law, are under the jurisdiction of the Federal Government. Individual states may regulate a domestic fishery prosecuted on the high seas, principally by the passage of "landing laws", but no state can legally enter into separate agreement with a foreign nation under U. S. law. Thus, when nationals of a foreign country engage in a fishery of vital interest to citizens of the United States, the Federal Government must act to insure that the interests of the United States are fully protected whenever possible.

There are numerous examples in international law of conventions, treaties, and agreements of such a nature to which the United States is signatory along with one or several foreign nations.

Four such agreements are of particular significance to Alaskans. These are the Continental Shelf Convention, International North Pacific Fisheries Convention, the bilateral agreement between the United States and Japan relating to fishing for king crab and a similar agreement between the United States and the Soviet Union. Either directly or indirectly, under the terms of these agreements the United States must conduct biological research and exchange research data with scientists of the other signatory nations. The ultimate goal of this research is to insure conservation of the resources and rational fishing of the commercial stocks. The biological information collected serves as a basis for negotiations to reach agreements that will best insure success in attaining these goals.

The second category of Federal research responsibility lies in the area of support to other Federal groups, both within and outside the Bureau of Commercial Fisheries. Bureau branches depending on research support here in Alaska that are particularly concerned with shellfish resources include Branch of Loans and Grants, the Federal Aid program and the Branch of River Basins. The Bureau also works closely with other Federal agencies such as the Federal Water Pollution Control Administration (FWPCA).

One primary consideration prompting our interest in the newly developed scallop industry was the fact that no information was available from other sources that could be used by Loans and Grants personnel to intelligently review applications for vessel conversion. Joint programs involving Federal research are designed to fill this gap in our knowledge. The initial VIKING QUEEN cruise was only the beginning. This summer personnel from the Shellfish Investigations staff of the Bureau of Commercial Fisheries Laboratory at Auke Bay will assist the Bureau's Exploratory Fishing and Gear Research Branch in a survey of the potential scallop resources west of Kodiak Island.

The Branch of Federal Aid assists in supporting a number of research projects jointly with the Alaska Department of Fish and Game. Currently, three of these projects are concerned with shellfish. When Federal money is used to support State research, Federal biologists assist the Federal Aid Coordinator by reviewing State proposals for Federal Aid projects and the periodic reports prepared by State project leaders conducting research under the Federal Aid program. Personnel from the Shellfish Investigations staff of the U. S. Bureau of Commercial Fisheries Laboratory at Auke Bay have accompanied the Federal Aid Coordinator on field reviews of State-Federal Aid projects and have assisted the State project leaders individually on a number of occasions.

With the increasing incidence of pollution in Alaska's estuaries and along Alaska's coastlines and the very real probability of more serious pollution problems in the near future, the U. S. Bureau of Commercial Fisheries has undertaken research and is planning research directed toward combating this threat. Wherever their assistance is requested, shellfish biologists help River Basins personnel and FWPCA staff members in the fight against pollution. Shellfish biologists participated in a recently completed estuarine study in southeastern Alaska involving the effects of pulpmill operation on environmental quality. A three-year study of the oceanography of Kachemak Bay will begin next summer. One of the major objectives of this research will be to determine the possible effects of a major oil spill in Cook Inlet on the several fisheries of the area.

The third category of Federal research is the broad area covered by cooperation with State agencies and the rendering of assistance to all segments of the commercial industry. Federal biologists must carefully and accurately assess stock condition as part of developing the biological foundation required for international negotiations. It is absolutely necessary that complete and accurate catch and effort statistics be available from the United States commercial fisheries so that the best estimate of stock condition can be developed. The exchange of data with foreign nations signatory to fishing agreements with the United States is also clearly outlined. When the United States cannot provide complete and reliable data, it proves difficult to obtain the same vital information from the other nations involved. Because such data are also vital to the conservation of the resource and the national management of the fishery, their collection is necessarily a function of the State management agency. When such data are not available both Federal and State agencies are severely handicapped.

The Federal Government is often in a position to provide State agencies and the fishing industry with background information otherwise unavailable to them. Primary areas in which Federal assistance can be beneficial are in the field of exploratory fishing and gear research and in the field of basic life history studies. Information on ecological requirements, behavior, factors setting year class abundance, and the collection and analysis of oceanographic data all require long term research programs that are often difficult or impractical to support by organizations with lesser resources or with different primary missions than those of the Federal Government. Where interests in large part overlap, such as in the eastern Bering Sea, carefully coordinated programs will lead to success in accomplishing the primary goals of conservation and rational management of the shellfish resources.

International Review -- Dr. David Hoopes

United States - Soviet Agreement

Apparently attracted by the success of the Japanese king crab fishery off Alaska and encouraged by their own reconnaissance fishing, the Soviets began a king crab fishery on the Continental Shelf of the eastern Bering Sea in 1959. This fishery was marked by modernization of the fleets and an increase in effort during the period 1961-1966. In addition to their Bering Sea king crab operations, the Soviets sent king crab fleets into the western Gulf of Alaska in 1963 and 1964.

The threat of further Soviet king crab fishing in the Gulf of Alaska was forestalled in February 1965 when the United States and the Soviet Union entered into an agreement governing Soviet fishing for king crabs on the Continental Shelf off Alaska during 1965-66. The agreement, similar to the one with Japan, restricted the Soviet crab fishery to the eastern Bering Sea, placed a quota on Soviet production, and provided for certain conservation measures to be observed. The annual Soviet production quota for each of the 2 years 1965 and 1966 was established at 118,600 twenty-four-pound cases. The agreement specified that the two nations would meet prior to expiration of the Agreement to decide on future arrangements.

In January 1967 the Agreement was extended for an additional 2 years (1967-1968). The only significant change was a slight reduction of the Soviet's annual quota to 100,000 cases. This 15 percent reduction in quota had little effect on the declining trend in stock condition. The ensuing 2 years were used by U. S. Bureau of Commercial Fisheries biologists to mount a concentrated research effort to demonstrate the need for stricter conservation measures. The results of this research program were instrumental in effecting a substantial reduction in quota during the current round of negotiations (January 1969). The present 2 year Agreement calls for a 48 percent annual reduction in quota to 52,000 cases and a substantial increase in the eastern Bering Sea pot fishing sanctuary. In addition, the Soviets were restricted to a tanner crab catch of 40,000 cases and prohibited from trawling in the pot sanctuary.

The United States - Soviet king crab fishing agreement also calls for an annual meeting of scientists and exchange of scientific data and commercial catch statistics. Such exchanges have taken place as outlined in the Agreement and have led to a better understanding of research methods and a freer exchange of research results. Future plans call for scientific meetings nearer the geographical areas of actual interest rather than in large cities. During the summer of 1968 both sides exchanged scientists aboard vessels conducting king crab research in the eastern Bering Sea. The next exchange will occur during the 1969 field season followed by a visit of Soviet scientists to Alaska sometime during the winter of 1969-70.

United States - Japanese Agreement

The treaty establishing the International North Pacific Fisheries Commission was concluded in 1954. At that time the United States requested a study of king crab be initiated in the eastern Bering Sea. Such a study was begun in 1955 and has continued to date. Prior to 1964 the Japan Fishery Agency unilaterally regulated Japan's king crab fishery through licensing restrictions and the establishment of quotas.

Evidence collected during joint research by the United States and Japan indicated that a substantial decline in stock condition occurred during the early 1960's as a result of the intensified fishing effort by both Japanese and Soviet fleets. To prevent further depletion of the resource, the United States and Japan signed a 2-year agreement in November, 1964, whereby it was agreed that, to avoid possible overfishing of the king crab resource in the eastern Bering Sea, Japan would limit her annual commercial catch to the equivalent of 185,000 twenty-four pound cases for the years 1965 and 1966. In November 1966, the agreement was extended for 2 additional years with a further reduction in annual quota to 163,000 cases.

Continued research by the U. S. Bureau of Commercial Fisheries demonstrated that these token reductions did not reverse the unfavorable trends in stock condition. The United States presented its case at the 1968 INPFC meetings and Japan was forced to concur that the present bilateral regulatory measures were not adequate. The United States - Japanese agreement was renegotiated in November, 1968, and resulted in severe curtailment of the Japanese king crab fishery in the eastern Bering Sea. The annual quota was slashed by 48 percent to 85,000 cases, night trawling was prohibited in the pot sanctuary, the existing pot sanctuary was almost doubled in area and provisions were made to restrict Japan's catch of tanner crabs.

Water Pollution Problems -- Mr. Raymond Morris

The waters of Alaska today are relatively free of pollution except those areas which are near large population centers or industrial complexes. It is apparent that precisely those practices which brought pollution to dangerous levels elsewhere, exist today in Alaska. These practices include (1) using water as a dumping ground for all types of refuse by individuals, (2) the widespread practice of dumping sewage with no treatment, and (3) inadequate attention by industry to the prevention of pollution.

The immediate needs for the United States just to clean up and correct the already existing pollution problems has been estimated to exceed 100 billion dollars. Of this, Alaska's portion exceeds 82 million dollars.

Municipal waste treatment is recognized as the foremost problem in Alaska and it has been estimated that over 58 million dollars would be needed to construct primary and secondary treatment facilities and the attendent interceptors and laterals. In addition to municipal waste treatment, other major areas include waste products introduced into the waterways by the fisheries industry, oil industry, logging and wood products manufacturing, and the placer mining and gravel washing industries. This is by no means the end of the list. It serves only to identify the major sources of water pollution known to exist in Alaska. If the trend toward discharging untreated wastes continues, Alaska will change rapidly from a high quality to a low quality environment.

Necessity forces us to abandon the old concept of trying to determine how much pollution can be discharged by any given city or industry. The Federal Water Pollution Control Administration is beginning to realize that to catch pollution after such a long time of almost total disregard can be a costly exercise in futility. The only sure way to overtake our compounding pollution is to leap ahead of it. Instead of trying to calculate how much waste can be safely discharged, we are beginning to concentrate more and more on how much can be prevented from reaching our waters. Our waterways cannot be used as dumping grounds for the wastes generated by our society. This is no longer just a local or state problem; it has reached proportions demanding National attention.

Without water pollution control, we will suffer the needless degradation of our water below the requirements of other water uses. The problems of control may be extensive and extremely difficult to solve or they may be surprisingly simple. One guide line to assist in the big job ahead is to simply include waste treatment as one of the costs of doing business.

My position in the Federal Water Pollution Control Administration brings me into contact with the burgeoning oil industry and its attendent oil pollution problems. Oil pollution is viewed nationally as a serious threat. Oil out of control can foul boats, fishing gear, wharfs, mooring lines, and buoys. Scraping, cleaning, and repairing oil-fouled boats can add appreciably to the cost of maintenance. Fishing nets fouled by oil are rendered useless and, coupled with the loss of fishing time, become an added expense, usually without compensation. Oil out of control constitutes a fire hazard when in the vicinity of oil loading docks or wrecked ships. Oil soaked debris on the waters of any harbor constitutes a fire hazard also. Complaints arise from oil polluted recreational beaches. Any oil on a beach is an inconvenience to the users. When severe, oil pollution is unaesthetic, disagreeable, and an expensive nuisance. The cost can only be appraised in terms of physical discomfort and mental anguish. Cleanup costs are high.

One of the most disturbing aspects of oil out of control is the damage it does to bird life. Attracted by patches of floating oil on the water, many sea birds in search of food inadvertently swim into or emerge into the oil after a dive. Oil may penetrate down through the feathers and reach the skin, displacing the air which normally forms insulation against the cold. Consequently, large numbers of birds freeze to death in the winter and many more are unable to become airborne and helplessly drift ashore to die of starvation, disease, or predation. Tens of thousands of birds perish each year from tanker accidents or the deliberate discharge of oily refuse into the water.

Claude E. ZoBell of Scripps Institute of Oceanography reports that only when oil pollution is severe and prolonged are oysters, clams, and other shellfish of economic importance injured, and then primarily in beds which occur between high and low tide levels. Galtsoff also found no direct correlation between the mortality of oysters and the presence of oil. Never-the-less, trade journals and court records document numerous instances of oysters and shellfish beds being seriously affected by oil pollution.

Chipman and Galtsoff indicate that toxicity of injurious oils appears to be a function of the concentration of the substances leached into the water, primarily cresols and phenol. Despite the sensitivity of diatoms and other phytoplankton organisms to toxicity, laboratory as well as field observations suggest that such organisms seem to be injured only by continuous prolonged exposure to large amounts of oil. Such conditions prevail in only badly polluted areas, such as tide pools, settling ponds or lagoons.

There is no evidence that bacterial species occurring in sea water are injured by oil pollution. Certain species may be unable to compete with hydrocarbon oxidizing bacteria, which generally reproduce rapidly in the presence of oil in marine environments. With few exceptions, hydrocarbons and their derivatives are neither bacteriostatic or bactericidal in ordinary concentrations. Oil exhibits a rather high B.O.D. Generally speaking, about 3 or 4 mg of oxygen is required for the complete oxidation of 1 mg of hydrocarbon. The fate of oil in sea water is made complex by dispersion, chemical modification, specific gravity, quantity, water temperature, depth, and other factors. Oil washing ashore will be influenced by beach and surf conditions. If the oil is discharged as an oil in water or water in oil emulsion, it is more widely dispersed and more susceptible to chemical, biochemical and physical modification. Small oil droplets tend to adsorb on particles or drifting flotsam.

Oil is generally moved across the surface of the water by wind with a velocity greater than that of the water. It tends to spread on the surface. Thin layers approaching monomolecular thickness exhibit interference colors or Newton rings in sunlight. High velocity wind can carry oil droplets into the air. Air movements promote the evaporation of volatile fractions; this process is enhanced by higher temperatures.

Acting with or against the wind are ocean currents or drifts. The action of currents may be decisive in bringing oil ashore despite the direction of the wind. Oil and oily substances discharged into the sea do not remain floating there indefinitely. They are readily adsorbed by clay, silt, and other particulate matter. Such adsorbtion weights the oil, causing some of it to sink. Cook Inlet exhibits a high glacial silt load and silt could be responsible for the fate of some of the oil introduced into the water.

If oil reaches the beach, it is subjected to the weathering action of sunlight and seawater. Whether oil is buried on the beach or deposited below the low tide level, it is subjected to slow bacteriological decomposition. Virtually all kinds of hydrocarbons, including asphalt, crude oils and waxes, are attacked my microorganisms. At best, the rate of decomposition is very slow and is dependent upon the abundance of microorganisms present, availability of free or dissolved oxygen, temperature, and the dispersion of oil in water. Oil persists only when protected from bacterial action.

Oil pollution comes in doses. A large dose, such as that provided by the TORREY CANYON, can bring about a multimillion dollar expense in cleanup and court costs. The oil present in an outboard motor exhaust is not offensive and can, for all practical purposes, be ignored. But we know that if we start with no oil, eventually a point is reached where opinion discerns a noxious substance classified by the courts of law as a nuisance. More important however, is the ecological change brought about through the introduction of toxic properties. Research into the effects of organic pollutants has been almost entirely confined to laboratory experiments which cannot duplicate the conditions in the sea. Subtle changes in the environment can go unrecognized until an ecological disaster occurs.

Biologists should not be held responsible for calculating how much waste pollution can be safely discharged into a waterway. Emphasis should be placed on how much we can keep out. The task at hand requires that abatement procedures be instituted on the known pollution problems to develop a sound preventative program aimed at keeping as much from reaching our waters as possible through the application of the best known technology. It is this way that the interest of the water user is served and at the same time the most is done for the protection of the biological community.

Future Role of the University of Alaska in Shellfish Research -- Dr. Jack M. Van Hyning

Except for some economic studies, the University of Alaska has not yet been very active in commercial fisheries or shellfish research. We hope to change this situation, however, and increase our contribution to research on these resources.

I would like to briefly mention our program in fisheries biology and some plans for the future. Fisheries biology is in the Department of Wildlife Management of the College of Biological Sciences and Renewable Resources. We have curricula leading to B.S. and M.S. degrees in Fisheries Biology and are developing a Ph.D. program. The course work in fisheries biology, ecology and management is being strengthened.

The functions of a university include education, service and research. Although the priority of the second two items is debatable, few would argue that education is the prime responsibility.

There is a real need for well-trained fishery scientists in Alaska, and Alaska should be producing more of its own. Many of you have mentioned recruiting of competent personnel as a major problem.

Being agency oriented, I have some opinions on the type of research universities should do. They should do the type of research that trains graduate students; life histories, for example, or the multi-discipline, team type of problem that could involve biologists, engineers, economists, etc.

As for services, many are aware of the efforts of Mr. John Doyle, a fisheries extension instructor with the Division of Statewide Services. He has formulated plans for a two-year associate degree program for training in fishing, processing and biology, and for expansion in the extension program.

We have three ideas in mind for expanding our fisheries program. The first idea is a Cooperative Fishery Unit, and we have begun some very preliminary negotiations toward that end; the University already has a very successful Cooperative Wildlife Unit. Although emphasis would be on sport fishery research, graduate students receiving training and degrees under this program could be available for employment by other groups. Research could be done on the recreational aspects of shellfish; clam toxicity, for example. The second idea is a study stream near Fairbanks. The third, and most important idea from the shellfish standpoint, is the Sea Grant Program. This program is modeled after the Land Grant College Act of many years ago which was so successful in developing many of our state universities as well as in helping American agriculture. The program is designed to get the universities involved, along with state and federal agencies, in research and education aimed toward the development of the sea resources.

We have been developing a Sea Grant proposal that is taking the form of an intensive study of Prince William Sound, with emphasis on assessment and utilization of its shellfish resources. The advantages of this area are: 1) it is reasonably convenient to the University campus at Fairbanks; 2) there has been relatively little research or development work done there by other agencies; and 3) it has a large and lightly utilized shellfish resource. The study would begin with developing personnel, expertise, and equipment, and could eventually involve: 1) assessment; 2) development; 3) processing; 4) marketing; 5) management, involving population models; 6) environmental and fishery forecasting; and 7) educational programs, in conjunction with other disciplines of the University. Life history studies and research on unexploited populations--projects particularly amenable to graduate student theses--will be emphasized. We will, of course, coordinate our activities at all times with BCF and ADF&G, and hope to complement and supplement their activities.

I appreciate the opportunity to attend this conference and have benefited a great deal. At the next meeting I hope we can make some contribution, and, in the meantime, we will appreciate any support to applied and academic fisheries work at the University. We are receptive to any ideas or suggestions as to how the University might best serve the agencies and the fisheries.

KING CRAB RESEARCH REVIEW

ADF&G

Review of King Crab Research -- Mr. Guy Powell

Observations by SCUBA divers and analysis of catch statistics have been used by ADF&G personnel for studying brood stock and age class composition of king crabs off Kodiak Island

Observations by SCUBA Divers

Two thousand nine hundred seventy three grasping pairs of king crabs have been captured and studied during the past six years (1963-1968). All except 131 pairs have been collected during the last 3 years. Collections have been made from 16 widely separated bays along 150 miles of the Kodiak-Afognak Island east coast.

Although 16 localities were sampled, most of the collections came from only seven localities. Of these seven localities the most pairs captured in any one locality (969) came from Saint Paul Harbor, sometimes called Kodiak City Harbor.

Sixty-one percent of all male breeders were skip molt but recent sampling shows that the percentage of new shell (recently molted) breeders in the stocks is increasing. For instance, in 1968 77 percent of the male breeders were new shells. A similar trend was evident with regard to size, i.e.: earlier sampling showed 24 percent of male breeders of non-commercial size, whereas in 1968 this figure increased to 83 percent. The smallest male grasper captured was 80 mm in carapace length, next smallest was 116 mm. Only 19 males were smaller than 120 mm. Data indicate that because of present minimum size regulations males mate only once before they are caught.

Of the 2,973 females grasped by males, 84 percent were in pre-molt condition and the remainder in post molt new shell condition. Data indicate that males grasp old shell females for longer periods than they do new shell females; or conversely, females mate shortly after molting and are therefore held as new shells for shorter intervals. Our observations indicate that the number of new shell female graspees is increasing. The increase may be attributed to inferior sexual abilities among smaller new shell males as compared to older males. It seems plausible that incapable or less capable males may grasp recently molted females longer than larger more capable old shell males. The proportion of new shell females increases as the mating season continues and is greatest at the time smaller males are most abundant among the brood stock. The fact that female crabs with smaller than normal egg clutches and lack of egg clutches are more common in the catch than in previous years may be directly related to the abundance of smaller males in the brood stock.

Female graspees ranged in size from 96 to 179 mm in carapace length. This size range is similar to that of adult females in the population, indicating our sampling is representative of the adult female population. Immature females, however, were not found. Probably better sampling is needed early in the season. Average size of females in recent years is not decreasing as seems to be the case among males. One should remember, however, that females are not harvested by commercial fishermen. The size frequency of females sampled increases as the mating season continues, illustrating that smaller, younger females mate first and larger, older females last. The reverse seems to be true for males to some extent, that is, larger, older skip molt males, believed to possess greater breeding capabilities, are breeding early in the season.

The earliest a breeding pair has been captured is March 10th and the latest May 26th. Peak mating occurs during April and the first half of May as indicated by the frequency with which breeding pairs are found. Catch per effort, expressed as numbers of minutes of time on the ocean floor required to capture one breeding pair, ranged from 15 minutes during March to approximately 2 minutes during April and early May, before increasing again to approximately 100 minutes during late May.

Size relationship of mating pairs was studied by comparing carapace lengths and widths of each pair. Using carapace width, there was less than 1 percent difference between mating pairs. Using carapace lengths, 2.6 percent of the males were smaller than their female partner.

The proportion of skip molt males found on the breeding grounds by SCUBA divers is considerably greater than the proportion found among adult males harvested on the fishing grounds. This is especially noticeable among the small breeders which normally are 100 percent newshell on the fishing grounds but only 64 percent in the male brood stock. Apparently skip molt males congregate on breeding grounds during the mating season.

Tagging of male breeders resulted in a 31 percent recovery during the following eleven months. Breeders were captured up to 25 miles seaward from the breeding location and apparently had not molted. In summary, our tagging studies have shown that (1) skip molt male breeders do not molt after mating, (2) mortality of "one skip" males after mating is very small, and (3) "two skip" male breeders may die after mating, and (4) multiple recoveries by divers of tagged male breeders showed that individual males breed with more than one mate and continue to breed for periods exceeding one month.

Summary of Catch Statistics Analyses, Kodiak District

King crab production has declined again for the third consecutive season from a high of 96 million pounds during the 1965-66 season to 16 million pounds during the 1968-69 season. Kodiak production showed a continuous increase up through the 1965-66 season because fishermen explored less accessible (unexploited) areas and because of entrance into the fishery of several successful year classes of king crab just prior to peak fleet buildup. Since then, recruitment to the fishery and abundance of older males has diminished.

Reduced production combined with increased demand caused competition among buyers that resulted in much higher payments than previously to the fishermen for the live product. Prices to fishermen climbed rapidly from approximately 13 cents a pound at the beginning of the 1968-69 season to 50 cents a pound shortly thereafter. The price increase prevented a disaster to the king crab fishery even though catch per effort had decreased to the extent that fishing would have been unprofitable at the 13 cents per pound level.

Average weight per crab has steadily decreased from 11 pounds in 1961 to 6 pounds in 1968.

There are three major stocks of king crab in the Kodiak Island district: stock I located northeast of the Island, stock II located to the southward, and stock III located southwest of the Island. Stock II is the most productive stock, but also the smallest in terms of area inhabited. It's average production is 651 crabs per square mile per year. The next most productive stock is stock III. Average production of this stock has been 283 crabs per square mile per year. The least productive of the three stocks is stock I. Average production has been 100 crabs per square mile per year even though the area inhabited by this stock is larger by 43 percent than either of the areas inhabited by stocks II or III.

During the peak production of 1965-66, 23 million pounds of the 96 million produced (24% of the catch) came from crabs recruited to the fishery that year.

Dependence of the fishery upon the recruit age class increased and at the same time availability of older age classes in the catch diminished.

Abundance of the recruits has not been sufficient to maintain the high catch experienced during the 1965-66 season. Since the 1965-66 season, recruit age classes have comprised a greater proportion of the catch but abundance of recruits has continued to decline. During the present season (1968-69) only 8 million pounds of recruits were captured but these comprised about 50 percent of the commercial catch. Our estimate indicates that the age class recruited during 1965-66 was approximately ten times more abundant than the age class recruited during 1968-69. It is interesting to note that these relatively low level age classes which have been recruited recently resulted from mating and larval survival in 1960-61 and 1961-62 which was prior to heavy utilization by the fishery. It is doubtful, therefore, if overfishing can be blamed for the low abundance of these age classes.

Review of Log Book Program -- Mr. Philip Gray

Objectives of the logbook program were reviewed during the First Alaskan Shellfish Conference. Since then, data collected from the program has been analyzed. Results of the analysis showed that: (1) a decrease in average catch per pot, (2) a different catch per effort for each of the king crab stocks around Kodiak, (3) catch per effort increases with pot size, and (4) catch per effort increases with soak time.

The average catch per pot was similar for the 1964-65 and 1965-66 fishing seasons (66 king crab per pot) but dropped markedly during 1966-67 (36 per pot) and again during 1967-68 (26 per pot). This decline in average catch per pot was similar for all stocks in the Kodiak area. It is expected that the average catch per pot for the present 1968-69 fishing season will decline even further.

Average catch per pot is consistently higher for certain stocks. Stock III (Alitak) had the highest average catch per pot (48) for the four fishing seasons (1964-1968). Stock II (Twoheaded-Sitkinak) had the next highest average catch per pot (46). Stock I (Chiniak-Marmot) and stocks IV-VI (Shelikof Strait) had the lowest catch per pot (24 and 21, respectively).

Comparison between catch rates of 6'x6', 7'x7', and 8'x8' pots showed that the larger the pot the larger the average catch per pot lift. The 6'x6' pots averaged 21 crabs per pot, the 7'x7's 37 per pot, and the 8'x8's 55 per pot. The increase in average catch of king crabs per pot lift with increasing pot size is due to the larger capacity of the pot and it's stability on the bottom in strong tides and storms.

Average catch per pot increases as soak time increases. The increase between one and two day soaks is small (2 crab). Between two and three day soaks the increase is 6 crab and between 3 and 4-10 day soaks the increase is 5 crab.

Some Behavior and Physiology Aspects of King Crab Reproduction -- Mr. Harvey Yoshihara

The general purpose of this project was to determine if king crab mating occurred on the continental shelf off Kodiak Island. Trawls and baited pots were studied to determine which of these types of gear was most efficient in capturing molting and mating king crab.

The first year's study (1965-1966) was divided into two phases. Phase I was to determine a suitable method for capturing relatively sedentary, non-feeding, molting and mating king crab on ocean banks. Phase II was to delineate environmental zones of the continental shelf adjacent to Kodiak and Afognak Island so that relation between mating areas and environmental requirements of king crab could be evaluated.

Portlock Bank, located 55 miles northeast of Kodiak and extending from 30-85 miles seaward, was selected as the study area. Trawling for mating crab on the bank began in April, 1966 and was successful. Nine grasping pairs of king crab were caught. Also caught were 2,152 females; 686 of these had recently undergone ecdysis, and 1,466 were approaching ecdysis. Seventy-five shed exoskeletons were found at this time thus substantiating our belief that the Bank is a mating area.

For study purposes, the continental shelf around Kodiak was divided into zones according to depth and relative distance from shore. Continuing efforts will be made to determine if breeding crab concentrate in specific areas.

Studies to determine depth and bottom type preference of molting and breeding king crab were conducted on Marmot Flats (east of Kodiak) during Spring 1967. Other objectives were to estimate numbers of king crab and to determine sex, size, and exoskeleton age. Six hundred fifty-four male king crab and 7,016 females (sex ratio 1:11) were captured. A sex ratio of 1:2 in favor of females was found on Portlock Bank during April 1966. The area surrounding Portlock Bank has not been fished commercially as intensively as Marmot Flats. This difference in fishing effort may account, in part, for the differing sex ratios in the two areas.

Sixteen grasping king crab pairs were captured on Marmot Flats, indicating that a substantial mating area may exist there. Other indicators of mating were the capture of 9 recently mated females having spermatophore bands spread around their oviducts and 23 newly molted females carrying new eggs.

The fate of eggs of unmated king crab has been examined. A group of female king crabs was held 3 months following ecdysis. During this time they were not associated with males. These females did not spawn their eggs but retained them internally. When the experiment ended, many of the eggs had been absorbed.

A second group of females was allowed to molt and mate. Their spawned eggs were then collected and preserved on each of twenty consecutive days. Egg development was studied microscopically and photographs taken of the various stages. Results of this study are being reviewed for publication.

The main objective of the Spring 1968 study was to determine if king crab were molting and mating on Albatross Bank, south of Kodiak. A second objective was to examine king crab for the presence of unmated newshell females on inshore mating grounds along the southeast side of Kodiak Island.

Mating king crab were found only on the southern end of Albatross Bank. These crab may not be an ocean-bank associated group, but may be members of a stock occupying the Sitkinak Island shallows for mating purposes. There was no evidence of mating king crab on outer Albatross Bank.

Unmated female king crab were found on the inshore mating grounds. Of 700 king crab collected in Kaguyak Bay, only 9 were males. Of 651 mature newshell females caught, 76 percent were without eggs and had not mated. Similar results were obtained at Ocean Bay, 282 (64 percent) of 441 mature newshell females were eggless and had not mated. Assuming that the trawl was non-selective and the observed king crab sex ratio was indicative of the real ratio, there is little chance that the non-ovigerous females would mate during that season.

A study to determine the effects of delayed mating on egg extrusion and fertilization was done at the Kitoi Bay Research Station on Afognak Island. The study consisted of allowing 76 females in 14 groups to mate on various days up to 15 days following their molt. Females mated within 9 days after molting extruded fertilized eggs. About 44 percent of the females mated after 9 days following ecdysis did not extrude eggs: no females extruded eggs after a 13-day mating delay.

Another study was done to determine the effect of decaying eggs on future reproductive capabilities of a crab. Mature king crab that had not spawned eggs in 1968, contained deteriorating eggs in their ovaries. The deteriorating eggs were mixed uniformly with eggs developing for spawning in 1969. Apparently, deteriorating, unspawned eggs in ovaries of king crab do not hinder development of new eggs.

BCF

Review of King Crab Research Methods and Physical Oceanography in the Bering Sea -- Dr. David Hoopes

Research by BCF to assess stock condition of king and tanner crab in the eastern Bering Sea continued during 1968. The major effort involved two research cruises in the eastern Bering Sea during which trawl surveys and tagging were conducted aboard the U. S. Bureau of Commercial Fisheries vessels JOHN R. MANNING (cruise 6805-6M) from May 1 to June 7, and MILLER FREEMAN (cruise 6809-10F) from September 17 to October 9.

The trawl surveys consisted of one-hour drags using a standard, 400 mesh, eastern otter trawl having a 1/2-inch bar mesh liner in the cod end. Stations were located at 20-mile intervals on a predetermined grid. All captured king crabs were sexed and classified according to shell condition. Measurements were obtained from all male king crabs. A total of 3,517 males was tagged and released during both cruises. A sample of at least 25 female king crabs and 25 tanner crabs from each tow was measured, if available. Egg development of female king and tanner crabs was recorded. Data on temperature, salinity, and associated fauna were recorded for each station. In addition, 53 sediment samples were taken during the fall survey.

Physical oceanographic data collected at each station during both cruises has received preliminary analysis. During the fall cruise physical oceanographic data collected at approximately 70 stations on the trawl survey grid consisted of continuous recording of salinity and temperature with depth at each station (STD instrument) and determinations of oxygen and reactive phosphate concentrations for bottom water at each station. Information collected on current direction and speed at several locations within the survey grid was also obtained with recording bottom current meters.

General patterns of surface temperatures and salinities suggest an upwelling of cold saline bottom water centered at about 57° to 58° N Lat and 160° W Long (Figures 1 and 2).

Temperature and salinity patterns of bottom waters suggest a movement along contour lines of cold, saline bottom water from the northwest and a movement of slightly warmer but more saline water from the southwest parallel to the Alaska Peninsula (Figures 3 and 4). Partial analysis of current

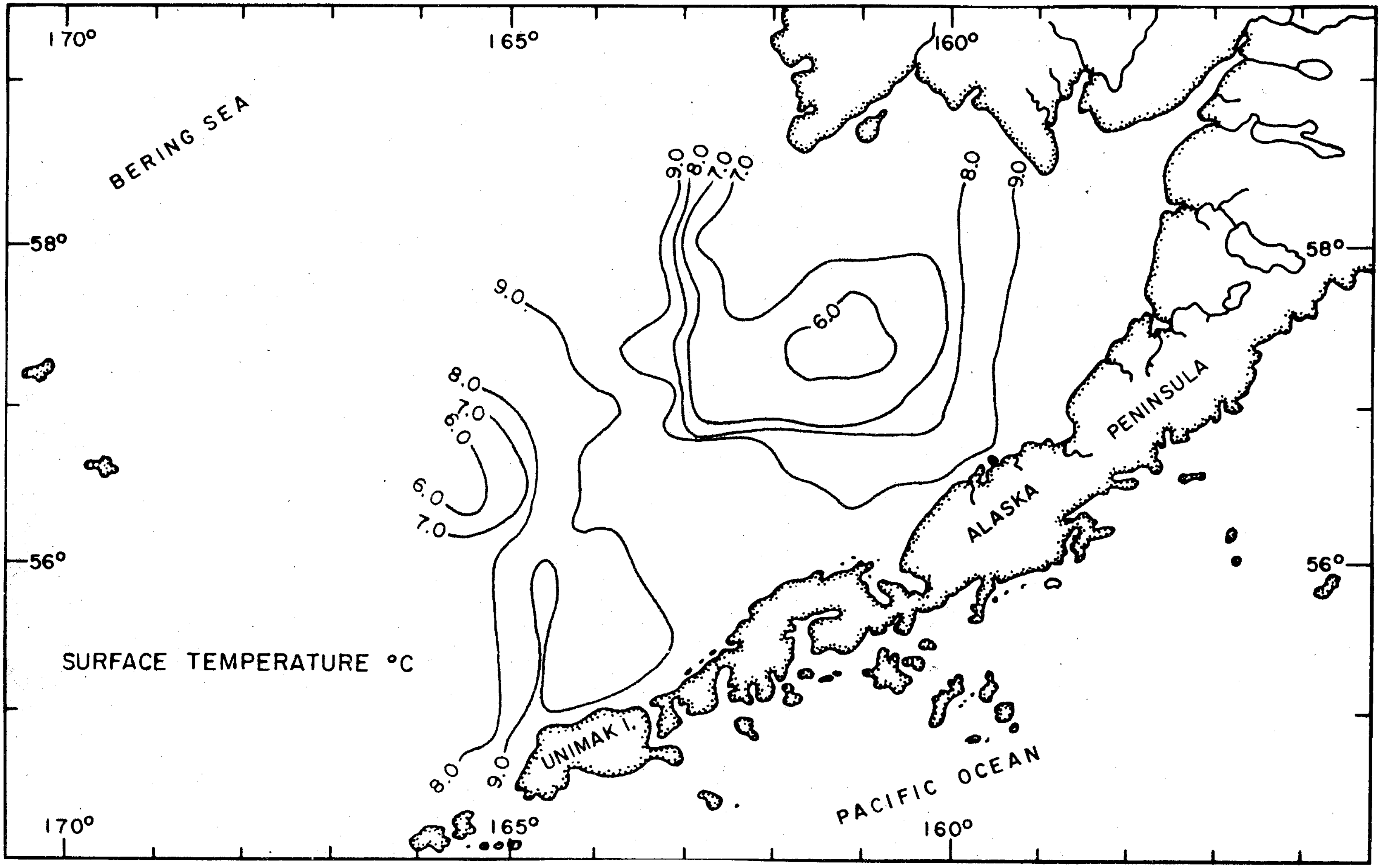

Figure 1. Surface temperature by 1° C. contours for the southeastern Bering Sea during September 1968, as determined from STD casts made at 71 stations during Cruise 6809-10F.

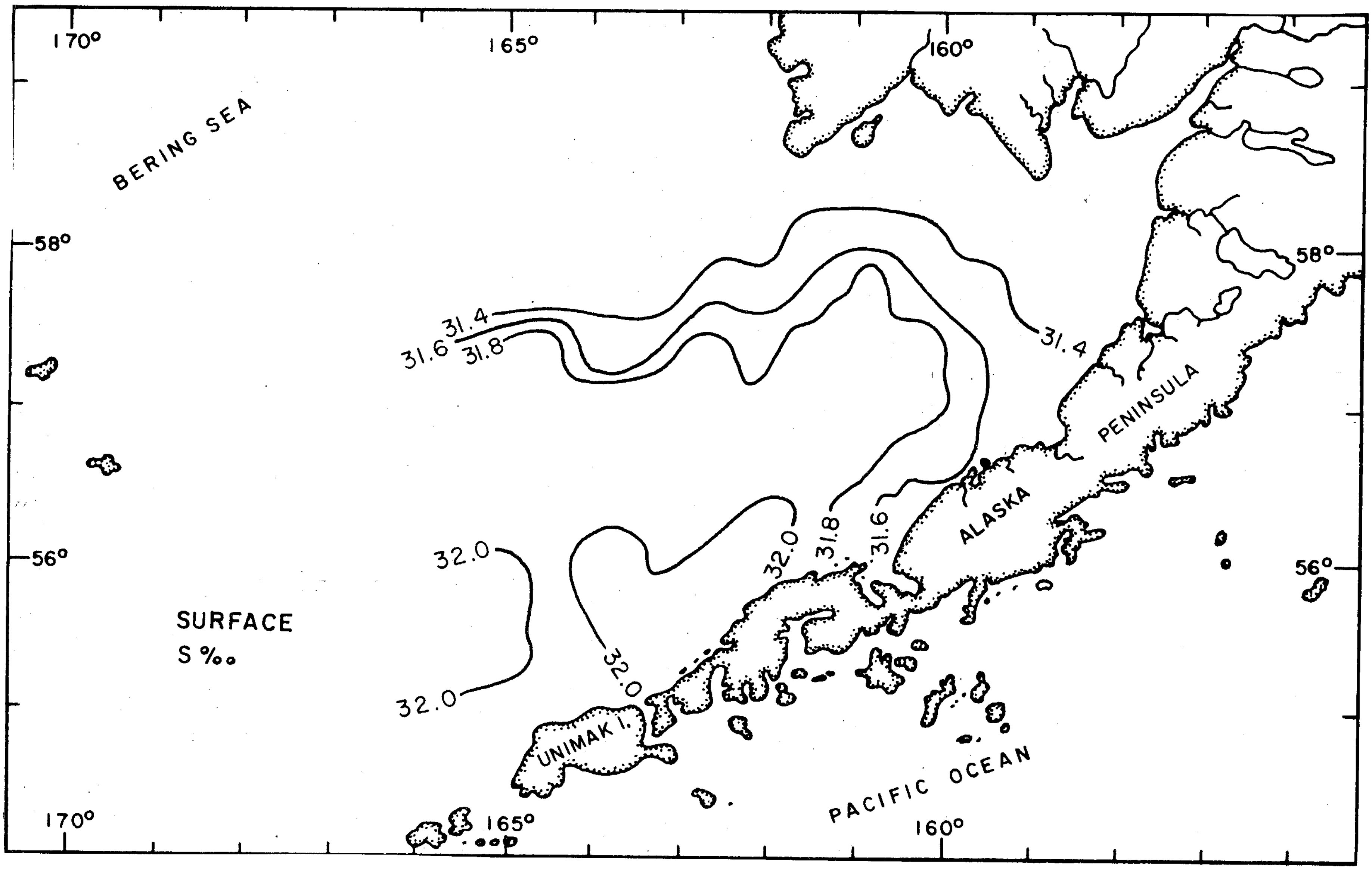

Figure 2. Surface salinity pattern for the southeastern Bering Sea during September 1968, as determined from 69 stations occupied during Cruise 6809-10F.

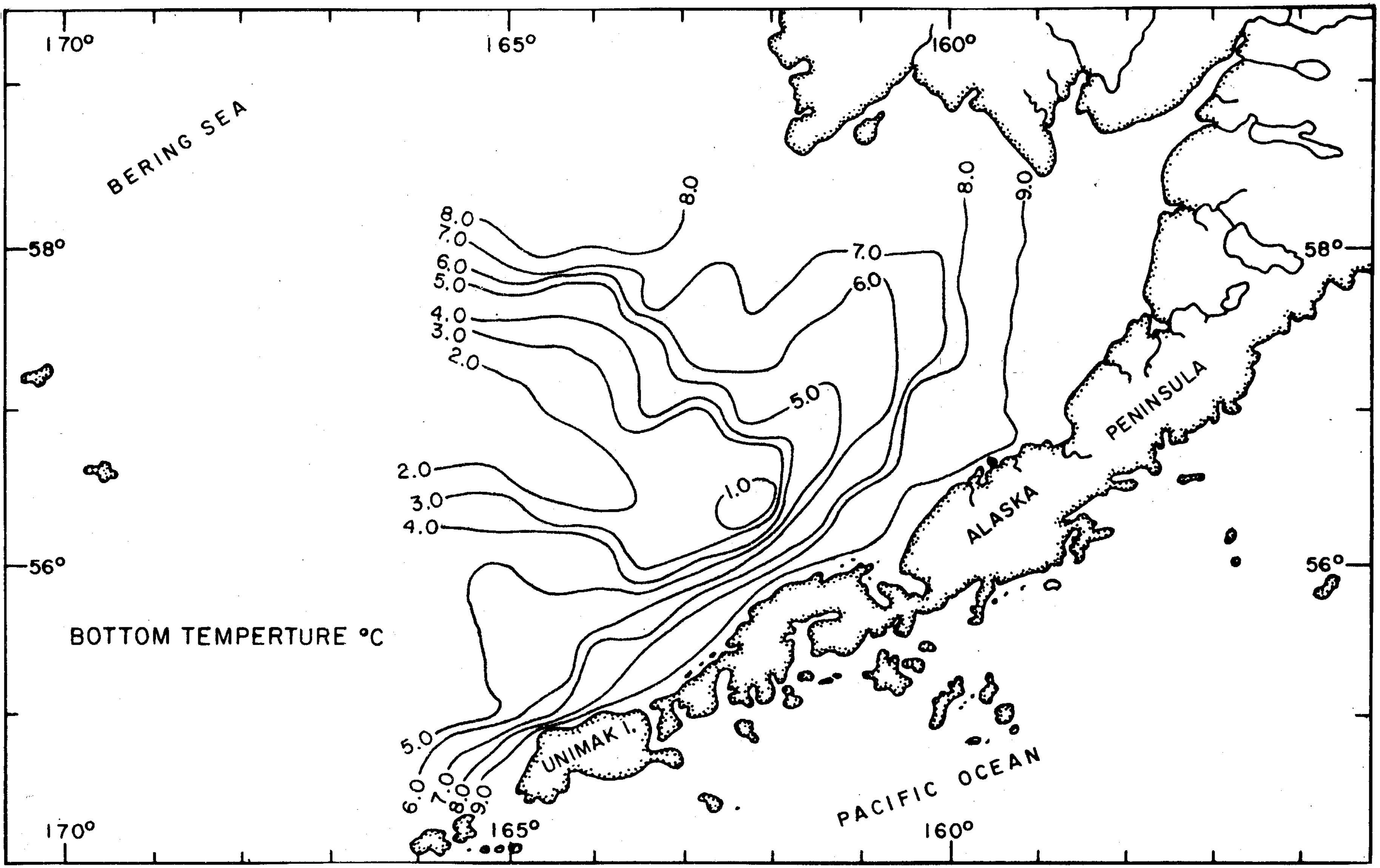

Figure 3. Bottom temperature by 1° C. contours for the southeastern Bering Sea during September 1968, as determined from STD casts made at 65 stations during Cruise 6809-10F.

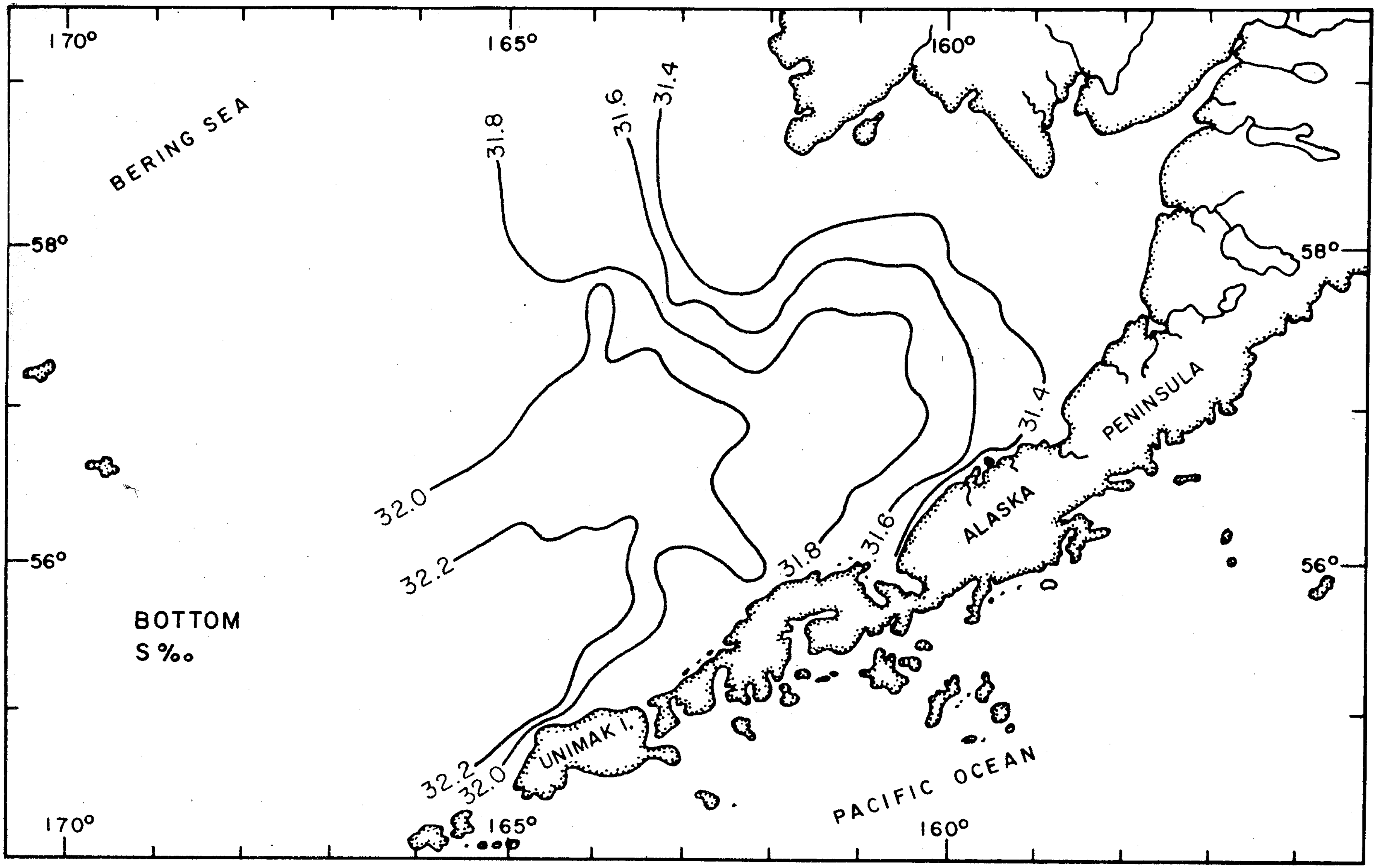

Figure 4. Bottom water salinity pattern for the southeastern Bering Sea during September 1968, as determined from 65 stations occupied during Cruise 6809-10F.

meter and density data suggest a counter-clockwise gyre over the entire Bering Sea east of Unimak Island.

King Crab Distribution, Southeastern Bering Sea -- Mr. John Karinen

To effectively manage and determine the condition of the king crab stock in the southeastern Bering Sea, it is essential that we know not only the distribution of crabs during the fishing season but also their seasonal migrations; that is, their distribution in time and space. A knowledge of the constancy of these seasonal movements in relation to variations in the environment from year to year is also essential if we are to estimate abundance, recruitment, and year class strength.

Comparison of the physical oceanographic data from the spring and fall indicates that the southeastern Bering Sea is an extremely dynamic environment. Bottom water temperatures range from 0° C to 7° C in the spring and from less than 1°C to above 9°C in the fall. Temperatures over a considerable area of the bottom, however, change as much as 4° to 9°C and may directly influence crab distribution.

Tagging studies have provided valuable information on distribution and movement of king crabs in the southeastern Bering Sea. For instance, tagging studies have shown that king crabs in this area constitute a single stock, separate from stocks of the Pacific Ocean and the Gulf of Alaska.

The two BCF surveys in 1968 have provided the first opportunity for U.S. researchers to study the seasonal distribution of king crab in the southeastern Bering Sea.

Data from these surveys were analyzed to determine the bathymetric and geographical distribution of the king crab stock. To study crab distribution with depth, catch per unit effort was calculated for each five fathom depth interval. Population estimates and geographical distribution were estimated in the following manner. For study purposes the sampling area was divided into 20 x 20 mile areas. Number of crab per area was estimated by multiplying the number of crab caught in that area by the appropriate correction factor (400 sq. mi./sq. miles trawled).

No attempt has been made to relate crab distribution with environmental factors, such as water temperature, salinity or bottom sediments.

Bathymetric distribution of king crabs in the fall differed from that observed in the spring. Distribution with depth of sublegal males (less than 100 mm carapace length) and mature females (100 mm or greater carapace length) was unimodal in the spring but bimodal in the fall (Figures 5 and 6).

Legal males (120 mm or greater carapace length) were most abundant at the deepest stations sampled (56-60 fathoms) during the fall cruise. In the spring, these males as well as the mature females, were most abundant at mid-depths (35-45 fathoms). Concentrations of female crabs in the fall were found at shallow stations (16-25 fathoms), whereas the males were relatively more abundant at these same depths during the spring.

Plots of the geographical distribution of legal males, sublegal males, mature females, and immature females do not indicate a distinct separation of these four groups on the fishing grounds. Certain trends of distribution, however, could be noted. In the fall, an impressive concentration of female crabs was present in the relatively shallow waters (20-30 fathoms) of the northeastern part of the station pattern (Figure 7). Legal males were more concentrated in deeper offshore waters (40-60 fathoms) in the fall, being most abundant in the southwest part of the station pattern (Figure 8). Concentrations of sublegal males apparently moved seaward from the positions they occupied in the spring, but they were still inshore of the concentrations of legal males.

Distribution of ovigerous and nonovigerous females was also examined. King crabs carrying eggs in the fall were concentrated in the northeast part of the station pattern in water 16 to 25 fathoms deep at 5° to 8° C and on the banks just north of Unimak Island (Figure 9). The distribution of female king crabs with no eggs overlapped that of the ovigerous females, except that major concentrations were in slightly deeper water.

Because tanner crab in the Bering Sea occupy much of the same habitat as king crab, there may be competition between them for this habitat. It is interesting, therefore, to compare the relative distribution of these species.

Comparing the geographical and bathymetric distribution of these two species in the fall leads to the following conclusions: (1) both male and female tanner crabs of all sizes were most abundant at depths (30-50 fathoms) where the abundance of male and female king crabs was low; (2) male tanner crabs were ubiquitously distributed over the sampled area, overlapping extensively major concentrations of king crab. Greatest concentration of male tanner crabs, however, was in an area where king crabs were sparsely distributed; (3) female tanner crabs were not as extensively distributed as the males and little overlap occurred between major concentrations of female king crabs and female tanner crabs; and (4) most of the tanner crabs were distributed to the west and north of the greatest concentrations of king crab.

Further analysis of these data and data from future surveys will help us

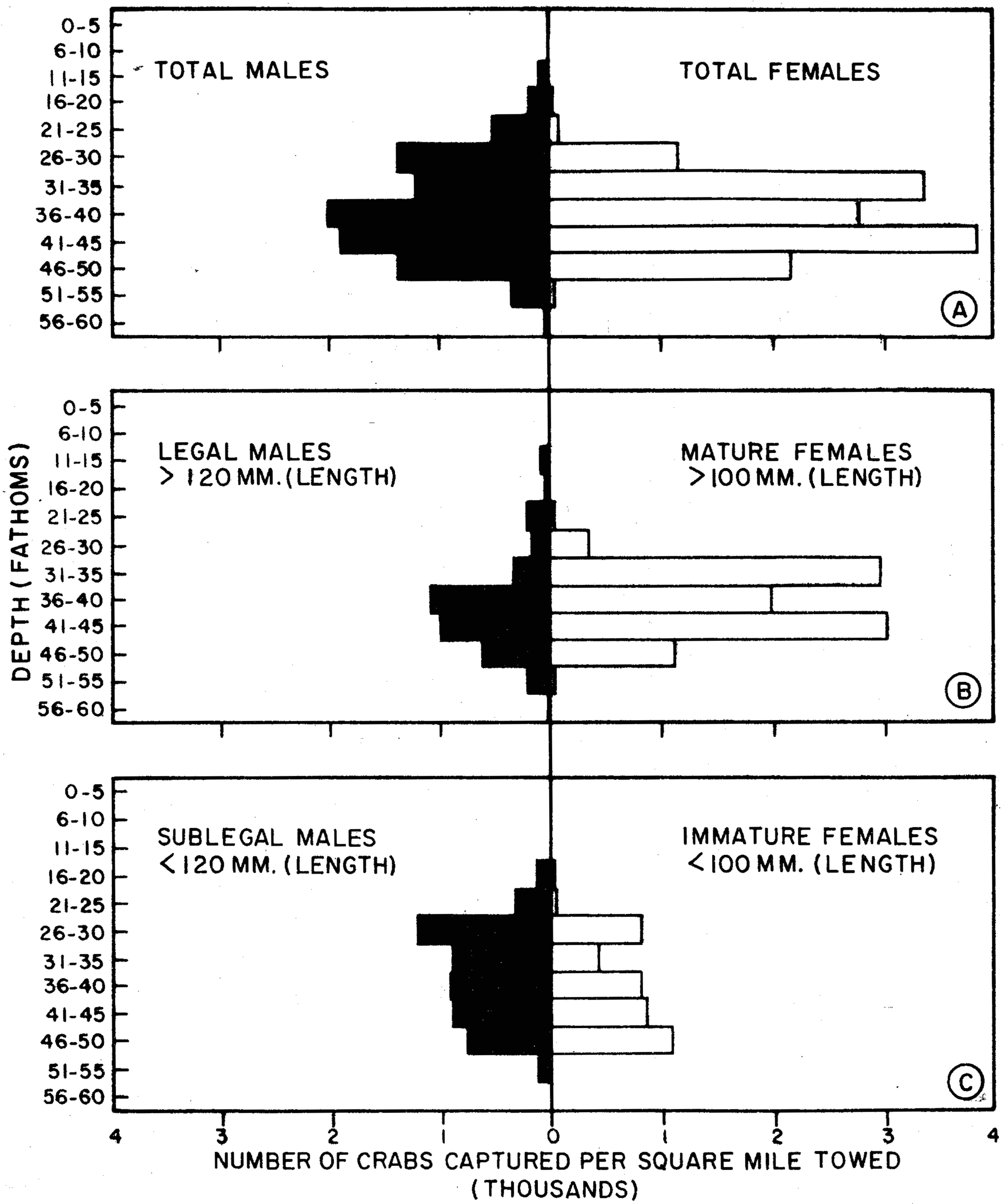

Figure 5. Distribution of king crabs by depth in the southeastern Bering Sea, as determined from catch analyses of 88 trawl samples collected during Cruise 6805-6M, May 1 to June 7, 1968.

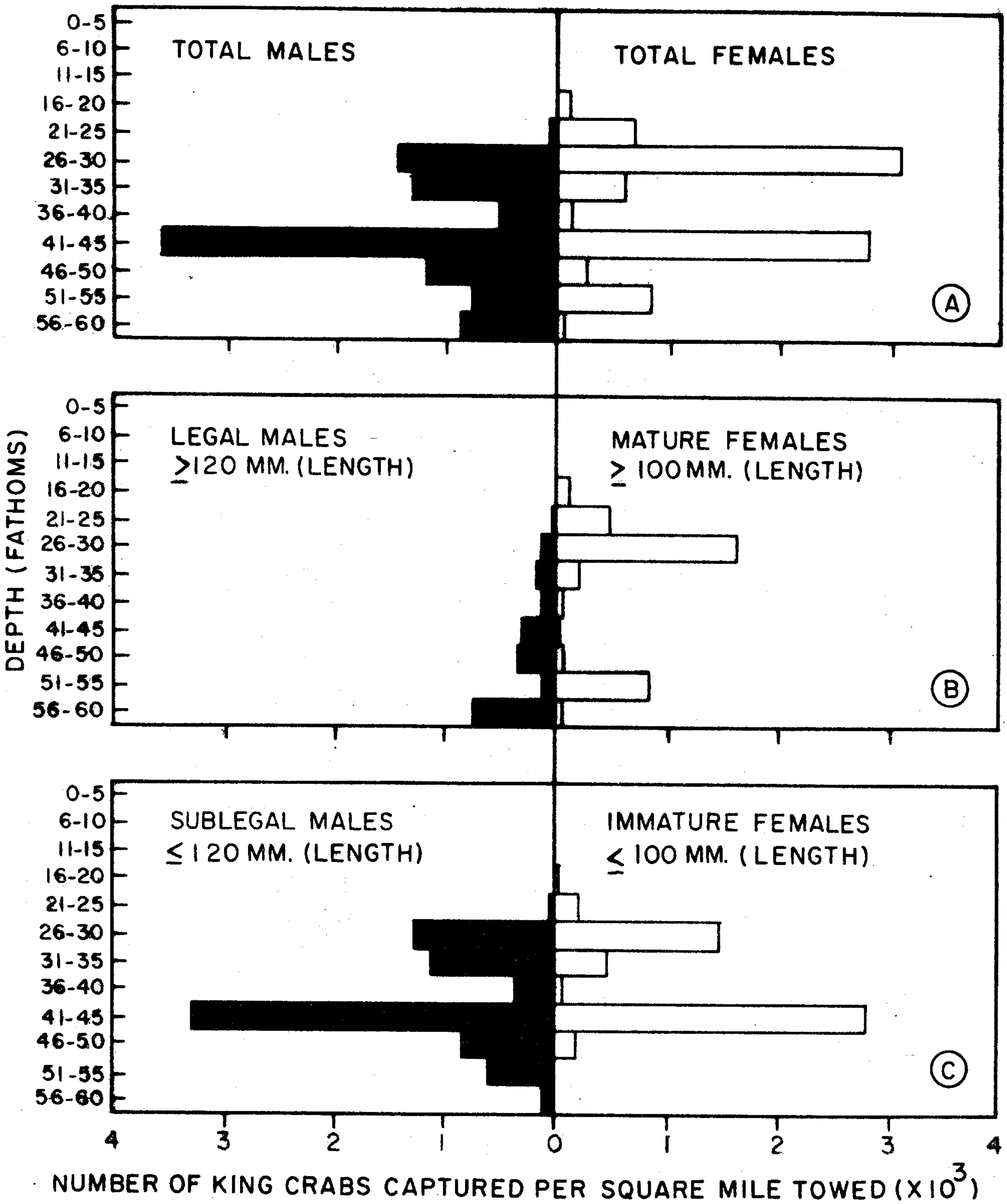

Figure 6. The distribution of king crabs by depth in the southeastern Bering Sea during September 1968, as determined from catch analyses of 75 trawl samples collected during Cruise 6809-10F.

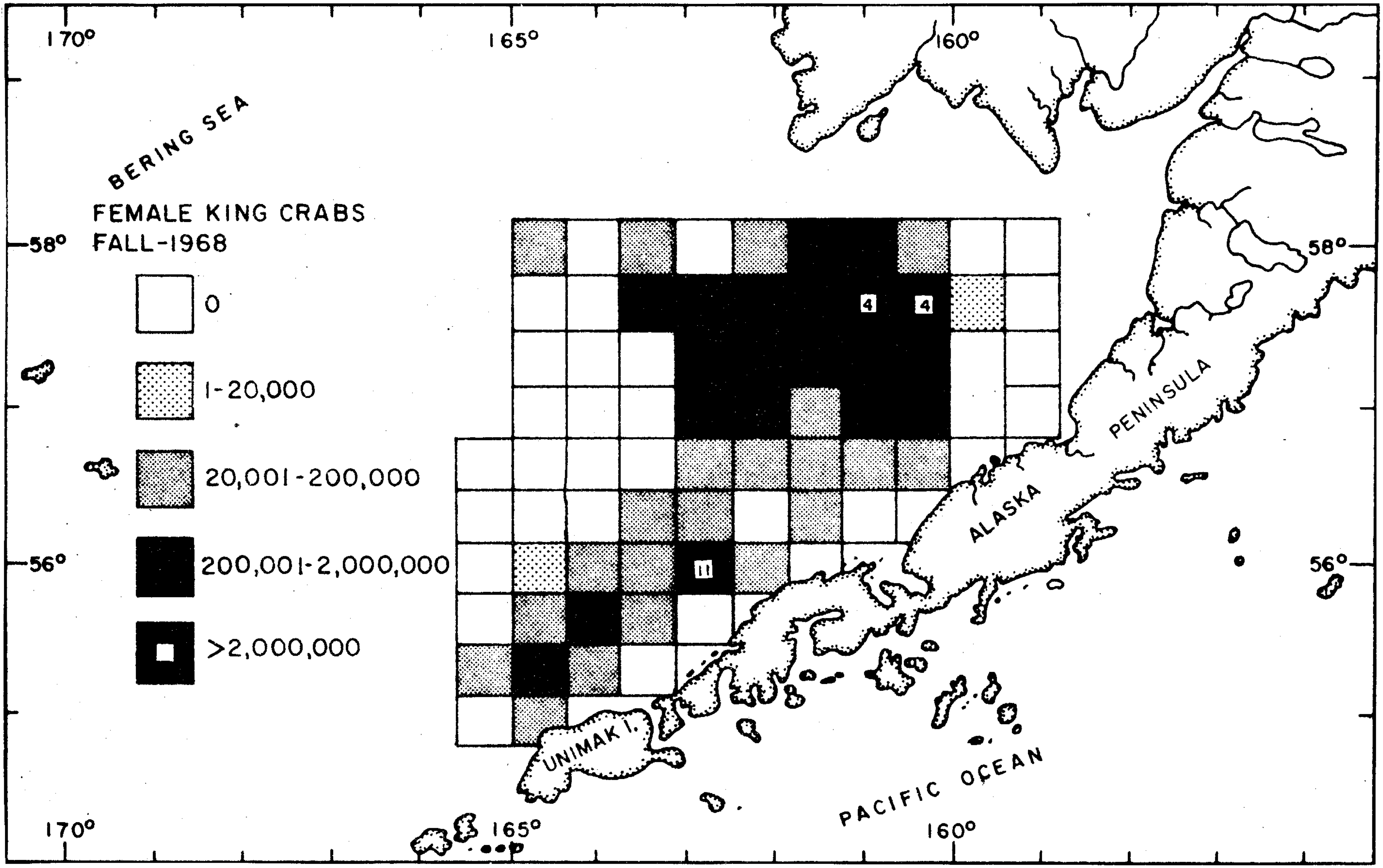

Figure 7. Relative distribution and abundance of female king crabs in southeastern Bering Sea during September 1968, based upon trawl catches made during Cruise 6809-10F. Numbers within squares indicate estimated population to nearest million.

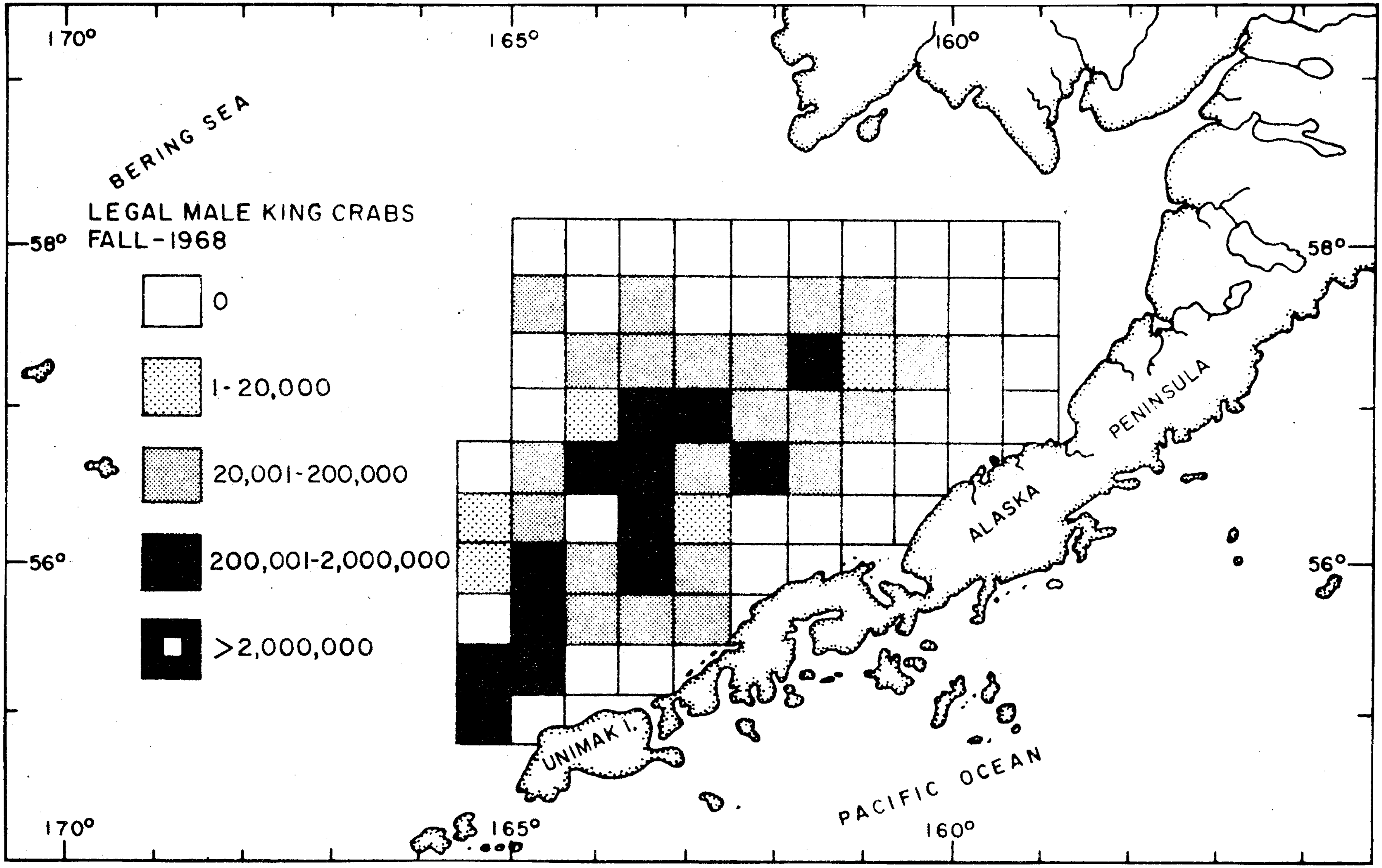

Figure 8. Relative distribution and abundance of commercial male king crabs (carapace length > 120 mm.) in southeastern Bering Sea during September 1968, based upon trawl catches made during Cruise 6809-10F.

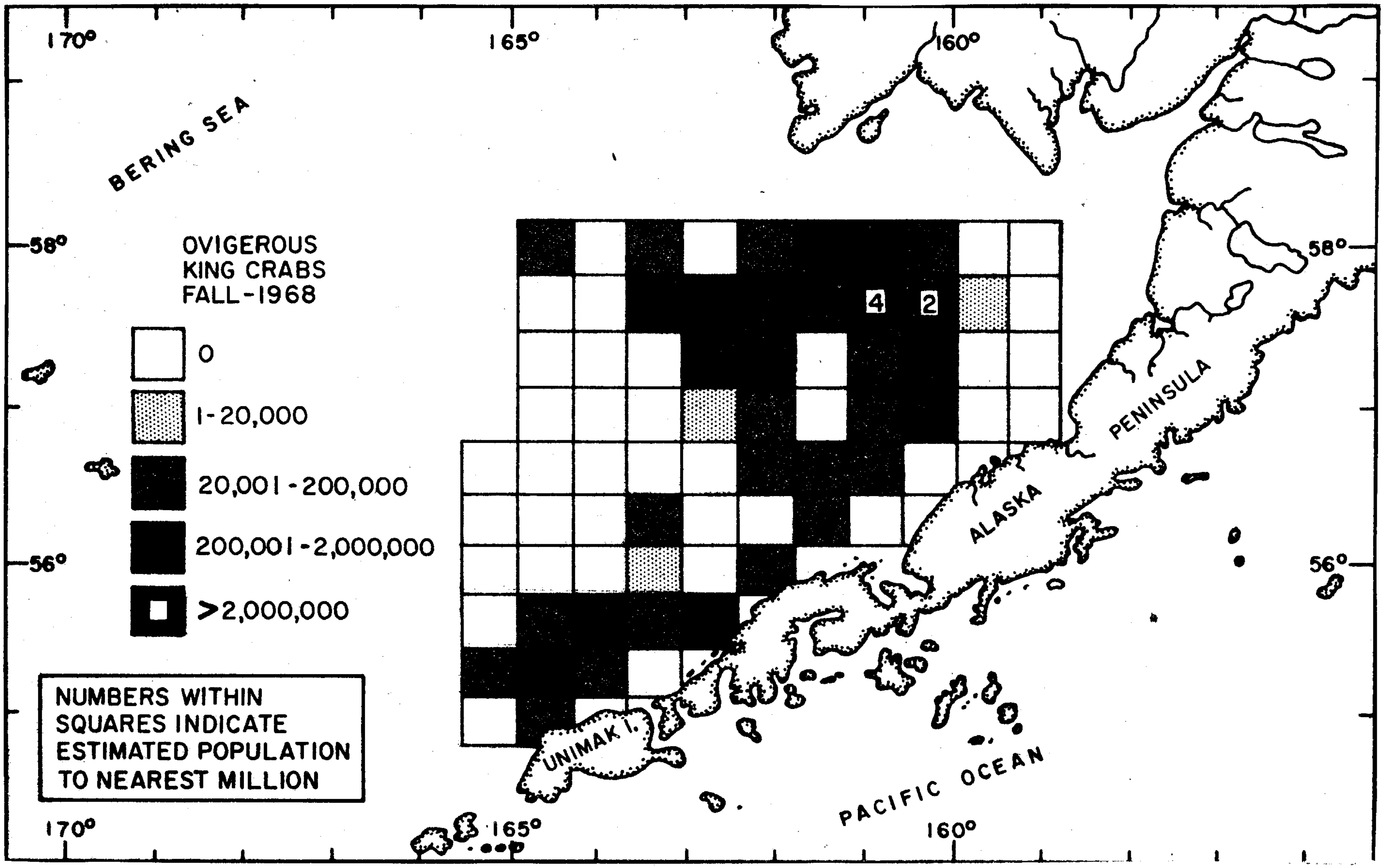

Figure 9. Relative distribution and abundance of ovigerous female king crabs in southeastern Bering Sea during September 1968, based upon trawl catches made during Cruise 6809-10F.

relate distribution of crabs of the Bering Sea with water temperature, salinity and bottom sediment types for various seasons of the year.

Population Dynamics of the Eastern Bering Sea King Crab Stock -- Mr. Joseph Greenough

Population estimates

Southeastern Bering Sea king crab population abundance has been estimated using three techniques. The first technique used tag release and recovery information; the second technique used trawl survey data; and the third technique used catch and effort data.

From data on the release and recovery of tagged crabs, standard Peterson estimates of population size can be made for individual size classes. In making these estimates, it is necessary to adjust for crab growth between time of release and time of recovery. The most serious difficulty with this type of estimate is that one must wait at least a year and a half for the first meaningful Soviet and Japanese tag recoveries to be reported, and if tags are released at only a few points, about two and a half years are required for the tagged crab to distribute themselves throughout the population of unmarked crabs.

Trawl survey population estimates use data from trawl hauls made at grid stations located twenty miles apart at the centers of areas 20 miles square. The observed density of crab in each trawled area is assumed to be representative of the density of crab over the entire 400 square mile area. By this means, population estimates are made according to size classes, and the results for all squares are summed to give size specific population estimates for the entire area surveyed.

Catch and effort data from the Japanese and Soviet commercial fisheries have been used in an attempt to estimate populations. The approach of basing population estimates on changes in catch per unit of effort during the fishing season has not proved to be of much value because commercial fishing operations shift from shallow inshore areas during the spring and early summer to deeper offshore waters during the late summer and fall. Thus different parts of the stock are fished at different times of year, so changes in catch per unit of effort are difficult to interpret.

Because trawl survey estimates are available as soon as the survey is completed, we must rely on estimates of this type for 1968. A comparison of abundance for male crabs based on data from the 1968 spring and fall surveys reveals some interesting differences (Figure 10). Population estimates for crabs 100 mm carapace length and larger are higher in spring than in fall, and the differences cannot be entirely accounted for by the removal of legal size male crabs by the commercial fishery. Although sampling variation and natural mortality may account for some of the unexplained differences, the fall distribution data show an important concentration of larger males in deep water along the western edge of the trawl survey area, suggesting that substantial numbers of these larger males went unsampled to the west of the survey area.

In case of smaller males under 90 mm carapace length, the situation was reversed with population estimates being much higher in the fall. Comparison of the geographical distributions of smaller crabs at the times of the two surveys suggests that these small males were in shallow inshore waters at the time of the spring survey and were inadequately sampled. This is especially apparent in the case of small males in the 40 to 69 mm length range which were missed almost entirely during the spring survey.

For males of intermediate size (90 to 99 mm length), results of the two surveys were similar.

Size specific popoulation estimates for female king crabs showed relationships that were similar to those observed for males: larger females were more abundant in the surveyed area at the time of the spring survey, whereas smaller females were more abundant in the fall (Figure 11). Furthermore, these differences also seem to be related to differences in the distribution of females at the times of the two surveys and to the problem of incomplete survey coverage.

Recruitment

Recruitment of male king crabs to a legal size of 135 mm carapace width, or approximately 120 mm carapace length is another factor under investigation. Trawl survey data from the 1966 summer cruise and the 1968 spring cruise have been used in estimating recruitment for the years 1966 through 1969. The 1966 recruitment estimate assumes that crabs in the 129-135 mm length class were recruited to a legal size during the 1966 spring molting period, whereas the 1967 estimate assumes that crabs in the 104-119 mm length class at the time of the 1966 summer survey molted and reached legal size in the spring of 1967. Similar assumptions were employed in making recruitment estimates for 1968 and 1969 based on 1968 spring trawl survey data. In all cases appropriate adjustments were made for the effects of natural and fishing mortality. It should be noted that these recruitment estimates are based on

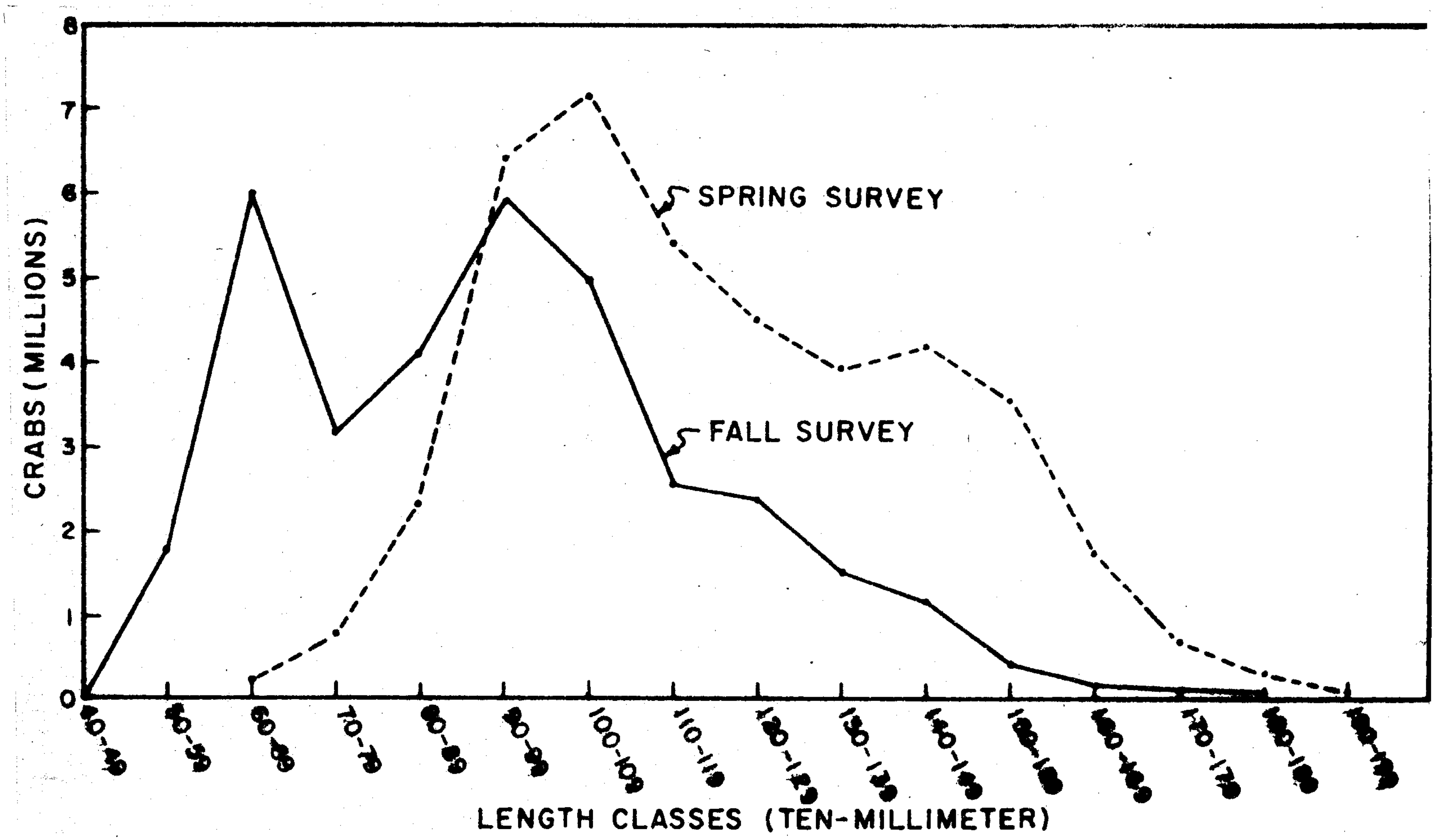

Figure 10. Comparison of 1968 trawl survey estimates of male king crab abundance.

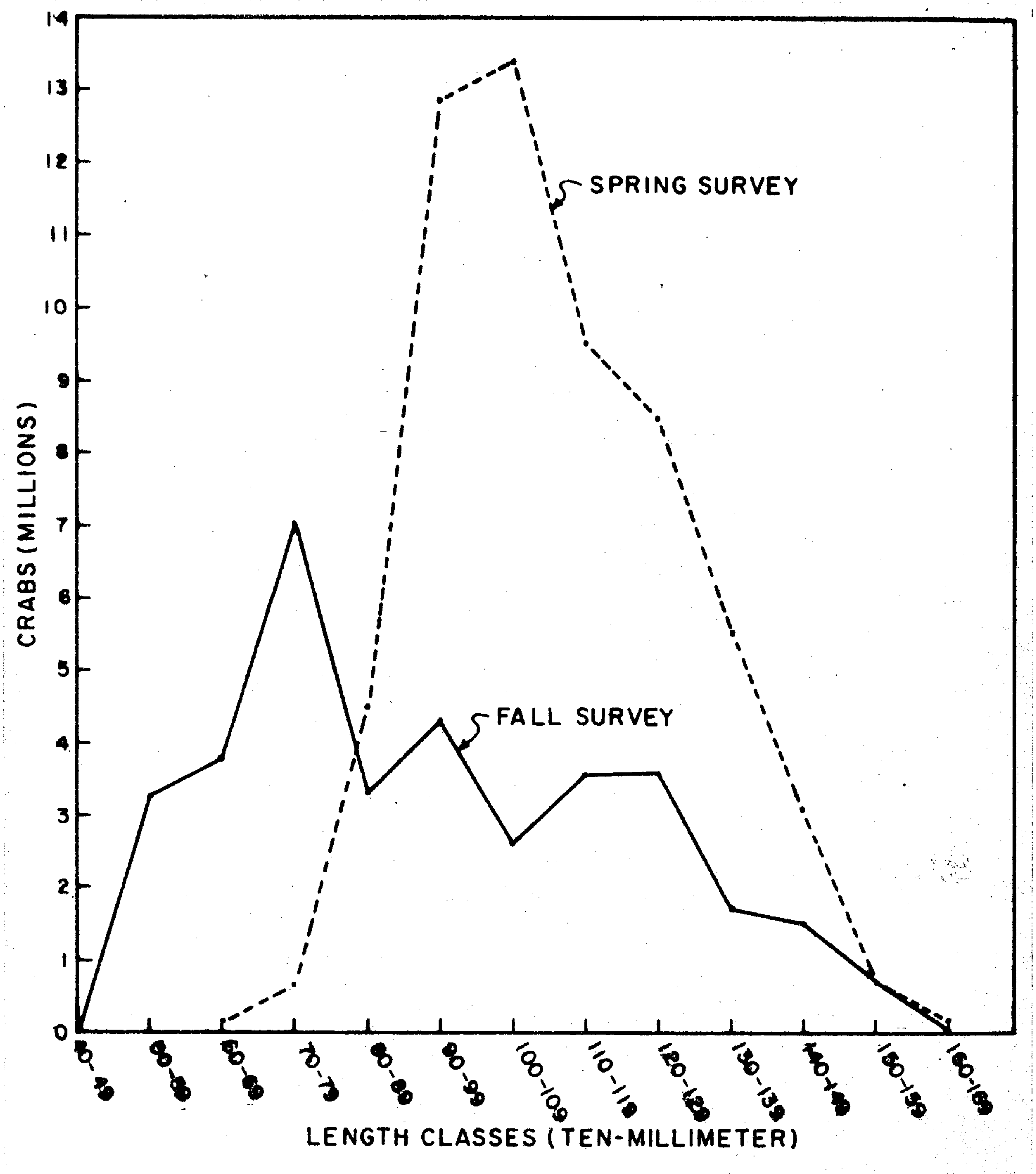

Figure 11. Comparison of 1968 trawl survey estimates of female king crab abundance.

trawl samples of crabs 104-135 mm in length, which we believe were fairly well sampled in both the 1968 spring survey and the 1966 summer survey.

The estimated numbers of male king crab reaching a legal size of approximately 120 mm carapace length are as follows: in 1966, 4.33 million crabs; in 1967, 2.07 million crabs; in 1968, 6.86 million crabs; in 1969, 9.04 million crabs. These estimates suggest that annual recruitment can vary from year to year by a factor of at least 4. With this degree of variability in recruitment, it will be important to treat each successive year class of recruited male king crabs as a separate entity, and yield models will have to be developed that take variability of recruitment into account.

Trends in the commercial fishery

At the 1968 INPFC meetings and at recent bilateral negotiations with the Japanese and the Soviets, there was general agreement among scientists that the king crab resource in the eastern Bering Sea was seriously depleted and that present regulatory measures were not adequate. These conclusions were largely based on trends observed in catch and effort data from commercial fishing operations. These trends are presented in Figure 12 for the Soviet fishery and in Figure 13 for the Japanese fishery. The rapid intensification of the fishery beginning in 1959 is very evident in these figures as is the precipitous decline in catch per unit of effort that accompanied this intensification. This decline is more or less continuous to the present time. Over the same period the average length of commercially used crab has also declined gradually (Table 1), although since 1966 average length seems to have leveled off at about 153 mm. This leveling off may be partially due to the nature of the tangle net gear which is selective for larger crabs.

As a result of the general agreement that the resource was depleted, both the Japanese and the Soviets agreed to a 48 percent reduction in their catch quotas for 1969 and 1970. These substantial reductions, together with the improvement in recruitment which is anticipated, indicate that this important king crab fishery may soon begin to recover from its present depleted state.

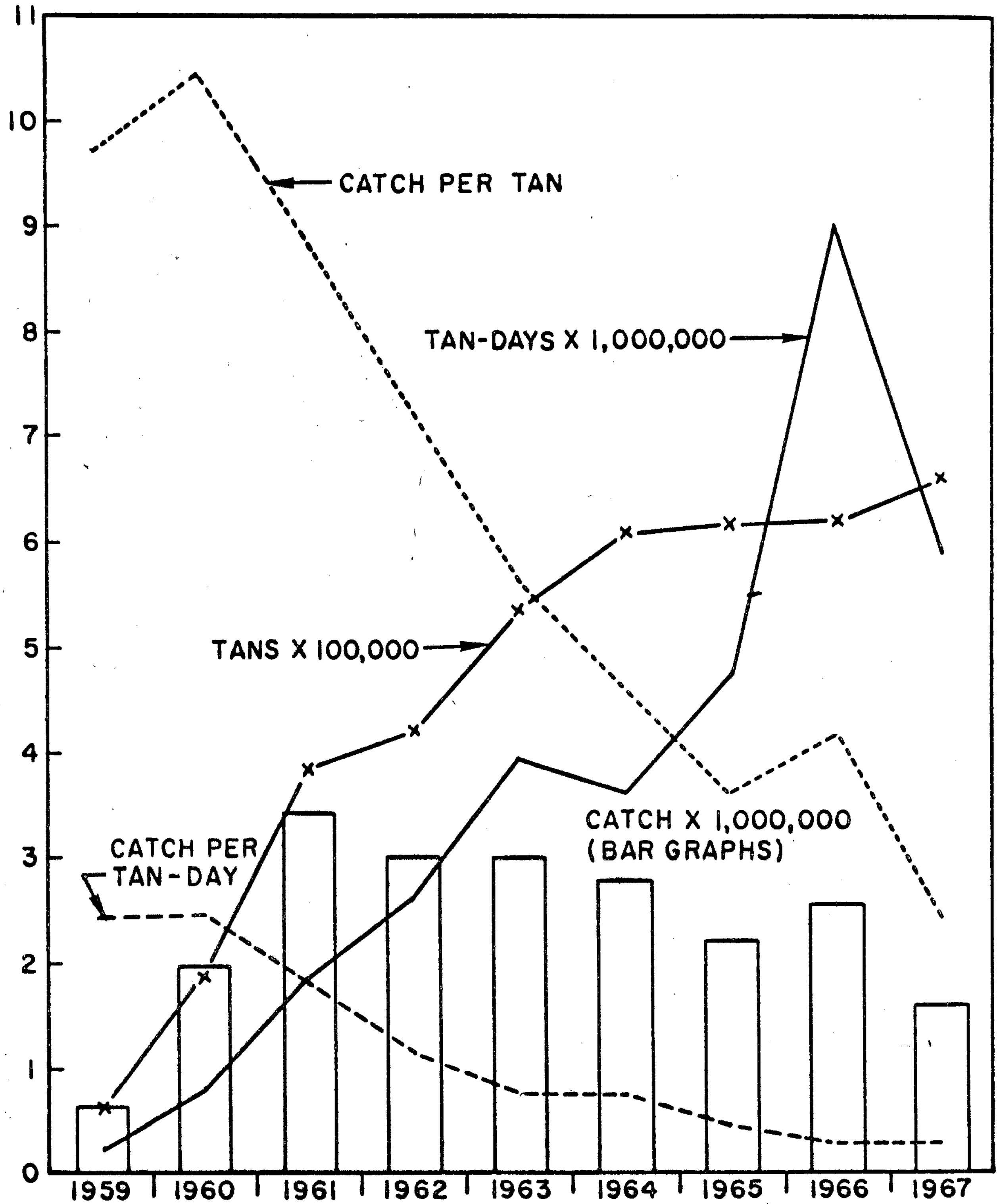

Figure 12. Catch and effort data for the Soviet king crab mothership fleet in the southeastern Bering Sea from 1959 to 1967 (unpublished data).

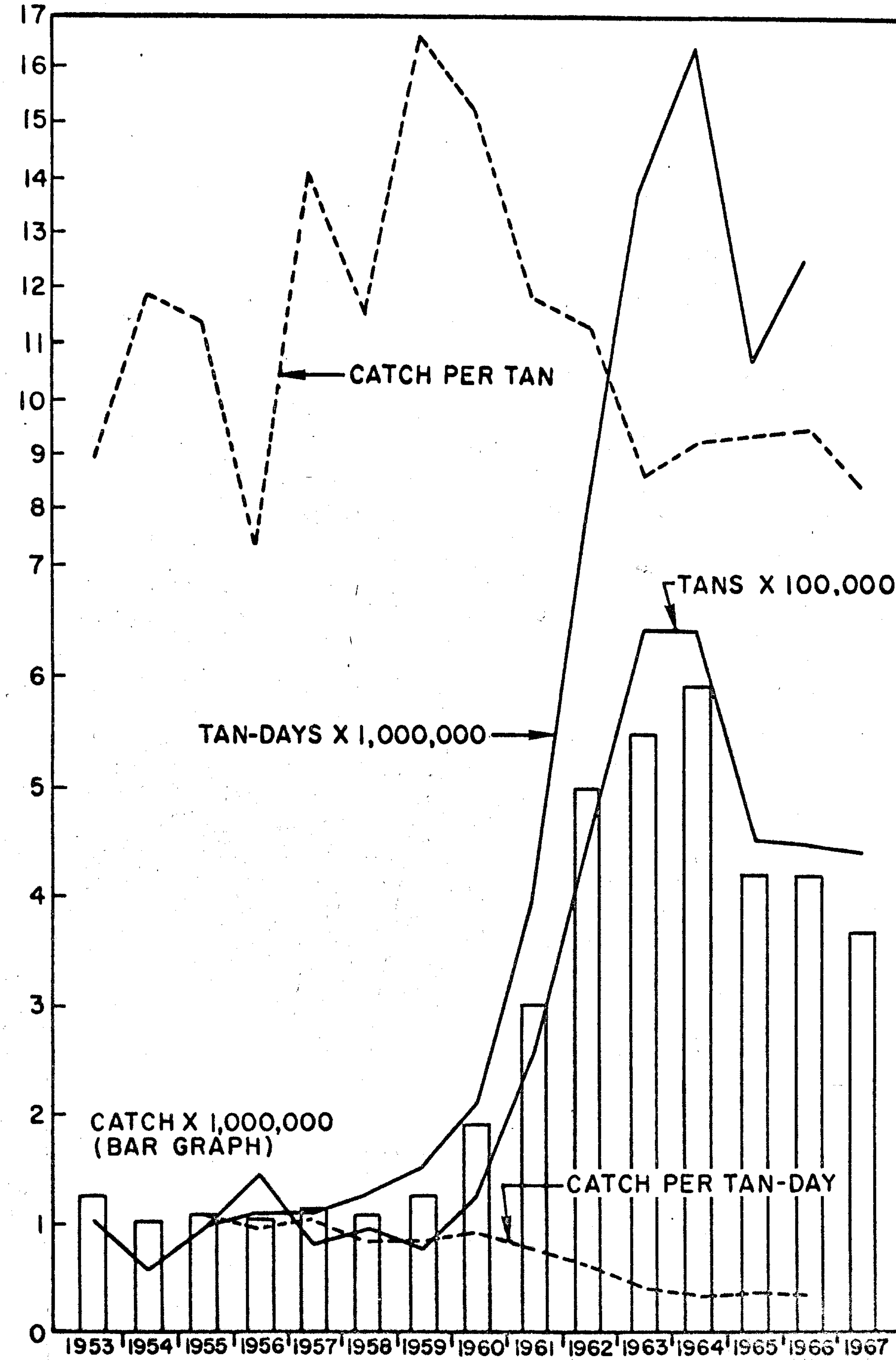

Figure 13. Catch and effort data for the Japanese king crab mothership fleet in the southeastern Bering Sea from 1953 to 1967 (data from INPFC Annual Reports).

Table 1. Changes in average carapace length for the Japanese commercial king crab catch in southeastern Bering Sea from 1953 to 1967[1/].

Year	Average length of king crabs in the commercial catch (mm)
1953	170.0
1954	166.5
1955	164.1
1956	162.5
1957	159.8
1958	158.9
1959	159.7
1960	158.1
1961	158.7
1962	158.0
1963	154.8
1964	156.9
1965	154.3
1966	152.9
1967	152.5

1/ Data from INPFC Annual Reports.

King Crab Fecundity, Kachemak Bay -- Mr. Evan Haynes

A long term fecundity study of king crab, begun in Kachemak Bay in the spring of 1967, will continue for at least another two years. Objectives of this study are to estimate (1) egg mortality during the egg carrying period, and (2) year to year variations in fecundity. These data will be used to derive equations for estimating average fecundity of the population at each sample date and to predict the probable number of larvae that would result.

Preliminary analysis showed that the fecundity increased with carapace length (Figure 14), but egg length did not. For crabs of the same size, the mean number of eggs carried was significantly greater than for crabs in a similar study of Kachemak Bay in 1960.

ADF&G

Plans for Future King Crab Research -- Mr. Guy Powell

The long range research plans outlined at the First Alaskan Shellfish Conference May 23-26, 1967 are still adequate and require little change. The basic goal, of course, is to conduct investigations needed by management to insure proper resource utilization.

Five goals of our future work are: (1) analyzing and publishing of accumulated data; (2) construction of population models for Kodiak stocks of king crab; (3) collection of catch per effort data throughout the fishing season using log books; (4) continuing present studies of reproductive biology during annual breeding season; and (5) placing more emphasis upon prediction studies, which for the past three years have had only preliminary status.

Plans for Future Federal Aid - King Crab Research -- Mr. Harvey Yoshihara

Future research will be divided into two phases. Phase I will consist of studies on king crab brood stock composition and conditions and phase II will consist of studies on relative abundance of pre-recruit male king crab. Trawling to determine brood stock composition and condition will be done on known mating areas around Kodiak in April and May, 1969. It is expected that changes in the observed sex ratio of king crabs will help determine if present fishing regulations are adequate to conserve the mating stocks. Estimates of relative abundance of pre-recruit male king crab will aid us in predicting year class strength of crabs recruited to the fishery.

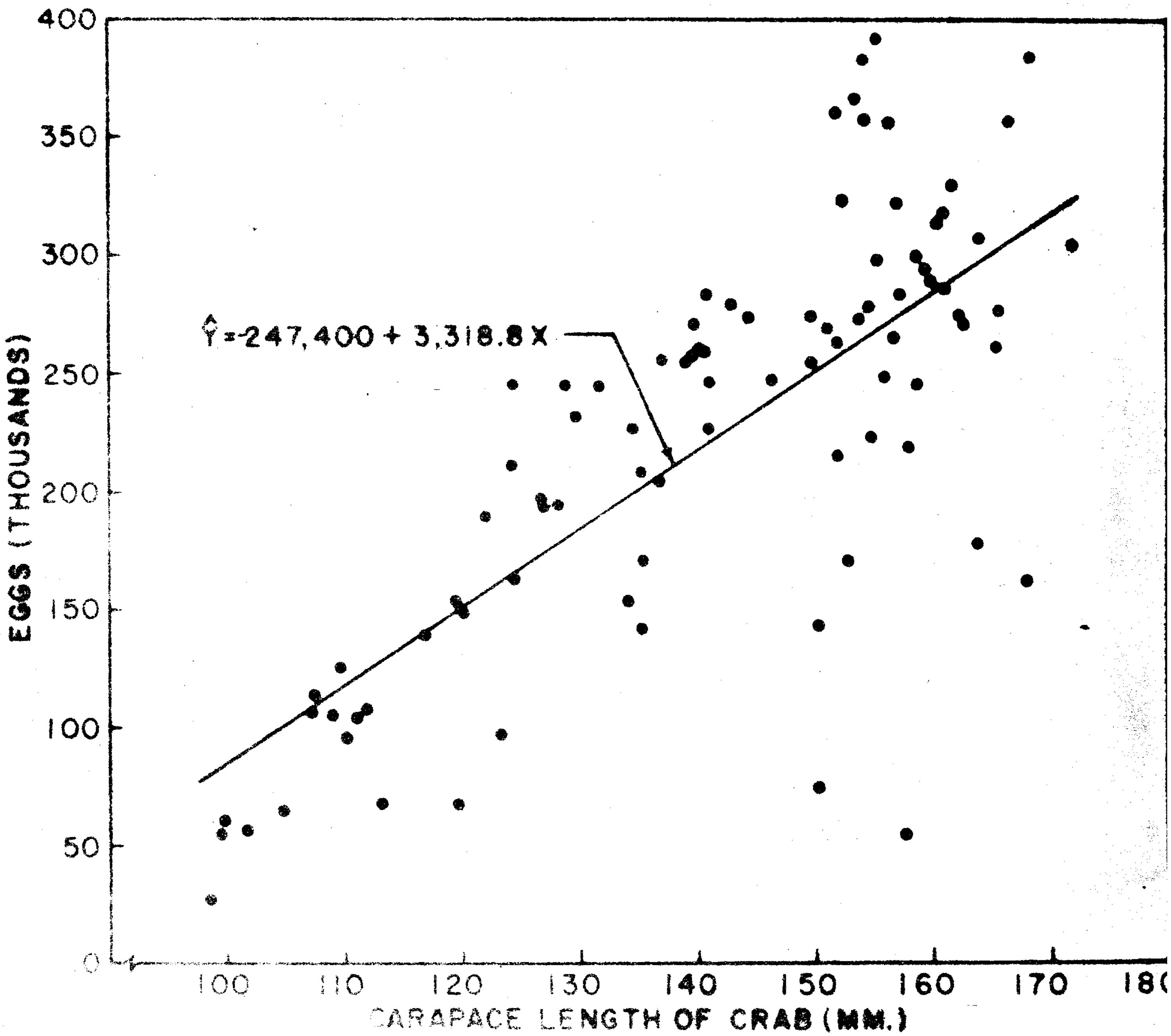

Figure 14. Relation of number of eggs to carapace length of king crab.

BCF

Plans for Future King Crab (and Tanner Crab) Research in the Eastern Bering Sea, 1969 -- Dr. David Hoopes

The BCF plans to pursue an intensive research program in the eastern Bering Sea during 1969. A synoptic oceanographic survey involving three separate research cruises will begin in April and terminate in October. The program will have as its goals: (1) a description of the Bristol Bay gyre, (2) a study of bottom currents, (3) a study of larval crab distribution, (4) an investigation of nutrients, and (5) an analysis of bottom sediments.

A king crab research cruise using the R/V MILLER FREEMAN will commence April 1 and end May 20. Objectives of this cruise are to: (1) determine abundance and distribution of adult king and tanner crab during the molting and mating period, and (2) continue tagging studies related to population estimates and growth rates. A second cruise will begin aboard the F/V COMMANDER on May 5. This cruise will be primarily concerned with the distribution and abundance of juvenile sockeye salmon but will also include collection of biological, physical and chemical oceanographic data, and trawling for tanner crabs. The final cruise of the season, aboard the R/V MILLER FREEMAN, will be devoted to a study of the distribution and abundance of pre-recruit king crabs and a continuation of the tagging study program. This cruise will begin September 1 and end October 10.

In addition to the three research cruises planned for 1969, we will collect tag returns from other nations fishing in the eastern Bering Sea and will sample the United States commercial catch for size-frequency and catch per unit of effort data. Also, we plan to place an observer aboard a Japanese king crab mothership for part of the Japanese commercial season.

Plans for Future Early Life History Studies -- Mr. Evan Haynes

Future work will emphasize studies on king crab larvae in Kachemak Bay. The studies will begin this spring and initially will consist of a comprehensive oceanographic survey of the Bay. The survey will emphasize those factors that presumably will influence directly larval survival. These factors are: water temperature, salinity, oxygen, nitrate, silicate, and phosphate, water current, sediments and their organic carbon content, and weather.

Preliminary larval sampling will begin this spring followed by intensive larval sampling a year later. Main objectives of the larval sampling are to determine larval distribution, abundance, and mortality. Following these studies, research emphasis will be on causes of mortality. Concurrent with larval sampling will be laboratory studies at the BCF Kasitsna Bay Field Station on problems such as effect of temperature and salinity on larval growth, reaction of various larval stages to different light intensities, and respiration of the larvae.

Eastern Bering Sea King Crab Research Plans - Population Dynamics -- Mr. Joseph Greenough

The goal of the BCF population dynamic research program is the development of a yield model tailored specifically to the requirements of a king crab fishery. A model is presently being developed that in certain respects is similar to a Ricker type of sustained yield model. That is to say, the life history of the king crab is broken up into a large number of stages, and parameters relating to growth, natural mortality, and fishing mortality are defined for each stage. This type of model allows the user to follow the fate of a unit of recruitment of given size over the entire period that it is subject to exploitation, and to determine total yield of each unit of recruitment for various combinations of fishing effort.

The model being developed for king crab will differ in two key respects from the Ricker model. First, the treatment of growth will be much more detailed to allow realistic simulation of the actual growth of king crab. A distinction will be made between crab that have molted during the most recent spring molting period and those that have skipped during the most recent molting period. The actual growth model used will be similar to the one indicated in Figure 15. Note that the probability of a crab molting during a given molting period depends upon both its size and whether or not it molted during the preceding molting period.

The second way in which the king crab yield model will differ from a standard Ricker model is in the treatment of recruitment. It will be possible to study the effects of different fishing strategies when the strengths of subsequent year classes vary. It is important for the model to have this capability because recent research indicates that recruitment of king crab in the Bering Sea is a highly variable factor.

Elaboration of the Ricker model along the lines indicated in the preceding paragraphs will enable us to free ourselves from many of the problems associated with interpretation of models which provide only an estimate of average sustained yield under equilibrium conditions. We will be able to consider much more realistic management problems where highly dynamic factors must be taken into account. With this model it should be possible to develop an optimum plan for the exploitation of each year class that passes through the fishery.

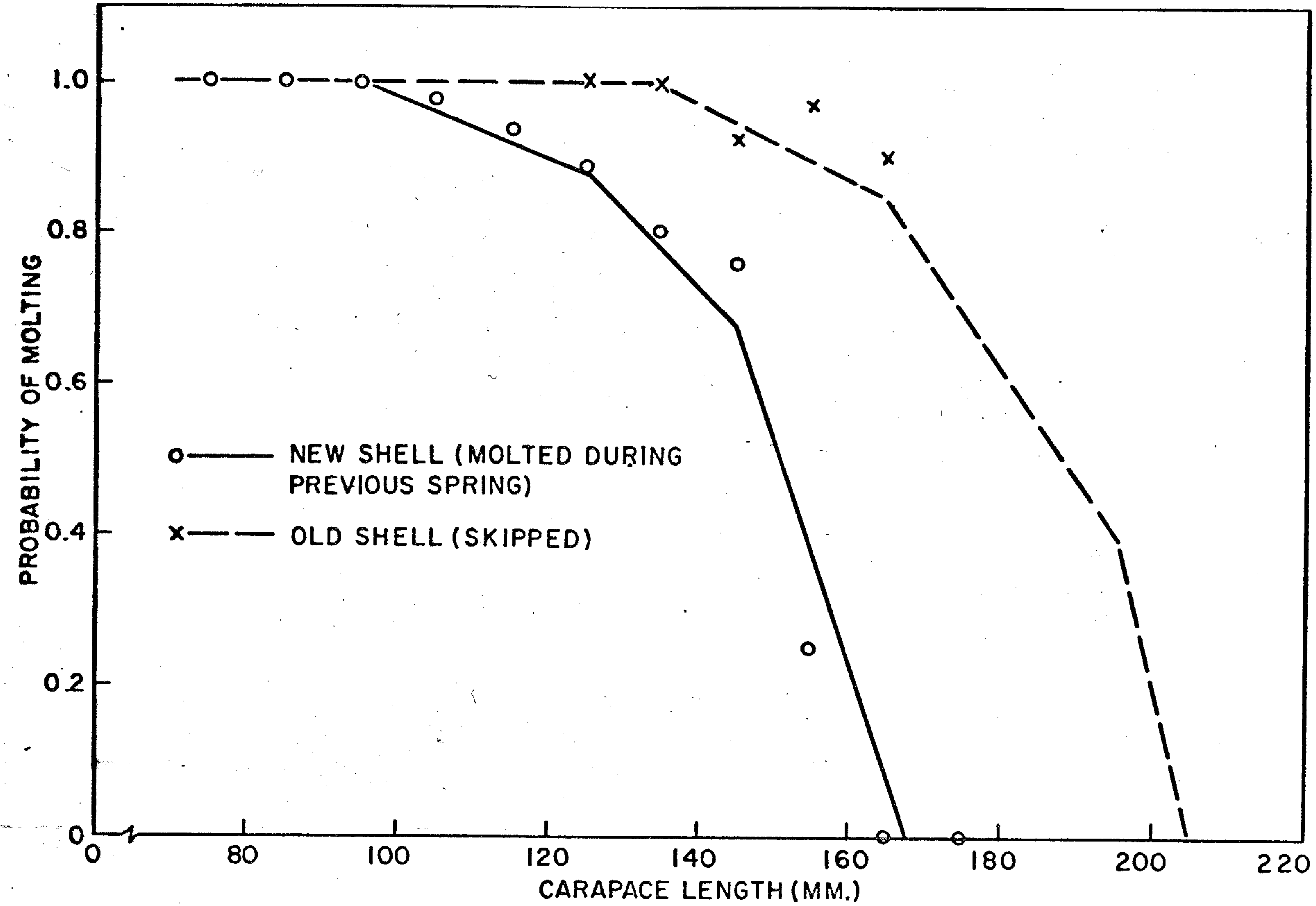

Figure 15. Male king crab growth model: the probability that a crab will molt during any given molting period expressed as a function of size and prior molting history. This figure is based on data from crabs tagged in 1966 and recovered in 1967.

One problem associated with the use of any type of yield model is the estimation of input parameters. In the case of the eastern Bering Sea king crab resources, we anticipate that most of the important parameters will be based on three types of data: (1) catch and effort data in the commercial fishing operations of Japan, the Soviet Union, and the United States; (2) trawl survey data on distribution, abundance and size frequency; and (3) mark and recapture data from the U.S. tagging program carried out in conjunction with trawl survey program.

SHRIMP RESEARCH REVIEW

ADF&G

Review of Federal Aid Pandalid Shrimp Research, Wrangell -- Mr. Jerry McCrary

The ADF&G has been conducting a year round shrimp research program in the Wrangell-Petersburg area since 1966. Primary goals of this research are: (1) describe in detail the life histories of the four species of commercially important pandalid shrimp; (2) determine relative abundance of the various species and age groups in the commercial catch; (3) establish a log book program to improve not only catch statistics but also the accuracy and analysis of cannery reports; and (4) determine the effect of water temperature and salinity on shrimp distribution.

Sampling is done on a monthly basis in the two areas of commercial importance, Duncan Canal and Thomas Bay. Historically these two areas have contributed the major portion of the total catch, their contribution the past nine years averaging 71 percent. The remainder of the catch is distributed among five other areas.

The two sampling locations, Duncan Canal and Thomas Bay, are about 35 miles apart and differ greatly in their types of shrimp habitat. Duncan Canal is a long, narrow, shallow bay with a maximum depth of 35 fathoms. Average trawling depth is about 15 fathoms, and approximately 80 percent of the area is trawlable. Thomas Bay is a deep glacial bay with depths to 139 fathoms. The average trawling depth is about 30 fathoms, and approximately 40 percent of the area is trawlable. Most of the remaining area of Thomas Bay is deeper than 100 fathoms and probably unsuitable shrimp habitat.

To retain all sizes of shrimp, including the smallest post larval forms, a Gulf of Mexico 10 foot tri-net equipped with a 1/4" square mesh liner throughout the cod-end was used as the sampling gear. It is light weight, relatively inexpensive, and capable of retaining all sizes of shrimp including the smallest post larval forms rarely retained by fishing gear.

Life history studies on the four major commercial species of pandalid shrimp, pink shrimp (*Pandalus borealis*), sidestripe shrimp (*Pandalopsis dispar*), coonstripe shrimp (*Pandalus hypsinotus*) and humpy shrimp (*Pandalus goniurus*) is nearly complete. These species have similar life histories, summarized as follows: the larvae are released in the spring and are free swimming for about 2-1/2 months during which time they metamorphose and settle to the bottom. At the time of settling, their appearance is similar to small adults and they are called post larvae. These early post larval shrimp are most abundant in deep water areas of more than 20 fathoms. Growth is slow throughout the first winter as they continue to migrate to inshore waters of less than 20 fathoms. During this first year of life many variations in the form of external (secondary) sex characteristics occur. Most individuals display male characteristics early in their first year of life. In two species, P. goniurus and P. hypsinotus, there are some individuals that develop as females from birth. Also in this first year group some individuals start to develop male characteristics but these characteristics soon disappear and the shrimp develop as females.

Growth is rapid through the second summer, some species showing up to 2 mm per month increase in carapace length. This increase is nearly three times the winter growth rate. At about 1-1/2 years of age most shrimp have matured and mate as males. Some of these individuals will mate as females; these individuals show a slightly greater growth rate than males the same age.

Mid-way through their second winter the predominantly male group begins transformation into females. There are four transition stages. Usually 9 months are required for a year class to complete transition but average time for a single individual is about 6 months. Sex change is completed at 2-1/2 years of age.

Spawning begins at about 2-1/2 years of age, the ovigerous period lasting until spring or about 7 months. By the time the larvae hatch, the adult shrimp have completed their third year of life. It has not been determined whether those females which spawn at 1-1/2 years of age survive to spawn again at 2-1/2 years of age. All the males may not transform during their second year; some of them may function twice as males, first at 1-1/2 and again at 2-1/2 years. These individuals probably transform at 3-1/2 years and live until the beginning of their fifth year. This hypothesis may explain the occurrence of these males that are identical in size to the 3-1/2 year old females.

In Duncan Canal, the commercial fishery is dependent upon 3 year old pink shrimp in the spring and early summer and mostly 2 year olds in the autumn. The decrease of 3 year old shrimp in the catches is due not only to fishing pressure but also the emigration of gravid females to deeper waters. The few ovigerous females that remain in Duncan Canal during the autumn are usually caught only in the deepest waters.

Pink shrimp in their first year appear in Duncan Canal about mid-July but the abundance remains low until autumn. From September through the winter months the abundance of these 0+ shrimp increases markedly, undoubtedly as a result of immigration from other areas.

Shrimp fishermen intimately acquainted with the Duncan Canal area believe that generally higher catches occur during small tides whereas the maximum tides produce lower catches. Validity of this theory was examined by comparing records of daily catches and tidal cycles from this area over a four month period using catch data from boats of equal fishing capabilities. The correlation between higher catches and small tides was significant at the 90% level.

Commercial catch from Thomas Bay depends upon older shrimp than the commercial catch in Duncan Canal. This is because older shrimp inhabit deeper waters and in Thomas Bay average trawling depth is somewhat greater than that of Duncan Canal. Also, catch rates in Thomas Bay are somewhat constant when compared to those of Duncan Canal. This is probably due to lack of shrimp migration in Thomas Bay whereas in Duncan Canal intensive shrimp migration occurs.

The commercial shrimp catch in Thomas Bay has continued to decline since 1960. Catch per effort in 1968 (1,842 lbs. per landing) was the lowest since 1960 (Table 2). The low catch per effort in 1968 was marginal economically and precipitated a self imposed closure several times during the fishing season.

Catches in Duncan Canal also have continued to decline and in 1968 were the lowest since 1962. A reduction in effort in 1968, however, resulted in an increase in catch per effort over the previous year (Table 2).

Total shrimp catch in Southeastern Alaska was slightly more than 2,000,000 lbs. in 1968. This is the lowest catch since 1956 (Table 3).

Fecundity of each species of pandalid shrimp was studied in 1968. Preliminary analysis shows that the average number of eggs carried by each species was somewhat lower than that determined in a similar study in 1929.

A log book program for the southeast Alaska shrimp fishery was begun in June 1968 but has been only partially successful. Presently log books are used only by the larger vessels that have more than one man crews, the largest gear, and the highest average catch rates. The main problem in obtaining complete log book coverage of the commercial fleet is that skippers of small, one man vessels do not have the time to fill out log books, as they must operate the vessel, gear, and sort catches alone. Skippers of larger vessels with bigger crews usually have more time to fill out log books, or at least they will have a crew member maintain the log.

Log book data collected to date shows a wide variation between catch rates of individual boats within the same area and time. This variation has

Table 2. Catch per unit effort data of pandalid shrimp for Thomas Bay and Duncan Canal 1960-1968, and the percentage contribution to the total annual pandalid shrimp catch in Southeastern Alaska.

	THOMAS BAY				DUNCAN CANAL			
Year	Catch (lbs.)	Landings	Lbs. per Landing	%	Catch (Lbs.)	Landings	Lbs. per Landing	%
1960	1,776,305	655	2,712	53	757,703	212	3,574	23
1961	1,309,024	403	3,248	31	1,107,805	252	4,396	26
1962	1,115,614	345	3,234	29	742,511	221	3,360	19
1963	908,069	307	2,958	29	1,100,871	326	3,377	35
1964	1,193,792	396	3,015	43	1,051,964	497	2,117	38
1965	707,041	357	1,981	24	1,889,674	707	2,673	64
1966	782,804	355	2,205	21	2,435,300	939	2,594	64
1967	653,133	291	2,244	29	1,082,219	494	2,191	48
1968	475,135	258	1,842	24	944,189	362	2,608	47

Table 3. Total catch of pandalid shrimp in Southeastern Alaska, 1956 to 1968.

Year	Catch (Lbs.)	Landings	Lbs. per Landing
1956	3,031,598	?	?
1957	2,350,449	?	?
1958	7,605,871	?	?
1959	5,518,843	?	?
1960	3,343,373	1,007	3,320
1961	4,212,300	1,394	3,022
1962	3,884,050	1,400	2,774
1963	3,110,340	1,080	2,880
1964	2,793,101	1,092	2,512
1965	2,941,429	1,338	2,198
1966	3,784,597	1,663	2,276
1967	2,242,158	1,119	2,004
1968	2,003,753	925	2,166

always been apparent from analysis of daily landings, but is much more pronounced on the pounds per hour basis shown by the log books. Differences in catch rates are the result of variations in gear size, individual fishing ability, and the type of market for which a vessel is fishing. Smaller vessels can not compete with larger vessels in quantity of catch. The smaller vessels, therefore, usually fish for a processor that deals in a low volume, quality hand-picked product. Larger vessels generally fish for a quantity processor that deals with a machine peeled product.

The Wrangell-Petersburg shrimp fishery seems to be slowly dying. The fishery is suffering from economic overfishing, marketing problems, and, at present, a shortage of fishermen. This shortage is a result of several of the older, more experienced fishermen retiring from the fishery. These people have not been replaced.

Some of the machine peeled canned pack did not compete well on the market this year with canned packs of ocean pink shrimp from other west coast states. The problem was lack of uniform shrimp size in the can as most of the pack was not graded and all sizes, therefore, were canned together. Grading will probably be a necessity this year.

The future of the fishery does not look very promising from the standpoint of expansion. Expansion will depend upon the development of new cooking and peeling methods. These methods are still in the experimental stage and will be costly to perfect. In general, the fishery is suffering greatly from lack of modern methods and mean of handling and processing shrimp.

Review of Federal-Aid Pandalid Shrimp Research, Kodiak -- Mr. Duane Petersen

The increasing importance and value of the shrimp fishery in Kodiak created a need for a fulltime research biologist to study the commercial species of Pandalid shrimp in the Kodiak district. The ADF&G filled this position under PL 88-309 at Kodiak in September, with Peter B. Jackson as project leader.

Program objectives were to: (1) review literature on shrimp research and gear design; (2) conduct a year-round catch sampling program to provide information on species composition, age class structure, and sex ratio of shrimp in the commercial catch; (3) design a shrimp trawl log book suitable for use by research personnel and fishermen; and (4) review the 1960-1966 Kodiak Island shrimp catch statistics.

Review of the 1960-1966 Kodiak Island shrimp catch statistics was completed in April 1968 and published as ADF&G Informational Leaflet No. 120.

The catch sampling program began March 1968 in Marmot Bay and July 1968 in Ugak Bay. Sampling is done by ADF&G research personnel aboard a commercial fishing vessel fishing in the sampling area. An objection to this method is getting the fishermen to drag at our discretion. Future plans will include sufficient funds for chartering a vessel. The samples are used to obtain basic life history information such as age and growth, ovigerous period, etc. A more detailed description on this phase of research is given in the following report by Peter Jackson. Summaries of the commercial shrimp catch samples from Marmot Bay and Ugak Bay are given in Tables 4 and 5, respectively.

A logbook program was begun in November 1967. Its purpose is to: (1) obtain catch per unit effort by area by gear type; (2) show exact location, length, direction of each drag; (3) provide a form for recording trawling data so that the data can be subjected to IBM analysis; and (4) provide a trawl log which can be used state-wide for all trawl fisheries and that will be of value to the fishermen.

The logbook contains 60 sets of two data sheets. The first sheet is retained by the fisherman and the second sheet is given to the biologist. In the front of each log book is a list of abbreviations used by the fisherman in completing the comments section.

A reproduction of the data sheet used in the log is shown in Figure 16. The vessel captain will complete the information needed in columns 1-53. He will also mark the exact drag location and the corresponding drag numbers on an enlarged section of a chart provided by ADF&G personnel. The chart and duplicate data sheet are collected from the fisherman at time of catch delivery. Staff personnel record the trawl location on the data sheet by recording the area and subarea (each area is divided into 50 subareas) at the start, middle and end of each drag. Presently we are getting approximately 70 percent of the total landed catch recorded in logbooks (Table 6).

For study purposes, Kodiak Island fishing waters are divided into 13 areas (Figure 17) and the catch statistics summarized by each of these areas. A sample summary is tabulated in Table 7.

An IBM format that will aid in summarizing the data has been prepared and submitted for approval.

Table 4. Summary of commercial shrimp catch samples from Marmot Bay, Kodiak District, 1968-69.

			Sex composition [1]					
						Female		
Month	Species	Percent species composition	No. in sample	Percent males	Percent transitionals	Percent of sample	Percent non-ovigerous	Percent ovigerous
March	*P. borealis*	68.4	292	75.0	19.5	5.5	12.5	87.5
	P. dispar	30.5	115	62.6	10.4	27.0	3.3	96.7
April	*P. borealis*	79.7	330	66.4	26.3	7.3	12.5	87.5
	P. dispar	20.3	107	61.7	22.4	15.9	11.8	88.2
May	*P. borealis*	76.1	331	66.2	5.7	28.1	100.0	0.0
	P. dispar	23.9	121	62.0	5.0	33.0	72.5	27.5
June	*P. borealis*	95.6	343	54.2	10.2	35.6	100.0	0.0
	P. dispar	4.4	142	50.7	15.5	33.8	85.4	14.6
July	*P. borealis*	93.4	346	83.3	0.9	15.8	100.0	0.0
	P. dispar	6.6	140	61.4	17.3	21.3	90.0	10.0
August	*P. borealis*	95.4	335	71.3	4.8	23.9	100.0	0.0
	P. dispar	4.6	168	61.9	19.6	18.5	87.1	12.9
September	*P. borealis*	92.6	389	66.8	4.1	29.1	100.0	0.0
	P. dispar	7.4	33	57.6	6.1	36.4	83.3	16.7
October	*P. borealis*	91.8	400	86.8	0.0	13.3	22.6	77.4
	P. dispar	8.1	143	64.3	1.4	34.3	10.2	89.8
November and December	*P. borealis*							
	P. dispar	Unable to obtain sample						
January	*P. borealis*	94.9	400	47.3	34.5	18.3	0.0	100.0
	P. dispar	5.1	104	51.0	7.7	41.4	0.0	100.0
February	*P. borealis*							
	P. dispar							

Table 5. Summary of commercial catch samples from Ugak Bay, Kodiak District, 1968-69.

Month	Species	Percent species composition	Sex Composition 1/ No. in sample	Percent males	Percent transitionals	Female: Percent of sample	Female: Percent non-ovigerous	Female: Percent ovigerous
July 30	*P. borealis*	100.0	330	54.2	26.7	19.1	100.0	0.0
August 28	*P. borealis*	98.7	397	94.7	2.5	2.8	100.0	0.0
October 4	*P. borealis*	96.0	400	81.5	2.5	16.0	93.8	6.3
October 28	*P. borealis*	80.7	400	93.0	0.0	7.0	39.3	60.7
November 29	*P. borealis*	83.2	400	83.5	2.3	14.2	3.5	96.5
January 4	*P. borealis*	98.2	400	70.3	16.8	13.0	3.8	96.2
	P. dispar	1.1	25	100.0	0.0	0.0	0.0	0.0
January 25	*P. borealis*							
February	*P. borealis*							

1/ Including transitionals

TRAWLER LOG

VESSEL NAME ____________________

Date Left Port			Date Returned					Gear			
MONTH 2	DAY 4	YEAR 6	MONTH 8	DAY 10	YEAR 12	VESSEL ADF&G NUMBER 17		TYPE 19	SIZE 22	VESSEL LENGTH 25	VESSEL H.P. 28

DRAG 30	DATE 34		TIME ON BOTTOM				AVE. DEPTH	POUNDS EACH DRAG 53	LOCATION OF DRAG						STATISTICAL AREA 73	COMMENTS: SPECIES COMPOSITION, AVERAGE SIZE, DEPTH RANGE, etc.
					TOTAL				START		MIDDLE		END: 68			
	MO.	DAY	START	END 42	HR	MIN	FATH 48		AREA	SUB	AREA	SUB	AREA	SUB		

REMARKS ON CRAB, HALIBUT, OTHER SHELLFISH, SNAGS, OTHER TRAWLERS ENCOUNTERED

Figure 16. Sample sheets of shrimp-trawl log book.

Table 6. Proportions of monthly shrimp catches recorded in trawl logbooks, Kodiak District, November, 1967 through December, 1968.

Month	Catch Pounds	Logged catch Pounds	Proportion of catch logged percent
November	1,893,049	153,000	8.1
December	1,012,072	285,500	28.2
January	1,646,051	452,685	27.5
February	1,775,495	470,400	26.4
March	2,922,160	1,799,700	61.5
April	3,114,803	1,021,800	32.8
May	1,903,386	894,925	47.0
June	4,400,907	2,953,100	67.1
July	3,923,288	3,873,850	98.7
August	4,018,109	2,784,100	69.2
September	3,452,640	2,812,200	81.4
October	3,357,756	2,529,000	75.3
November	2,195,279	1,632,500	74.3
December	1,787,617	1,243,500	69.5
Totals	37,402,612	22,906,260	61.9

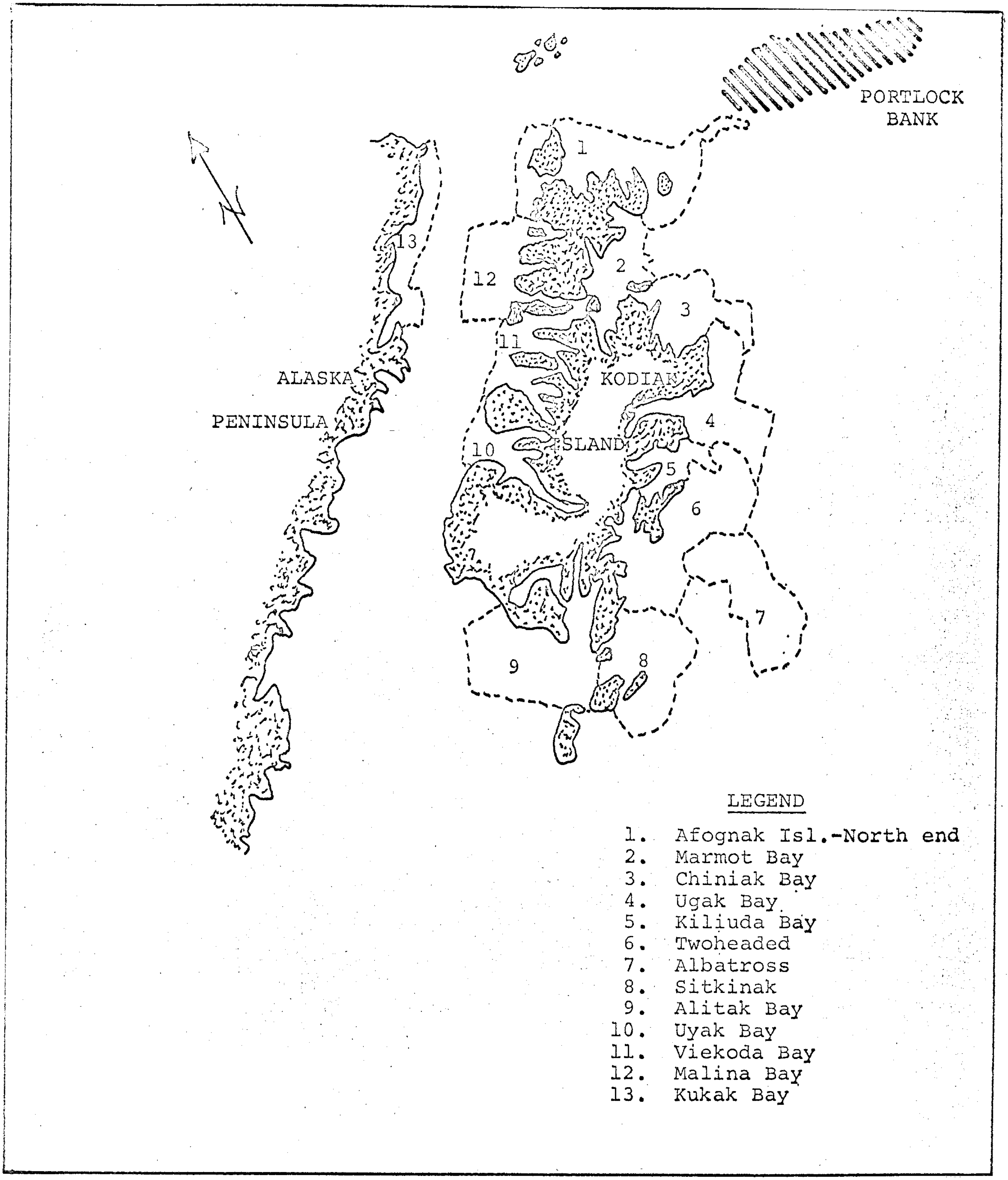

Figure 17. Description of shrimp catch areas, Kodiak District.

Table 7. Shrimp catch per unit effort by catch area: Kodiak District, 1968. These logbook data do not represent total shrimp catch.

Area	Month	No. drags	# hours	No. lbs.	Avg. # hours
Afognak	March	28	45.85	129,300	2,820
	April	2	2.33	4,500	1,931
	May	3	3.58	2,300	642
	June	1	2.00	500	250
	July	2	3.33	11,000	3,303
	August	3	5.67	14,000	2,469
	October	10	20.34	59,000	2,901
	December	3	9.00	21,000	2,333
Area Total		52	92.10	241,600	2,623
Albatross	-	--	--	--	--
Alitak	April	16	31.33	110,000	3,511
Area Total		16	31.33	110,000	3,511
Chiniak	January	6	7.25	18,300	2,542
	February	4	7.50	7,900	1,053
	May	13	21.33	28,525	1,337
	June	12	21.92	49,000	2,235
	August	18	42.33	69,500	1,642
	September	13	35.67	57,500	1,612
	October	1	2.00	8,000	4,000
	December	1	1.00	1,000	1,000
Area Total		68	139.00	239,725	1,724
Kiliuda	January	6	9.59	29,000	3,024
	February	5	6.50	18,000	2,769
	March	55	107.76	308,800	2,866
	April	30	57.43	181,800	3,166
	May	37	80.06	140,000	1,749
	June	101	153.08	841,500	5,497
	July	215	415.76	1,790,000	4,305
	August	59	111.43	483,000	4,335
	September	4	7.75	14,000	2,143
	October	64	127.34	391,200	3,072
	November	33	64.17	190,000	2,961
	December	22	44.00	155,500	3,534
Area Total		631	1184.87	4,542,800	3,834

Table 7. Shrimp catch per unit effort by catch area: Kodiak District, 1968. These logbook data do not represent total shrimp catch (continued).

Area	Month	No. drags	# hours	No. lbs.	Avg. # hours
Kukak	March	10	17.18	54,000	3,143
	May	49	92.40	269,000	2,911
	October	2	3.50	6,000	1,714
Area Total		61	113.08	329,000	2,909
Malina	February	8	13.09	43,000	3,285
	March	63	125.37	317,000	2,529
	April	42	91.07	224,500	2,465
	May	1	1.00	200	200
	August	2	2.42	--	--
	October	6	12.30	59,000	4,797
	November	26	48.77	176,500	3,619
Area Total		148	294.02	820,200	2,789
Marmot	January	14	29.37	38,585	1,314
	February	25	52.75	87,000	1,649
	March	4	8.61	17,500	2,033
	April	49	123.49	247,500	2,004
	May	45	112.68	210,900	1,872
	June	26	56.30	107,100	1,902
	July	43	105.04	227,500	2,166
	August	45	109.82	269,000	2,449
	September	20	49.56	99,500	2,008
	October	14	31.24	68,500	2,193
	November	15	33.52	83,000	2,476
	December	2	3.08	12,000	3,896
Area Total		302	715.46	1,468,085	2,051
Twoheaded	January	17	26.65	136,500	5,122
	February	58	66.68	295,000	4,274
	March	104	200.04	696,500	3,482
	April	11	22.58	71,000	3,144
	May	31	62.75	134,500	2,143
	June	16	24.49	114,500	4,675
	July	54	114.70	441,000	3,845
	August	12	19.66	175,000	8,901
	October	58	104.57	379,800	3,632
	November	60	105.50	611,500	5,796
	December	30	53.59	232,500	4,338
Area Total		451	801.21	3,287,800	4,103

Table 7. Shrimp catch per unit effort by catch area: Kodiak District, 1968. These logbook data do not represent total shrimp catch (continued).

Area	Month	No. drags	# hours	No. lbs.	Ave. # hours
Ugak	January	31	64.08	230,300	3,594
	February	1	1.00	1,000	1,000
	March	45	66.11	276,600	4,184
	April	33	56.51	172,500	3,053
	May	2	3.50	4,500	1,286
	June	144	241.90	1,221,500	5,050
	July	137	279.94	828,350	2,959
	August	216	408.87	1,481,100	3,622
	September	387	834.30	2,617,200	3,137
	October	182	405.49	1,274,000	3,142
	November	29	60.42	174,000	2,880
	December	113	263.12	794,500	3,020
Area Total		1320	2685.24	9,075,550	3,379
Uyak-Viekoda	February	5	7.08	18,500	2,613
	April	1	1.50	10,000	6,667
	May	31	54.59	105,000	1,923
	June	96	243.77	619,000	2,539
	July	98	179.43	576,000	3,210
	August	59	115.16	292,500	2,540
	September	8	17.01	24,000	1,411
	October	37	79.07	283,500	3,585
	November	59	124.67	349,000	2,799
	December	6	16.58	27,000	1,628
Area Total		400	838.86	2,304,500	2,747
Grand Total		3449	6895.17	22,419,260	3,251

Review of Federal Aid Commercial Shrimp Catch Sampling Program, Kodiak -- Mr. Peter Jackson

The objectives of the Kodiak commercial shrimp sampling program are to: (1) determine life history of pink shrimp (Pandalus borealis) and sidestripe shrimp (Pandalopsis dispar); (2) monitor age group composition of commercially-caught pink and sidestripe shrimp; and (3) monitor species composition of commercially-caught pandalid shrimp.

Monthly commercial shrimp catch samples have been taken in Marmot Bay since March, 1968, and from Ugak Bay since July, 1968. Samples were obtained by research personnel aboard chartered trawl vessels. All drags were made with conventional otter trawl with 1-9/16 stretch mesh in the cod end. Each monthly sample consisted of several 4 to 5 pound sub-samples from widely separated areas in the bays. Samples were preserved aboard the vessels in a 5% solution of formalin and sea water. Age groups were defined by carapace length frequency modes and sexual development by the secondary sex characteristics on the first and second pleopods.

Length frequencies of P. borealis from Marmot Bay and Ugak Bay shows year groups from 0+ through 4+ (Figure 18). Because of the selection characteristics of commercial trawls, not all age groups may be represented in the catch. Future plans call for sampling with small mesh bait trawls to obtain more complete samples of the younger age groups.

Both pink shrimp and sidestripe shrimp in the Kodiak area are protandric hemaphrodites, a term indicating a sexual change that is characteristic of most species of pandalid shrimp. Pink shrimp larvae are hatched in April. The post-larvae remain immature during their first and second summer. At the beginning of their third autumn (30 months of age) some of them function sexually as mature males. These shrimp are termed "active" males. The remaining ("in-active") group function for the first time as males a year later. After functioning as males, the shrimp transform into females.

Spawning of the pink shrimp populations in both Marmot Bay and Ugak Bay occurs from mid-September to early October. By the end of October about 75 percent of the mature females are ovigerous and by the end of November nearly all are carrying eggs. These findings are similar to those for pink shrimp in British Columbia.

In Marmot Bay, hatching of pink shrimp begins in February and is completed during April. By early May ovigerous females are not found in the samples. Ovigerous females were again found in the samples October 4, when 6 percent of the females caught in Ugak Bay were carrying new eggs.

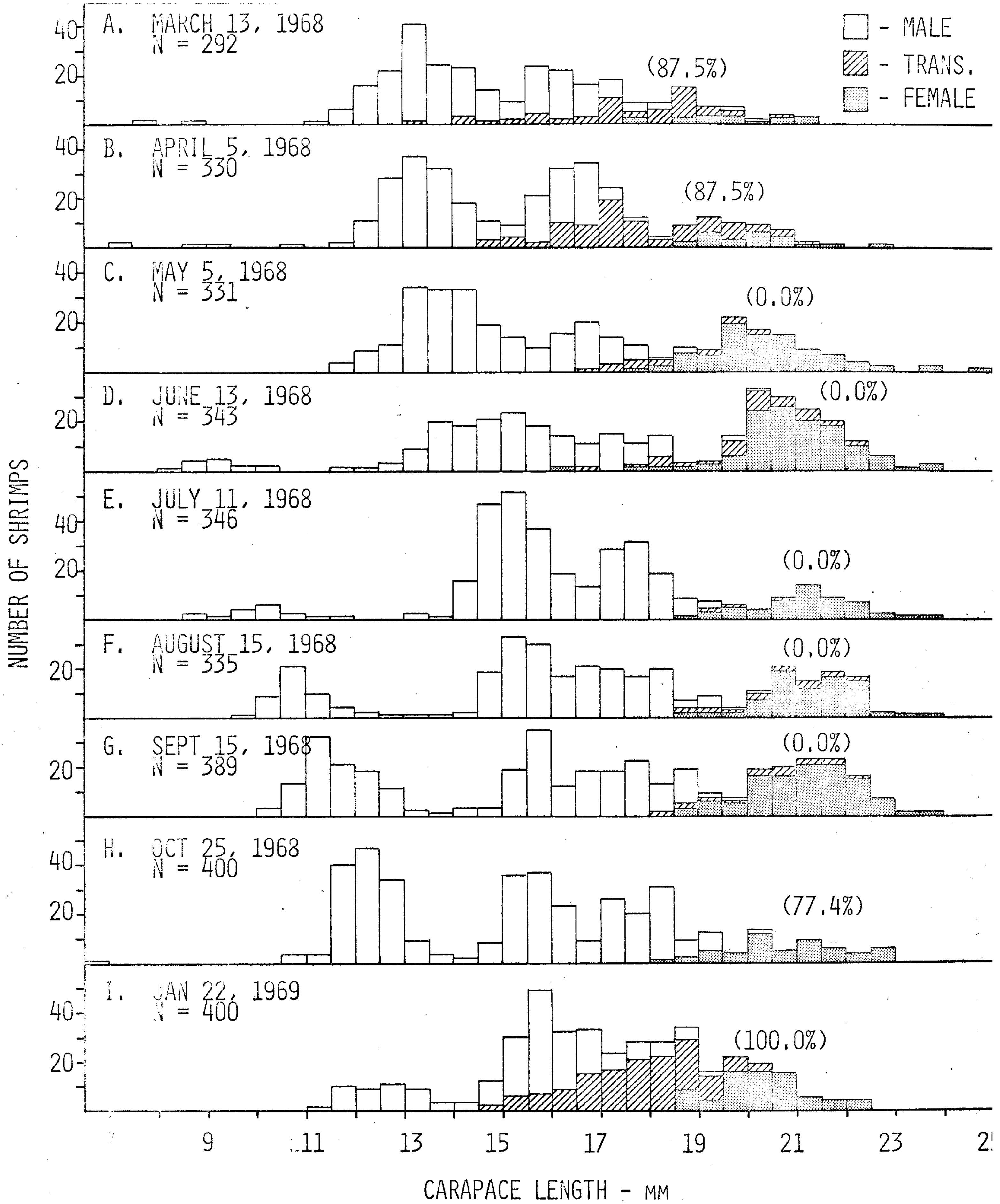

Figure 18. Pink shrimp (Pandalus borealis) carapace length-frequency distributions in 0.5 mm size groups from Marmot Bay, Kodiak Area, March 13, 1968 to January 22, 1969. Percentage of ovigerous females in the sample is indicated in parenthesis.

Life history of the sidestripe shrimp (P. dispar) in Marmot Bay is similar to that of the pink shrimp. The most obvious difference is in the length of the spawning and hatching periods. Sidestripe shrimp begin spawning in August, a little earlier than pink shrimp. Hatching begins in April and, for the sidestripe population, may extend to mid-July.

BCF

Review of Studies on Juvenile and Adult Pandalid Shrimp -- Mr. Louis Barr

Principal research activities on shrimp during the last two years are: (1) completion of a preliminary study of the food and feeding habits of pink shrimp, *Pandalus borealis*, in Kachemak Bay, and (2) a study of the role of a nursery area in the early life history of the spot shrimp, *Pandalus platyceros*. During this period much time was devoted to manuscript preparation. The following two reports were published: Surface-to-Bottom Pot Fishing for Pandalid Shrimp, by Louis Barr and Roland McBride; U.S. Fish and Wildlife Service, SSR-Fisheries No. 560, December 1967; and A Shrimp Pot for Experimental Fishing, by Roland McBride and Louis Barr; J. Fish. Res. Bd. Canada, 24 (3) 1967. A manuscript on diel vertical distribution and vertical migration of pink shrimp in Kachemak Bay is in the final stages of editing. A first draft of a manuscript on post-reproductive survival of pink shrimp in Kachemak Bay has been completed.

A preliminary study of the food habits of pink shrimp was done in 1967. The shrimp were collected in late August by sampling at various levels in the water column using pots. The pots were pulled and emptied once every three hours from 1200 hours of one day until 0600 hours of the following morning. The stomach analysis work was conducted by Martin Sattler, a graduate student at Scripps Institution of Oceanography. The two objectives of this study were to determine what the shrimp eat and at what time of day they feed most heavily. Both of these behavioral characteristics were to be examined for relation to the diel vertical migratory behavior shown by pink shrimp.

The most common food item found in the pink shrimp stomachs was brachyuran crab larvae. Crab larvae fragments were found in most of the shrimp that contained food. Other organisms identified from the shrimp stomachs were foraminifera, copepods, nauplius larvae, cypris larvae, chaetognaths, and shrimp. Pink shrimp appear to be principally zooplankton feeders, but will also feed (probably scavenging) on larger organisms, such as other shrimp.

The period of most intense feeding activity (judged by fullness of stomachs and degree of digestion of the contents) was between 2100 hours and 2400 hours. The early night time peak in feeding activity, coupled with the fact that the shrimp are principally plankton feeders, provides an apparent explanation for the nightly upward migration of shrimp.

A study of the early life history and ecology of the spot shrimp was begun in March, 1967, at Little Port Walter on southern Baranof Island. This study was begun on the hypothesis that many juvenile spot shrimp, for their first year and a half of life, inhabit shallow, rocky, estuarine nursery areas completely distinct from the environment of the adults. The objectives of this study were to determine: (1) time of year and size at which spot shrimp enter and leave the nursery area; (2) growth rate of the shrimp while in the nursery area; (3) specific habitat requirements and general ecological relationships of the shrimp while in the nursery area; and (4) seasonal changes in relative abundance of the shrimp while in the nursery area.

There are two principal reasons for conducting this study of the early life history and ecology of spot shrimp. First is the obvious need to know all we can about a commercially important species to assist in the management of that species. Second, and even more important, is the need to know as much as we can about the basic ecology of our estuarine environments as these areas are being increasingly threatened by industrial activities along the coast. Both of these needs have been considered in conducting this study. In addition to seeking fulfillment of the immediate objectives, we are also trying to develop new methods for conducting estuarine ecology studies.

Progress in this project so far includes determination of the approximate times of immigration and emigration, seasonal and overall growth of the shrimp while in the area, and the changes in relative abundance during the time they inhabit the nursery area.

Table 8 provides a description of the role of the nursery area in the life history of the spot shrimp. The shrimp enter the bay by July of their first year when they are 3 months old and have a carapace length of about 4 mm. They remain in the area through two summers and leave in the fall of their second year when about 19 months old and have a carapace length of about 26 mm. A detailed illustration of the growth of the shrimp while in the nursery area is given in Figure 19.

The relative abundance of spot shrimp in Little Port Walter was estimated five times during the year (Table 9). The estimates of relative abundance were obtained by counting the shrimp along 19 underwater transects which were uniformly distributed around the perimeter of the bay. The counts were made at night, and always by the same team of observers. With the exception of the earliest count made of young-of-the-year, the counts show a steady decline in the abundance of shrimp during their stay in the nursery area, perhaps

Table 8. Role of the salmon nursery areas in the life history of spot shrimp (*Pandalus platyceros*) in Southeast Alaska.

Area	Age in Months	Life Stage	Average Carapace Length (mm)
Deep Water	0	Shrimp hatch in April in deep environment of adults	-
	1-2	Larvae transported (drift or swim - ?) toward nursery area	-
Nursery Area	3	Post-larvae enter nursery area; develop into immature males	4
	7	End of first season of rapid growth	14
	12	One year old; start of second season of rapid growth	16
	19	End of second season of rapid growth; leave nursery area	26
Deep Water	20-60	Return to deep environment of adults; mature as males, then transform to females to complete life cycle	26-60

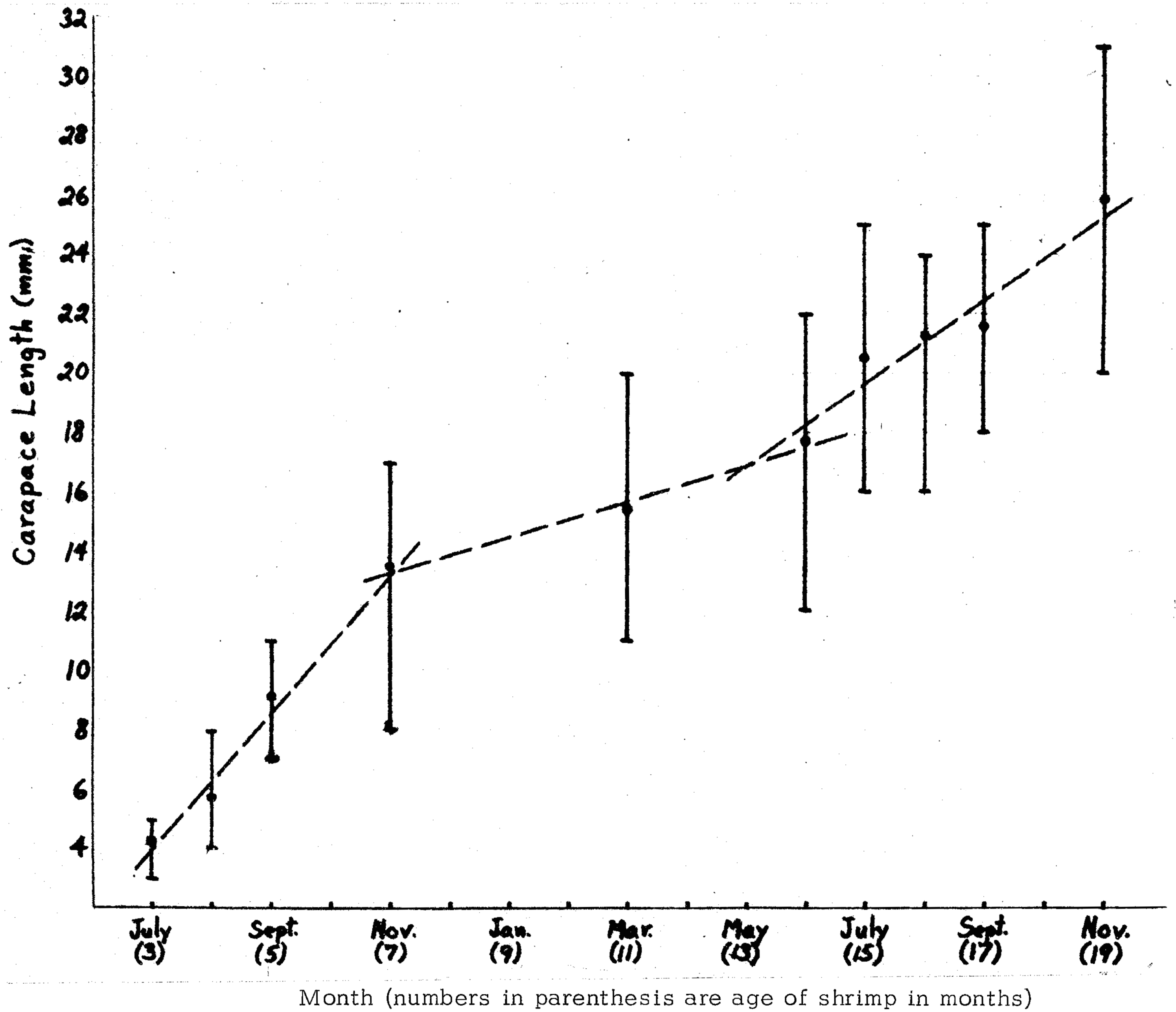

Figure 19. Growth of Juvenile Spot Shrimp (Pandalus platyceros) in Little Port Walter, Alaska.

Table 9. Total counts of juvenile spot shrimp (*Pandalus platyceros*) along a series of 19 underwater transects at various times of the year, Little Port Walter, Alaska.

Month	Age of Shrimp (months)	Total Count of Shrimp 1/
September	5	168
November	7	648
March	11	430
June	14	219
July	15	201
September	17	144
November	19	15

1/ Each number represents the total counts of spot shrimp by 2 divers along 19 transects.

indicating the rate of natural mortality plus emigration during the period they spend in the bay. The low count of young-of-the-year made in September can probably be attributed to the small size of the shrimp at that time and the consequent inability of the divers to see most of these small shrimp along the transects.

Review of Shrimp Fecundity, Kachemak Bay Area -- Jack McBride

This study is designed to determine the fecundity of five species of pandalid shrimp: *Pandalopsis dispar*, *Pandalus borealis*, *Pandalus hypsinotus*, *Pandalus goniurus*, and *Pandalus platyceros*. Objectives of this study are to determine: (1) relation between number of eggs to length of shrimp for each species; and (2) any changes in the number and size of eggs with time.

The shrimp were caught in several small bays adjacent to Kachemak Bay largely with pots, but sometimes with trawls. Shrimp for the study were selected by size to ensure that all sizes of ovigerous females would be represented. Plans were to sample at the beginning (November 1968), mid-term (January 1969), and at the end (March 1969) of the ovigerous periods. To date, all but the March 1969 collections have been made. Egg counts for some species were made in March 1968.

For each species studied, the number of eggs increased with increases in shrimp length. The number of eggs carried by a given size shrimp, however, differs among the species.

Average numbers of eggs carried by each shrimp species during the present ovigerous season are considerably greater than the number of eggs at the end of the previous ovigerous period. An example of this difference is shown in Figure 20. The egg counts are not directly comparable because collections for the present season are from November whereas collections from the previous season are from March. When egg counts of the present season are completed, they will be compared to those of the previous season. This comparison will indicate any significant differences in fecundity between the two seasons.

The number of non-viable eggs for each shrimp was also recorded. Non-viable eggs were found on nearly all shrimp of each species but were less common on shrimp collected during the present ovigerous season compared to shrimp collected the previous season.

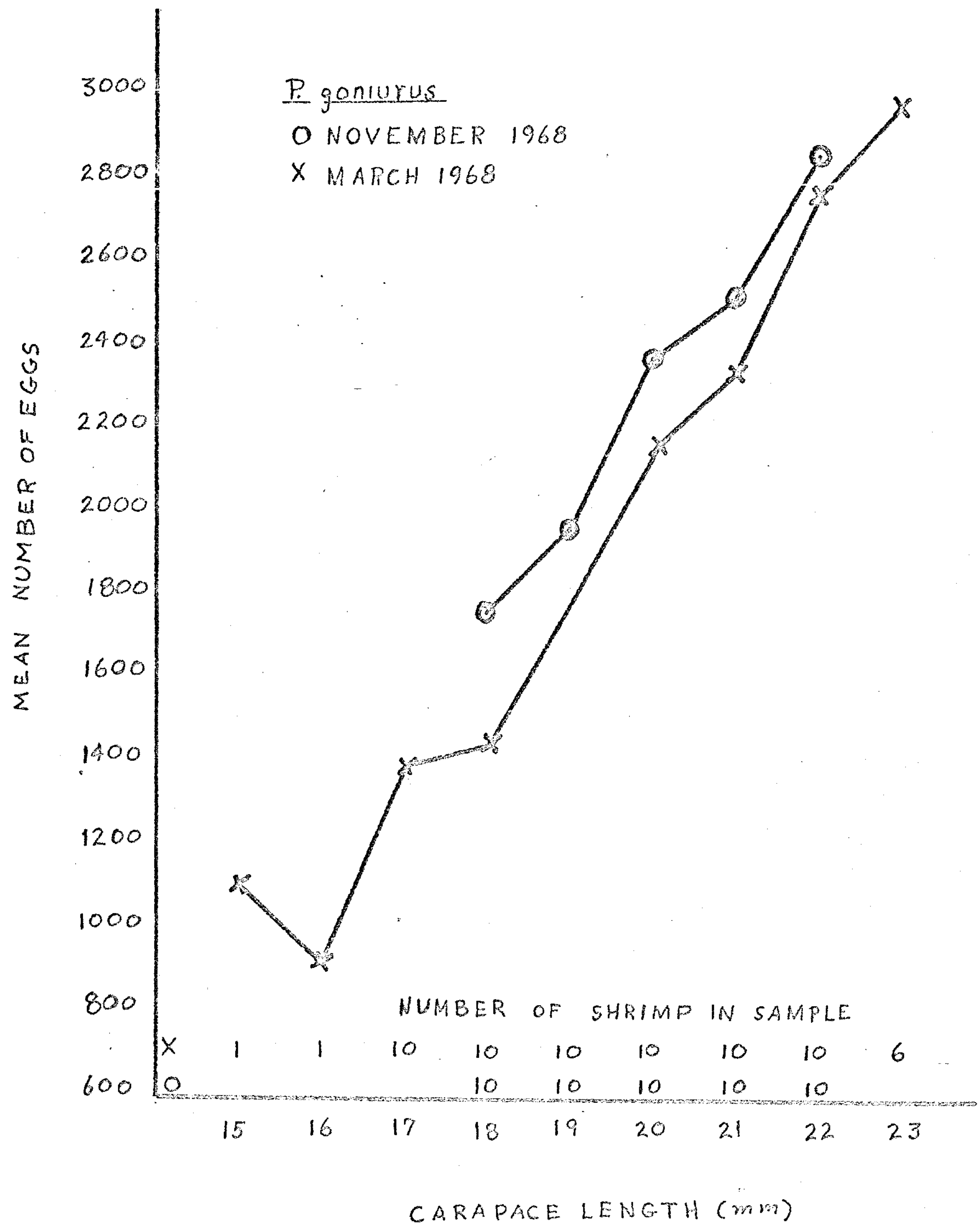

Figure 20. Example of relation between number of eggs and carapace length for pandalid shrimp in Kachemak Bay during 1967-68 (March) and 1968-69 (November) ovigerous period. Data in Figure are for P. goniurus.

Review of Collection and Analysis of Shrimp Catch Data from the Gulf of Alaska -- Mr. James Olsen

The shrimp fishery in the Gulf of Alaska has expanded rapidly in the last 5 years from a catch of about 6,000 metric tons in 1963 to over 30,000 metric tons in 1967 (Table 10). The United States, Japan, and the Soviet Union fish for shrimp in the Gulf. The U.S. fishery is primarily in inshore waters near Kodiak Island whereas other countries fish in offshore waters throughout the Gulf.

Expansion of the fishery by the three nations makes the collection and analysis of basic catch and effort data necessary. This should be done to provide: (1) information on the shrimp populations and development of the fishery and (2) data that can be used to estimate optimum yields from shrimp stocks.

Of the commercial species of shrimp in the Gulf of Alaska, *Pandalus borealis* is the most important. It comprises 97 percent of the U.S. catch landed at Kodiak. The second most commonly caught species is *P. dispar*.

Three areas of research require immediate attention so that rational management of shrimp stocks in the Gulf of Alaska may be accomplished: (1) define the stocks of commercially important shrimp species in the Gulf because each species of shrimp may constitute only one stock or population, or several stocks; (2) obtain abundance estimates or indices for each shrimp stock. If separate stocks of shrimp are found, each stock may require management as a distinct unit; efficient management will require estimates of abundance, growth, and mortality; and (3) determine optimum yields for shrimp stocks using data on distribution, abundance, growth, and mortality.

If separate stocks of shrimp are present in the Gulf, they may be difficult to define because of the possibility of widespread drift of their planktonic larvae and migratory behavior of adults. Marking techniques are probably not practical to use in evaluating shrimp stocks in the Gulf because of the large numbers of shrimp involved. Thousands of marked shrimp would have to be released to have a favorable probability of recapture. Detection and recovery of marks from the commercial catch would also be difficult because of the large numbers of shrimp in the catches and the processing techniques involved. But continued improvement of tagging methodology may make future shrimp tagging practical.

Stock definition may be possible using morphometric studies. Also, catch and effort data from different areas of the Gulf may provide knowledge of separate stocks. A uniform change in catch per unit of effort throughout

Table 10. Shrimp catches in the Gulf of Alaska by three nations, 1958-67.

Year	Catch (metric tons)			
	United States	Japan	Soviet Union	Total
1958	116	--	--	116
1959	3,418	--	--	3,418
1960	1,857	--	--	1,857
1961	5,339	--	--	5,339
1962	5,925	--	--	5,925
1963	5,452	640	0	6,092
1964	2,247	2,371	0	4,618
1965	6,295	84	8,000	14,379
1966	11,074	474	12,000	23,548
1967	17,699	1,297	11,500	30,496

the Gulf may indicate the existence of one stock. On the other hand, different rates of change in catch per unit of effort between areas would provide some evidence for separate stocks.

Catch and effort statistics can be used to obtain population indices. The expected catch is assumed to be proportional to population density, i.e.,

$$E(C_t) = qf_tN_t$$

where q is the proportion of the population at time t (N_t) which is captured by one standard unit of effort, and f_t is the total effort at time t.

Fishing effort is determined from statistics of fishing time by gear type for each vessel. Since all fishing effort is not equivalent, adjustments are made to determine the units of standard effort. The relative difference between two types of effort is defined as the fishing power; the standard effort will have fishing power of one, whereas other types of gear will have fishing powers less than or greater than one. For example, a 60-foot trawler fishing for 3 hours constitutes less effort than a 120-foot trawler fishing for the same time period with a larger trawl.

When the fishing power of each type of vessel and gear has been determined, then all effort can be standardized and total fishing effort determined. These data along with catch data provide indices of population sizes.

The third objective, determining optimum yields, can be realized only after data from several years have been collected. Statistical models are available which provide population estimates of maximum sustainable yield. Data required as input to the model are catch per unit of effort and estimates of the catchability coefficient (q). This type of model or modification of it, may be applicable to the shrimp stocks after the first two objectives are realized.

Shrimp catch data from the Gulf of Alaska are presently collected from the United States fishery by ADF&G personnel and from the Japanese fishery by the International North Pacific Fisheries Commission (INPFC). Catch data for the Soviet Union are generally lacking. Recent negotiations with the Soviet Union have been completed for the purpose of defining data exchange needs. These efforts should continue so that adequate data can be acquired.

The ADF&G has begun a logbook program for the trawl boats based at Kodiak Island and have cooperation from about 75 percent of the boat operators. Complete catch and effort data are collected and recorded for each trawl haul on a form which can be used for direct IBM analysis.

Japan provides annual data summaries of catch and effort to the INPFC. Catch and effort data by gear type are summarized within statistical areas (one degree longitude by one-half degree latitude squares) by month and by species.

Specific data needed to achieve the three proposed objectives are: (1) catch by species and by area. INPFC statistical areas, defined as squares of one degree longitude by one-half degree latitude, should be used. Monthly catches within areas will provide adequate data. Catch data should be reported by species and by gear for each vessel within statistical areas; (2) effort data within statistical areas by vessel and gear. Because most shrimp gear are trawls, the best measure of effort is probably hours trawled; and (3) data on vessel and gear characteristics. These data will be collected along with effort data and are needed so that effort may be standardized.

Review of Shrimp Studies by BCF Exploratory Fishing and Gear Research Base, Juneau -- Mr. Lael Ronholt

During 1968, the Exploratory Fishing and Gear Research Base (EF&GR) conducted two spot shrimp (*Pandalus platyceros*) cruises in southeast Alaska and one 13-week cruise for shrimp near Kodiak Island.

The first cruise for spot shrimp, aboard the charter vessel CAPE FALCON, was made along the northwestern coast of Prince of Wales Island, the eastern coast of Keku Island, and in Kasheverof Passage (Figure 21).

Seven types of traps were tested during the cruise; they were:

1. Pot Type No. 32: (standard pot)

   Rectangular metal frame trap, 18x18x30", reinforcing steel rod (1/2" on bottom, rest 3/8") frame covered by burlap. Two conical tunnels of 1-1/2 inch stretch mesh nylon web with 6-8 inch lead-ins. 3-inch ID tunnel opening.

2. Pot Type No. 26:

   Rectangular metal frame trap, 18x18x30", reinforcing steel rod (1/2" on bottom, rest 3/8") frame covered by 1-1/2 inch stretch mesh nylon web. Two conical tunnels of 1-1/2 inch stretch mesh nylon web with 6-8 inch lead-ins. 3-inch ID tunnel opening.

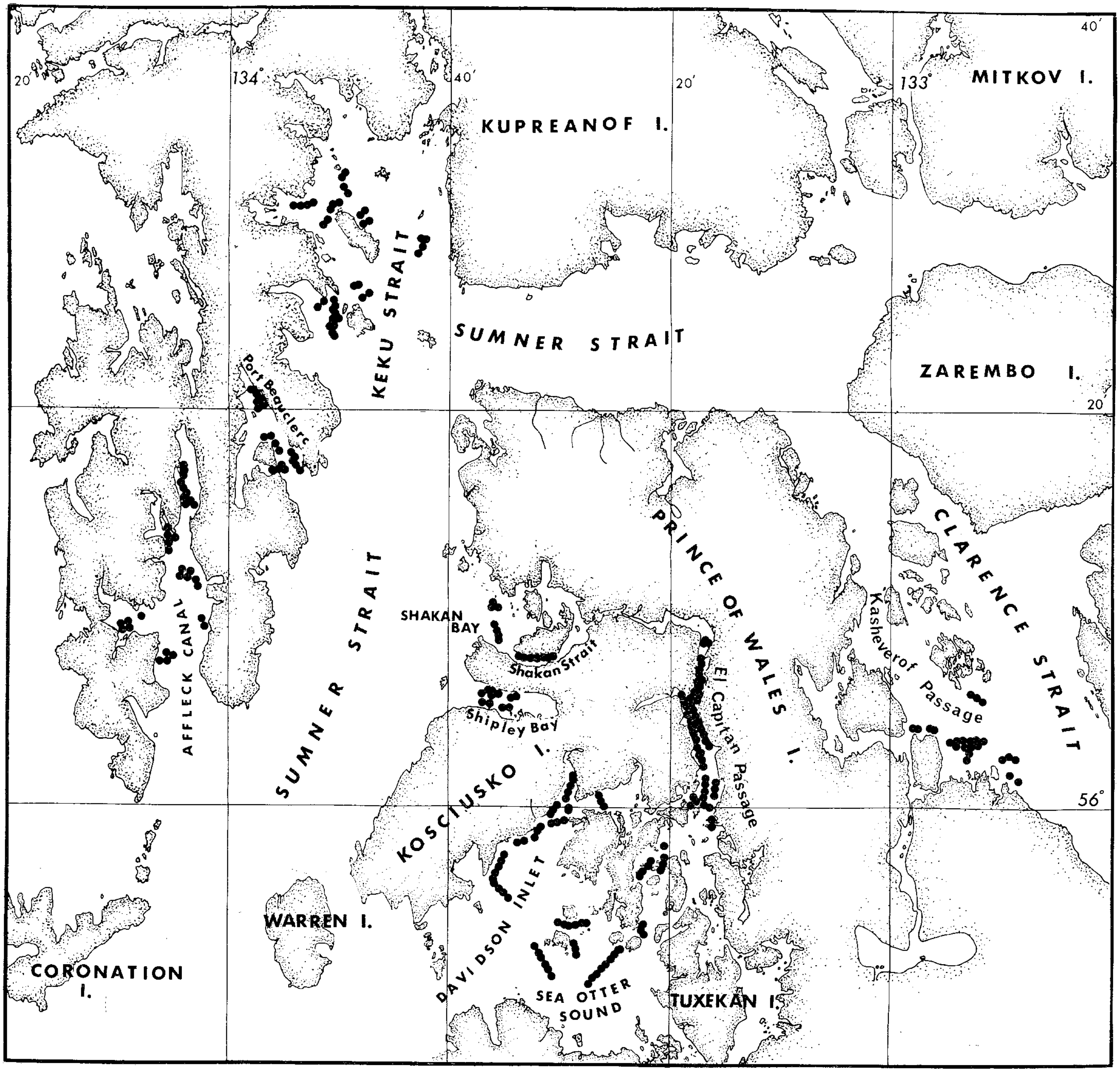

Figure 21. Areas fished by M/V CAPE FALCON during Cruise 68-1.

3. Pot Type No. 27:

Rectangular metal frame trap, 18x18x30", reinforcing steel rod (1/2" on bottom, rest 3/8") frame covered by burlap. Two conical tunnels of 1-1/2 inch stretch mesh nylon web with 6-8 inch lead-ins. Rectangular tunnel opening 2-1/2 inches high by 5 inches wide.

4. Pot Type No. 28:

Rectangular metal frame trap, 18x18x30", reinforcing steel rod (1/2" on bottom, rest 3/8") frame covered by burlap. Two conical tunnels of 1-1/2 inch stretch mesh nylon web with 6-8 inch lead-ins and 4 inch lips. 3-inch ID tunnel opening.

5. Pot Type No. 29:

Rectangular metal frame trap, 18x18x30", reinforcing steel rod (1/2" on bottom, rest 3/8") frame covered with burlap. Two conical tunnels of 1-1/2 inch stretch mesh nylon web with 6-8 inch lead-ins and 4 inch lips. Tunnel opening rectangular 2-1/2 inches high by 5-inches wide.

6. Pot Type No. 30:

Rectangular metal frame trap, 18x18x30", reinforcing steel rod (1/2" on bottom, rest 3/8") frame covered with burlap. Two conical tunnels of 1-1/2 inch stretch mesh nylon web with 4-6 inch lead-ins and 4 inch lips. Rectangular tunnel opening 2-1/2 inches high by 5 inches wide, near top of trap side.

7. Pot Type No. 31:

Rectangular metal frame trap, 18x18x30", reinforcing steel rod (1/2" on bottom, rest 3/8") frame covered by burlap. Two conical tunnels of 1-1/2 inch stretch mesh nylon web with 5-7 inch lead-ins. Rectangular tunnel opening 2-1/2 inches high by 5 inches wide.

Two trap efficiency experiments were conducted. In the first experiment, traps were fished one day or approximately 24 hours, whereas in the second experiment, traps were fished for about 48 hours.

Results of the one-day fishing experiment showed that the trap with a rectangular tunnel and 4" lips (No. 29) produced the highest average catch. Traps with rectangular and circular tunnels but without 4" lips produced the second highest average catches (No. 30 and No. 32). The remaining traps (Nos. 28, 27, 31 and 26) produced smaller and similar average catches (Table 11). Poorest catches were made by the web covered or "open" trap (No. 26), and the large 18" by 30" by 30" burlap covered trap (No. 31). Trap No. 31 was identical to Trap No. 30 except for size.

Relative differences between traps in the two-day fishing experiment were greater and the average catch higher than in the one-day experiment. Trap No. 32 showed the highest relative efficiency for two days of fishing. Trap No. 28 had the second highest efficiency. Traps in third (No. 27), fourth (No. 29), and fifth (No. 30), position all had rectangular tunnels. Trap No. 26, web covered, and Trap No. 31, had the lowest average catches (Table 12). Traps with rectangular tunnels appeared to be more efficient in the one-day experiment than during the two-day experiment.

A comparison was made between our experimental shrimp trap (No. 32) and a commercial shrimp trap (No. 25). The commercial trap consisted of a rectangular metal frame, measuring 2' by 2' by 3' constructed of 1/2" steel rod. The frame was covered with 1-3/4" stretch mesh nylon webbing and had two oval tunnels (1-7/8" by 4-1/2") with 4 inch web lips. Both traps were fished simultaneously in alternate positions on a single longline. The results of both 24-hour and 48-hour fishing periods using this configuration, are shown in Table 13.

Data in Table 13 indicate that Trap No. 32 (experimental) produced higher average catches in both fishing periods, than Trap No. 25 (commercial).

Bait Preference Experiment

Ground frozen herring was tested for bait preference against two emulsified baits, flatfish and ratfish, prepared by the Ketchikan Technological Laboratory. Results of the test (Table 14) indicate that emulsified flatfish produced slightly higher average catches than herring, and emulsified ratfish slightly lower catches than herring. When considering the overall economic aspects of bait selection, frozen herring appeared to be the most suitable because of the additional cost involved in preparation of the emulsified baits.

Results of exploratory fishing in April and May showed a low abundance of spot shrimp in all areas surveyed, except in upper El Capitan Passage. During April, 390 traps caught 598 pounds of 12 count spot shrimp for an average

Table 11. Catch of spot shrimp taken by various trap types during 24 hours of fishing.

Trap type	Total catch (pounds)	No. pots fished	Average catch per trap (pounds)
29	90.33	72	1.25
30	77.82	72	1.08
32	76.61	72	1.06
28	69.87	72	.97
27	68.58	72	.95
31	65.17	72	.90
26	63.91	72	.89

Table 12. Catch of spot shrimp taken by various trap types during 48 hours of fishing.

Trap type	Total catch (pounds)	No. pots fished	Average catch per trap (pounds)
32	52.07	27	1.93
28	50.60	27	1.87
27	47.68	27	1.76
29	38.50	27	1.42
30	35.66	27	1.32
26	32.20	27	1.19
31	25.72	27	.95

Table 13. Catch comparison of experimental and commercial traps.

Trap type	Total catch (pounds)	No. traps fished	Average catch per trap (pounds)
		24 hours fishing	
32 - BCF	84.07	70	1.20
25 - Commercial	61.69	70	.88
		48 hours fishing	
32	57.45	25	2.30
25	39.97	25	1.60

Table 14. Comparison of catches by bait types.

Bait type	Total catch (pounds)	No. traps fished	Average catch per trap
Experiment I			
Emulsified flatfish	64.01	66	.97
Ground herring	57.70	66	.87
Experiment II			
Ground herring	70.44	57	1.24
Emulsified ratfish	64.24	57	1.13

catch of 1.50 pounds per hour. In May, 240 traps caught 405 pounds of 11 count spot for an average catch of 1.68 pounds per trap.

The second spot shrimp cruise using the JOHN R. MANNING (October 18 to December 12) was conducted in the offshore waters of Forrester Island, bays of Dall and Baranof Island, and in Hoonah Sound. Because of the fishing time lost due to inclement weather and engine failure of the JOHN R. MANNING, insufficient data were collected to compare relative trap efficiency.

Objectives of the 13 week shrimp cruise in the Kodiak Island area were to: (1) explore industry selected areas for commercial concentrations of pandalid shrimp; (2) test-shrimp-bottomfish separating ability of the Dutch style two-bag trawl; (3) conduct preliminary fishing trials with a Universal trawl modified for shrimp; and (4) conduct preliminary bulk-quantity shrimp pumping trials for unloading vessels.

Shrimp explorations were conducted in the inshore and offshore waters of Kodiak Island and Shelikof Straits (Figure 22) using a standard commercial 66-foot shrimp trawl. Fifty-seven stations were fished throughout the survey area. Catches ranged from 0 to 13,500 pounds of shrimp per hour with an average of 1,343 pounds per hour. Catches are summarized in Table 15.

Table 15. Summary of shrimp catches.

Pounds of shrimp	No. of drags
0 - 499	31
500 - 999	6
1000 - 1999	7
2000 - 2999	6
3000 - 3999	3
over - 4000	7

The average catch at inshore stations was six times greater than that observed at offshore stations. Inshore catches ranged from 0 - 13,500 pounds and average 3,729 pounds per hour fished, while the offshore catches ranged from 0 - 5,200 pounds and averaged 608 pounds per hour fished.

Drags which produced over 1,000 pounds per hour were made in Marmot Bay, Marmot Gully, 13 miles ESE Geese Island, Wide Bay, Raspberry Strait, south and north arms Uganik Bay, Uganik Passage, Kuliak Bay, Kinak Bay, 5

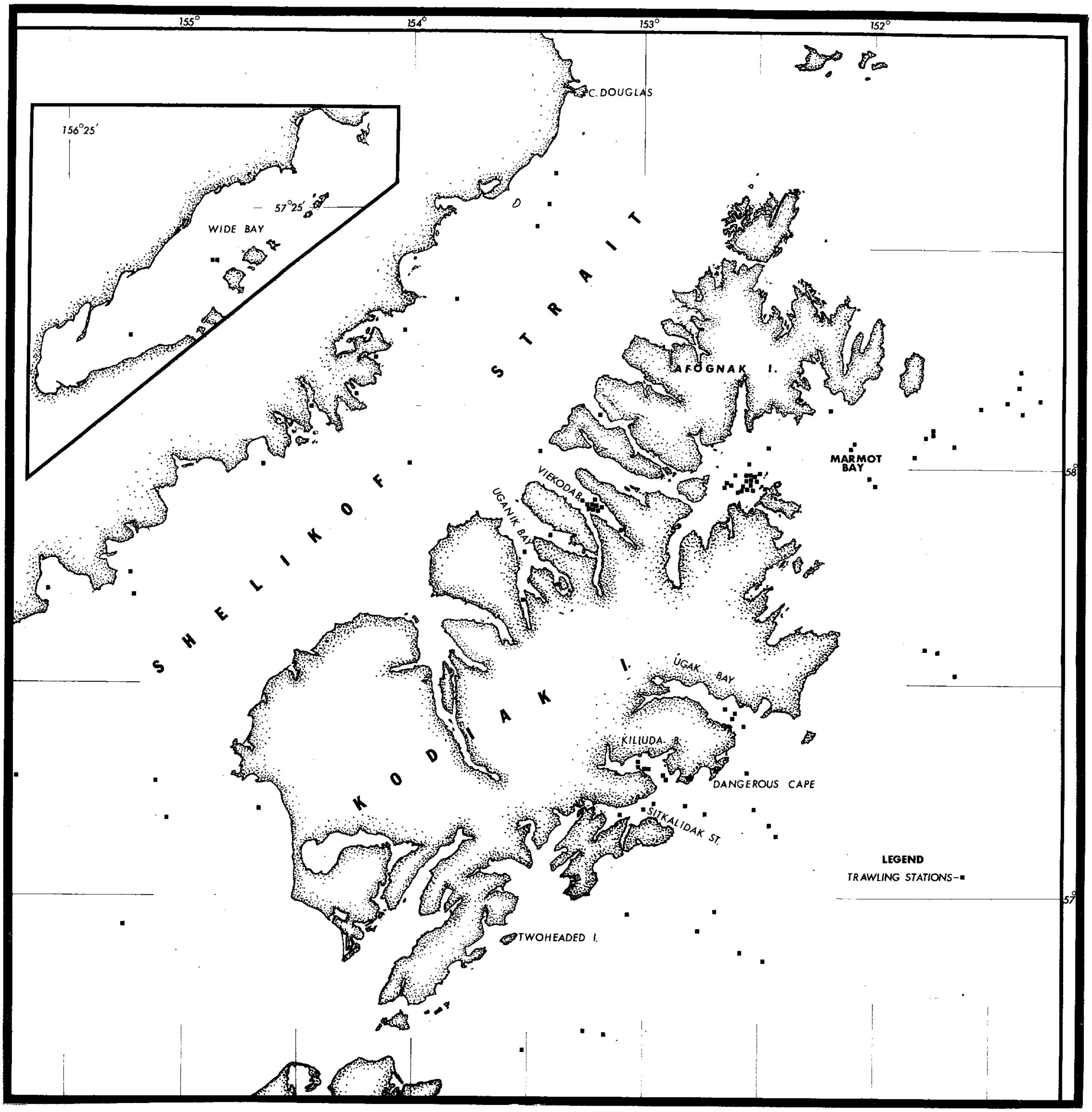

Figure 22. Area of Operations Cruise 68-2

and 7 miles east of Kiukpalik Island and Kukak Bay.

Fifteen test drags were made with the two-bag trawl in Marmot Bay, Uganik Bay, Kiliuda, Sitkalidak Strait, Viekoda Bay, and off Dangerous Cape. Sampling depth varied between 32 and 85 fathoms. The total trawl catch for both the shrimp and fish cod ends averaged 2,049 pounds per drag. Shrimp catches averaged 1,366 pounds per drag. 83.33 percent (17,078 pounds) of the total shrimp catch of 20,494 pounds was taken in the upper shrimp cod-end, and 16.66 percent (3,415.5 pounds) were captured in the fish cod-end. 87.53 percent (8,962 pounds) of the total fish catch of 10,238 pounds was taken in the lower fish bag cod-end, and 12.46 percent (1,276 pounds) was taken in the upper shrimp cod-end bag. Species composition was similar for both fish and shrimp cod-ends. The fish cod-end showed a slightly higher percentage of flatfish, cods and crabs, while the shrimp cod-end showed a slightly higher percentage of cottids, smelt, herring, eelpouts and miscellaneous fish (Figure 23).

Preliminary tests were made with an 85-foot universal shrimp trawl designed by the EF&GR Base at Seattle, Washington. The universal trawl was designed and constructed to be fished either on-bottom or off-bottom, at intermediate depths. Initial trials were conducted in Viekoda Bay in an area showing a light echo trace of shrimp in midwater. Four drags were made with the otter boards 4 - 7 fathoms off-bottom and the footrope of the trawl contacting the bottom. Four additional drags were made with the otter boards 7 - 33 fathoms off-bottom. The on-bottom catches ranged from 301 to 2,160 pounds and averaged 1,173.5 pounds of shrimp per hour fished, whereas the off-bottom hauls ranged from 85 to 858 pounds and averaged 430.7 pounds of shrimp per hour fished. The species composition changed considerably between the on-bottom and off-bottom drags. The on-bottom catches consisted of 67.12 percent pink, 26.27 percent humpy, 5.55 percent sidestripe, and 1.05 percent coonstripe, whereas the off-bottom catch consisted of 80.78 percent humpy, 18.74 percent pink, and 0.48 percent sidestripe shrimp (Figure 24).

A capsule pump, identical to those used in the South American anchovetta fishery, was utilized in shrimp pumping trials aboard the JOHN R. MANNING. The submersible pump housing was lowered into a test tank filled with sea water and shrimp. Results of the trials were negative in that shrimp, unlike fish, did not flow toward and into the pumping stream. A vertical mass of shrimp remained surrounding the housing after the water had been pumped from the test tank. An adapter, designed to increase the effective drawing range of the pump, will be installed for testing aboard a commercial trawler in the future.

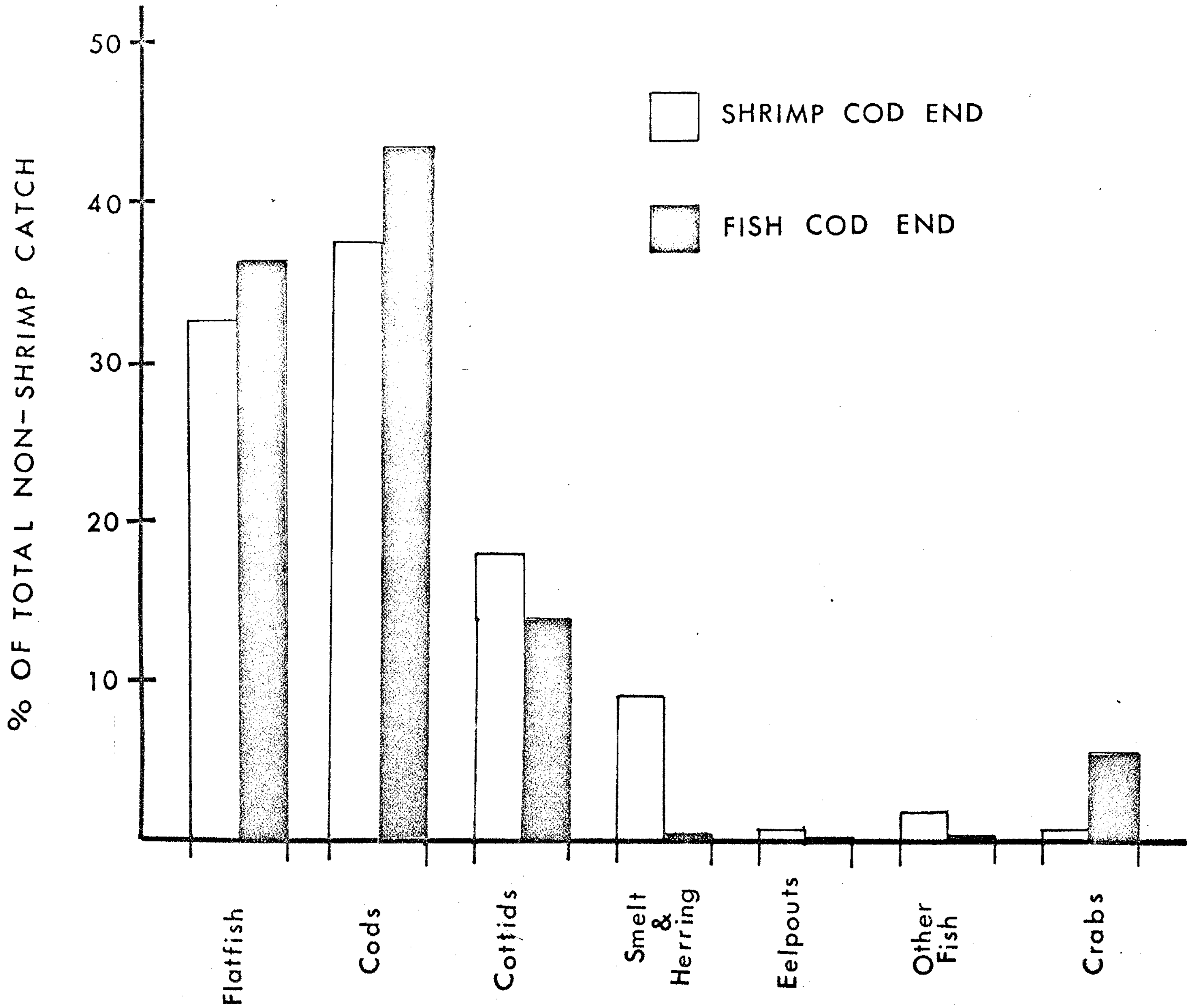

Figure 23. Species groups by percent of total catch by cod end.

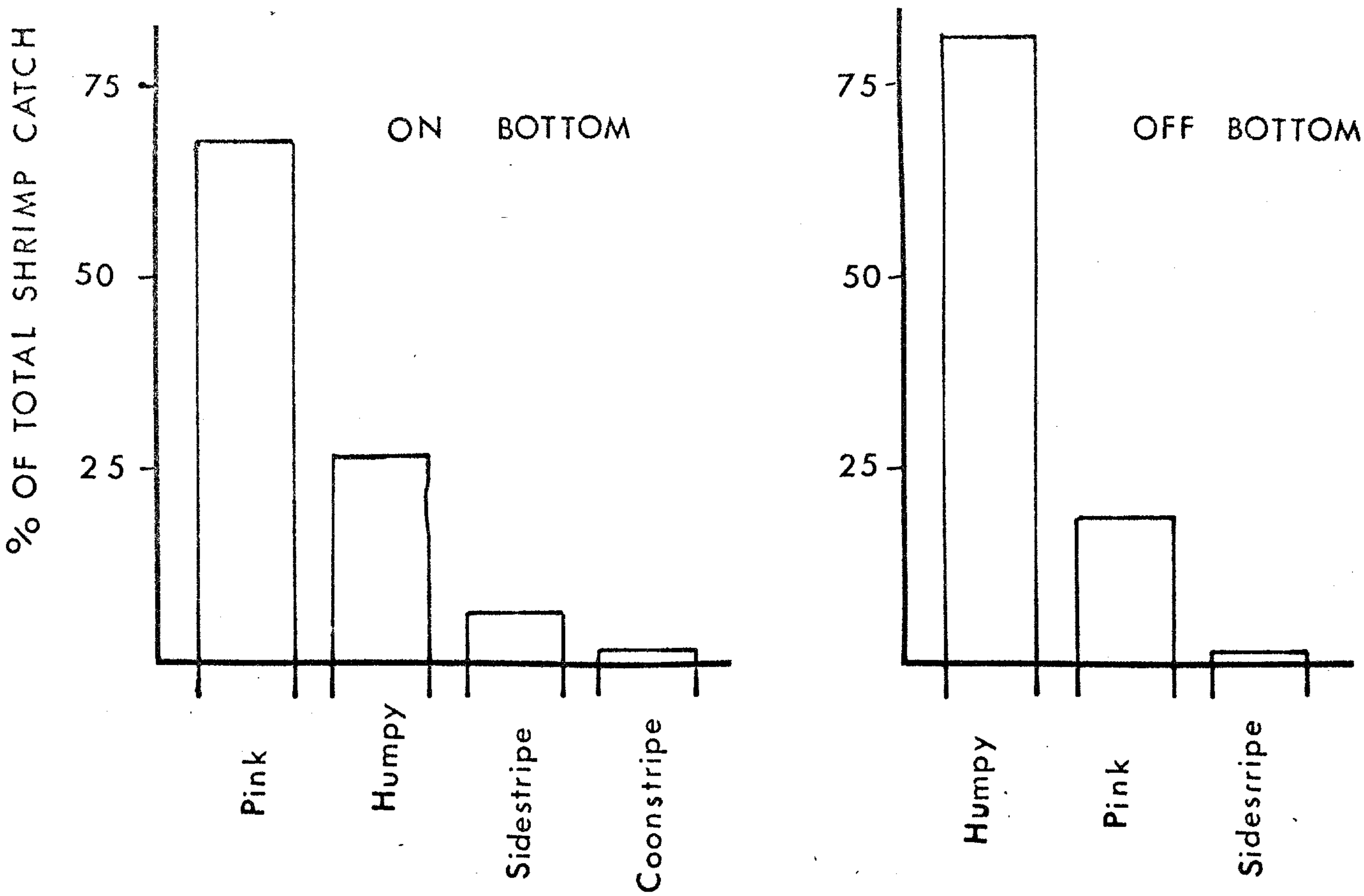

Figure 24. Species composition of shrimp catch: on-bottom and off-bottom fishing.

PLANS FOR FUTURE RESEARCH

ADF&G

Plans for Future Federal Aid Shrimp Research, Wrangell -- Mr. Jerry McCrary

Tentative plans are to conclude shrimp research in Southeastern Alaska and place greater emphasis on shrimp research in the Kodiak Island area. A report on the work accomplished thus far will be written in 1969 for formal publication. The log book program in Southeastern Alaska will be continued by ADF&G management personnel.

Plans for Future Federal Aid Shrimp Research, Kodiak -- Mr. Duane Petersen

Future work in the Kodiak Island area will consist of continuing and expanding the existing logbook and catch sampling programs.

The logbook program will provide catch per unit effort data by exact drag location. These data can be directly compared with data obtained during the previous year. The program will be expanded to include data from the shrimp fishing grounds off the Alaska Peninsula.

The catch sampling program will provide basic life history and year class composition data from two or more sampling locations on a monthly basis. Sampling with small mesh trawling gear will be done periodically in each sampling area to determine selectivity of commercial trawls and relative abundance of first year old shrimp.

Locations where pandalid shrimp are in sufficient commercial quantities will be sampled on a regular basis depending upon commercial fishing effort. In these programs it is intended to utilize the fishing vessel crew members to gather the monthly samples. Sampling will commence in the Twoheaded and Viekoda Bay catch area under this plan in February, 1969.

BCF

Plans for Future Shrimp Research -- Mr. Louis Barr

Future plans of this project are to: (1) estimate total population of spot shrimp in Little Port Walter; (2) identify the plants and animals most closely associated with the spot shrimp in the nursery area; and (3) obtain a quantitative description of the physical and biological characteristic of preferred habitat of the spot shrimp in the nursery area.

Two methods will be used to estimate total spot shrimp population: (1) by using a direct proportion of the average number of spot shrimp per unit area along transects to the total area of shrimp habitat in the bay, and (2) by a Petersen estimate using vital dyes to mark the shrimp.

Plans for Future Larval Shrimp Research -- Mr. Evan Haynes

Studies on shrimp larvae will be done concurrently with those on king crab larvae at Kachemak Bay. The studies will be identical to those planned for king crab larvae and will emphasize distribution, abundance, and mortality. Initial studies will probably consist of describing certain larval stages that presently are inadequately described. Also, work will be done on the distribution and abundance of the spawning stocks of each species.

Plans for Future EF&GR Shrimp Research -- Mr. Lael Ronholt

During the spring of 1969, EF&GR plans a brief shrimp trap experiment in Southeastern Alaska. The dates and length of the cruise have not been determined as we are in the process of accepting transfer of the R/V OREGON from the EF&GR Base at Brunswick, Georgia. The start of this cruise will depend upon the time necessary to transfer gear and equipment from the JOHN R. MANNING to the OREGON. Exploratory fishing will be conducted in bays on the western side of Baranof Island. Trap efficiency studies will compare trap size (18" x 18" x 30" and 18" x 24" x 30"), trap covering (herculite and poly-burlap), and tunnel openings (rectangular and circular).

We are planning a 60-day exploratory fishing and gear research cruise during August and September in the central Gulf of Alaska. The exploratory phase will attempt to locate and delineate commercial concentrations of pandalid shrimp using standard commercial otter trawls. Gear experiments under consideration include a 50-foot two-bag separator trawl, wing trawl, and universal shrimp trawl.

During 1969, we plan to have a 90-day exploratory fishing and gear research for king crab and tanner crab in the central Gulf of Alaska. The area of operation will be decided upon after interviews have been held with members of the fishing industry. Primary objectives will be to: (1) locate and delineate commercial concentrations of king crab and tanner crab; (2) collect data on the general distribution and abundance; (3) collect length frequency data to adequately describe the composition of available stocks; and (4) to test for differences between the relative efficiency of modified 6' by 6' king crab traps, and 5' Japanese style tanner crab traps.

OTHER FISHERIES

Sea Scallops

Status of Alaska Scallop Fishery -- Mr. Daniel Hennick

During 1968 approximately 1-1/2 million pounds of shucked scallop (Patinopecten caurinus) meats were taken in Alaska. About 800,000 pounds were taken in the area between Icy Bay and Yakutat from June through September. From October through December the effort was near Kodiak Island, primarily Marmot Bay-Ugak Island areas, and the area between Cape Ikalik and Rocky Point. During this period an additional 719,000 pounds of meat were landed. Prices per pound of scallop meat paid to the fishermen have fluctuated between $1.20 and $.70 making the 1968 landings worth between 1.3 and 1.5 million dollars.

To date landings during 1969 have amounted to about 60,000 pounds, all taken in the Kodiak area. The fleet currently consists of five vessels, with one more vessel reportedly on its way north from Seattle.

Research objectives of the ADF&G at the present time consists primarily of an observer program. Because the fleet is small, it is relatively easy to get good catch and effort statistics. Data collection by the observer program consists of recording the area fished, number of tows during each trip (trips normally are 10 to 14 days), time the individual drags are on the bottom, bottom type, size frequency samples, and the number of bushels caught for each tow. From these data we will be able to define, at least in general terms, the size and extent of the scallop beds, and harvest rate of individual beds. Also, from each dockside delivery we are obtaining a sample of 120 to 150 live scallops from the last day of dragging. These scallops are weighed alive, sexed, the meat shucked and weighed, and the upper valve (shell) measured and saved for aging.

In addition to data collected on scallops, notes are kept on numbers of king and tanner crabs caught in the dredge. All king crab are sexed, measured, shell condition determined and injuries to the crab are noted.

ADF&G personnel are vitally interested in the results of the proposed BCF exploratory scallop program in the Alaska Peninsula area. There is great need for the program, and it will provide many of the answers regarding the extent of resource. Apparently there is great interest by the industry in the areas westward of Kodiak and in the very near future, there may be a shift in the commercial effort to that area.

Biology of the Pacific Coast Sea Scallops -- Mr. Evan Haynes

Information on the biology of the Pacific Coast sea scallop (*Patinopecten caurinus*) has been derived primarily from two cooperative cruises by the ADF&G and the BCF, the scallop fishing trip of the VIRGINIA SANTOS off Marmot Flats in January 1968, and the 40-day scallop charter of the VIKING QUEEN in the Gulf of Alaska in spring 1968. Since then, information collected has consisted mostly of catch and effort data obtained by ADF&G personnel acting as observers aboard vessels fishing for sea scallops. Data from the samples collected aboard the VIRGINIA SANTOS have been analyzed and the results released as ADF&G Informational Leaflet No. 125. Station identification data and the catch of scallops at each station of the VIKING QUEEN survey has been summarized by the BCF EF&GR Base, Juneau, and released to the public. Biological data from the samples collected during the VIKING QUEEN survey are in various stages of analysis. A report on the meat weight-shell height data collected from the survey has been written and presently is in editorial review. Scallop shells collected during the survey have been aged and a report on age and growth is being written. A review of the meat weight-shell height and age and growth data collected during the VIKING QUEEN charter is given below.

The meat weight-shell height samples were from off Ocean Cape and Kodiak Island. The meat (shucked adductor muscle or "eye") was the only part weighed; the rest of the scallop was discarded. Shell height, the greatest distance between the mid-point of the hinge (umbo) and shell margin, was measured to the nearest mm.

Regressions of meat weight on shell height for scallops from the two areas are shown in Figure 25. Also shown in Figure 25 is the 95% confidence limits (dashed lines). These dashed lines show limits within which 95 percent of the meat weights may be expected to occur.

Analysis of the age and growth data shows that scallops from the Kodiak Island area grow faster and to a larger size than scallops from other areas of the Gulf. Scallops from Southeast Alaska grow much slower and not as large as scallops from the Kodiak Island area (Figure 26). Scallops living in areas between Southeastern Alaska and Kodiak Island have intermediate growth rates.

EF&GR Scallop Explorations -- Mr. Jerry Reid

The BCF EF&GR Base, Juneau, is contemplating a 90 day exploratory cruise for sea scallops southwest of Kodiak Island probably beginning in spring, 1969. Purpose of the cruise is to locate and delineate scallop beds and to collect biological samples. Final plans for the survey, however, have not been completed.

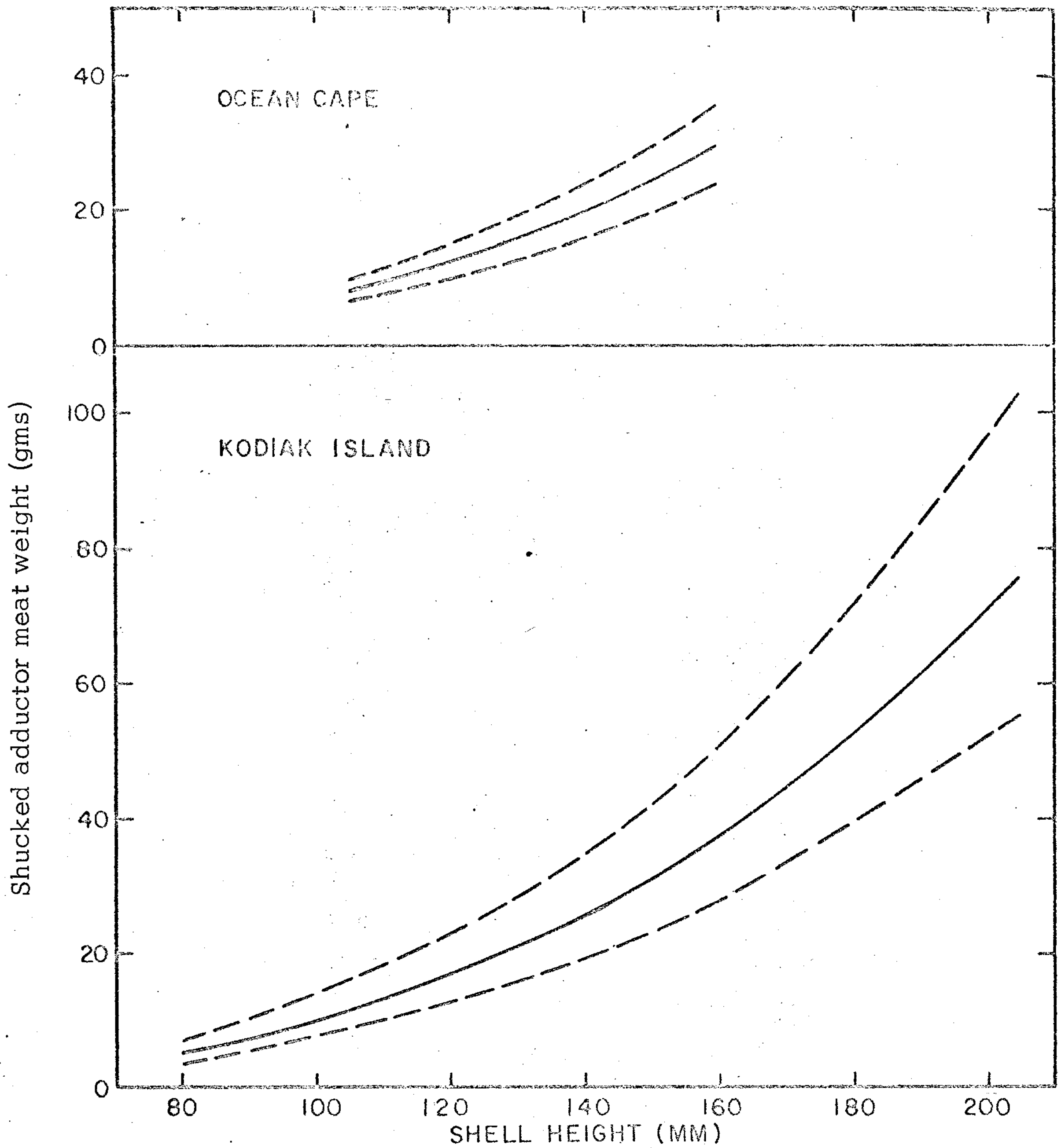

Figure 25. Regression (solid lines) of meat weight on shell height for sea scallops from off Ocean Cape and off Kodiak Island. Dashed lines show limits within which 95% of the meat weights may be expected to occur.

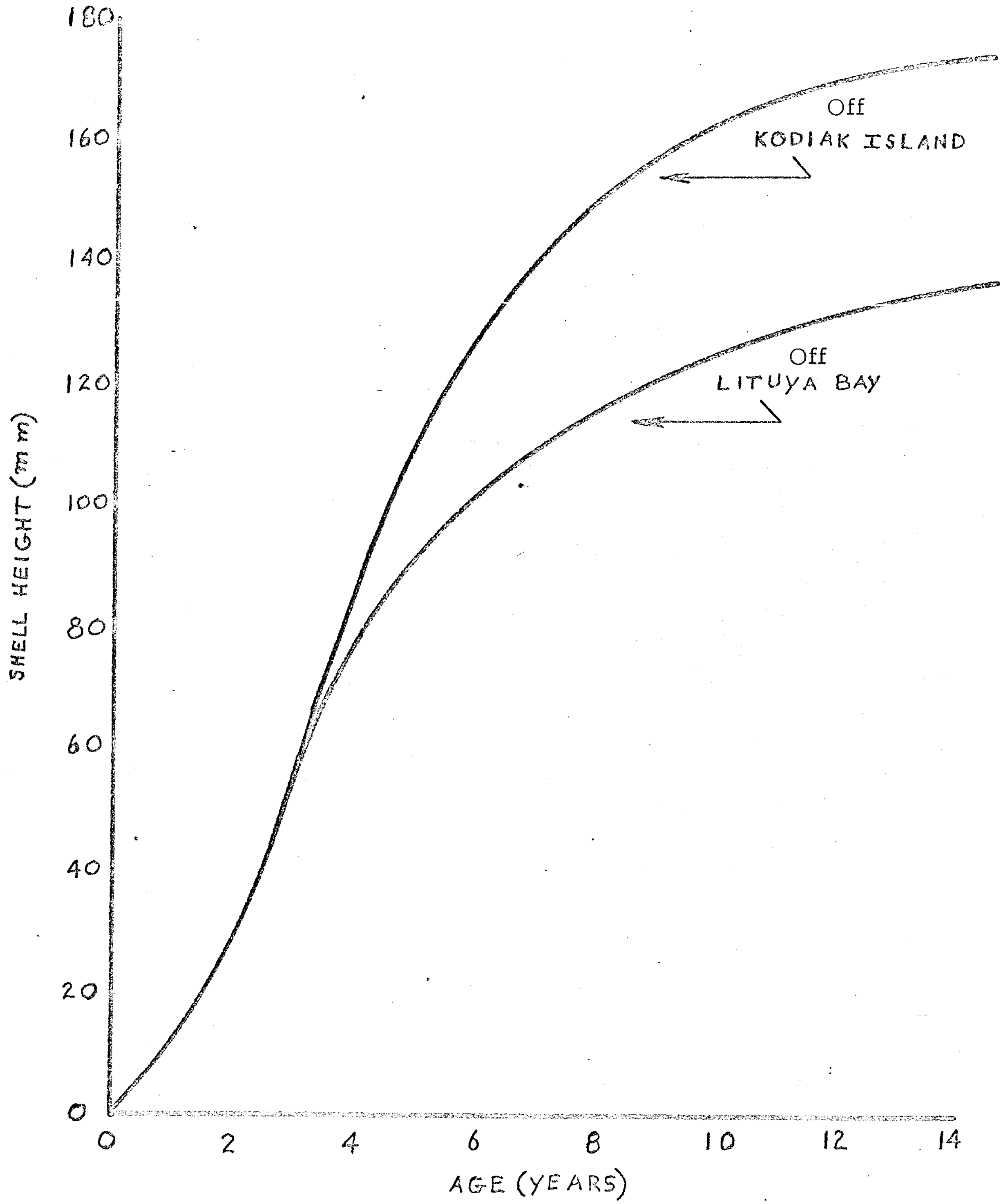

Figure 26. Age and growth of sea scallops from off Lituya Bay and off Kodiak Island.

Dungeness Crab

St. John's Harbor Dungeness Crab Research -- Mr. Carl Lehman

Although the Dungeness crab has been fished in Alaskan waters since 1900, it was not until 1963 that a detailed study of its life history was begun. In 1963, tagging studies on Dungeness crab was begun in the Petersburg area and continued to 1966 in an effort to outline geographically various stocks and to determine migration patterns of each stock.

The present project was started in 1967 in St. John's Harbor on the northwestern tip of Zarembo Island. This area contains a small, local population of crab that is not being exploited.

Previous projects were dependent upon the commercial fishermen to return tagged crabs. This project does not depend upon the fisherman for tag returns. Every crab caught out of the population is examined, and most are tagged.

The objectives of the St. John's Harbor study are to establish growth and natural mortality rates, to make an assessment of tag loss, and to test one method of estimating population size.

Tagging

The crabs used in this project are captured in round, commercial crab pots, fished by the author, utilizing the SHEARWATER, a 38 ft. ADF&G vessel equipped with fathometer and hydraulic crab pot lifting gear.

Crabs for tagging are selected without regard to size or sex. Crabs which are extremely soft or badly damaged are excluded from tagging as it is believed that these have a poor survival potential. However, every crab caught is carefully examined and sex, size, depth, shell condition (soft or hard, old or new), and location is noted whether the crab is tagged or not.

Specimens are measured to the nearest one-tenth millimeter with a pair of stainless steel calipers across the back of the carapace and just anterior to the tenth anterolateral spines.

As the crabs are captured they are placed in large wash tubs filled with sea water. As they are tagged they are removed from the tubs and released immediately.

The crabs are tagged by placing the anterior end of the crab in a small shallow box so that the chela are immobilized. Two holes are punched one half inch apart on the demersal line of the carapace near the posterior end of the crab. A red plastic "spaghetti" tag with ADF&G and a serial number imprinted upon it is threaded through the two holes with a needle. The two ends of the tag are tied together with a double overhand knot leaving a loop through the two holes and two easily discernible pigtails hanging from the crab. This method allows the tag to remain on the crab for more than one molt.

Tag Recovery

As previously mentioned every crab captured is carefully examined. In this manner, previously tagged crabs are recovered and noted whether or not they have a tag attached. If the crab has been previously tagged but the tag is missing, there will be scars from the two holes punched in the carapace. By examining these scars, it is also possible to tell if the crab has molted during the period it was at large.

When a crab with the tag missing is found, the date of capture, sex, size, and molt or non-molt is recorded. This crab is retagged with a new number and released so that tag loss is not exaggerated by returning these crabs without tags to the water to be recaptured.

Each crab recovered is re-released in the same area as the original release. All original captures, releases, and re-releases are contained within an area of approximately one-fourth square mile in St. John's Harbor. By re-releasing the crab upon recovery it is possible to keep track of some crabs over a period of time with respect to their growth or lack of same at various sizes. It may also be possible to make direct assessment of natural mortality through these multiple recapture-re-releases in a small, unexploited population.

Many variables are eliminated by not having to rely upon the commercial fishermen to recover tags. The tag recoveries are completely reported and the fishing gear can be distributed within the area to assure all of the area involved is sampled adequately.

Tag Returns

Since May of 1967, 4,931 tagged crabs have been released in St. John's Harbor (Table 16). Of these, 1,455 have been recaptured at least once and three have been caught six times during the course of the project.

Table 16. Dungeness crab released and recaptured in St. John's Harbor May 1967 - December 1968.

	Male	Female		Male	Female
Original Release	2,177	2,754	Recovery	914	541
Re-release 1	763	514		275	109
Re-release 2	221	104		82	32
Re-release 3	68	27		28	7
Re-release 4	22	6		10	1
Re-release 5	10	0		3	0
Re-release 6	3	0		0	0

It is still too early in the project to draw any conclusions from these data regarding natural mortality, however, it is anticipated that the reduction rate of tags by size class will yield estimates of natural mortality.

One further advantage of multiple recaptures and releases is that it may be possible to follow crabs of various sizes through a number of years and/or molts and establish growth rates for these size classes.

Tag Loss

It can be seen from the data given in Table 17 that tag loss on females was much greater than on males. The average loss on males was 8.2 percent, for females 19.7 percent, and total loss was 10.2 percent.

Both males and females were tagged in the same proportions (63.4 percent and 69.3 percent of the males and females, respectively) with respect to the number captured untagged by the gear.

If the tagged crabs are distributed homogenously on the grounds with the untagged crabs in the same proportions with respect to sex then one would

Table 17. Tag Loss by Date

Date	Captured untagged	Tags Missing M	Tags Missing F	Tags Missing Total	Tags Recaptured M	Tags Recaptured F	Tags Recaptured Total	Loss Recaptured M	Loss Recaptured F	Loss Recaptured Total
5/15-16/67	301	0	0	0	3	0	3	0.0	0.0	0.0
5/21-22/67	340	0	0	0	4	5	9	0.0	0.0	0.0
5/30-31/67	592	0	0	0	9	4	13	0.0	0.0	0.0
6/ 5- 6/67	299	0	0	0	24	9	33	0.0	0.0	0.0
6/15-17/67	560	0	0	13	35	26	61	not separated		21.0
6/21-22/67	442	0	0	3	56	30	86	"	"	3.0
6/28-29/67	356	0	0	4	52	60	112	"	"	4.0
7/11-12/67	364	0	0	5	85	48	133	"	"	4.0
7/21/67	369	0	0	8	98	79	177	"	"	5.0
8/ 9/67	450	9	12	21	96	89	185	9.0	13.0	11.0
8/22-24/67	357	8	13	21	81	69	150	10.0	19.0	14.0
9/21-22/67	322	11	6	17	94	38	132	12.0	16.0	13.0
10/18-19/67	165	5	6	11	53	26	79	9.4	23.0	13.0
2/14/68	10	0	0	0	3	0	3	0.0	0.0	0.0
2/20-21/68	53	2	2	4	24	4	28	8.3	50.0	14.3
3/ 5/58	25	2	1	3	13	2	15	15.0	50.0	20.0
4/10-11/68	57	4	2	6	28	6	34	14.2	33.3	17.6
5/14-15/68	60	4	0	4	23	7	30	17.3	0.0	13.3
5/21/68	120	1	5	6	38	18	56	2.6	27.7	10.7
6/26/68	105	4	5	9	44	11	55	9.0	45.4	16.3
7/ 9/68	186	2	11	13	62	31	93	3.2	35.4	13.9
7/24/68	210	0	5	5	51	38	89	0.0	13.1	5.6
7/30/68	181	0	6	6	29	35	64	0.0	17.1	9.3
8/ 5/68	141	1	4	5	22	26	48	4.5	15.3	10.4
8/14/68	136	3	3	6	32	30	62	9.3	10.1	9.6
8/21/68	46	1	1	2	22	9	31	4.5	11.1	6.4
8/27/68	97	1	1	2	22	12	34	4.5	8.3	5.8
9/10/68	188	1	3	4	21	28	49	4.7	10.7	8.1
10/25/68	98	7	7	14	54	22	76	13.0	31.8	18.4
12/ 5/68	77	3	8	11	31	12	43	9.7	66.7	25.5
Total	6,707	69	101	203	1,209	774	1,983	8.2	19.7	10.2

expect to capture both tagged and untagged crabs of both sexes in the same ratio. In this project, the ratio of tagged to untagged males was 41.0 percent and for females 20.4 percent. This indicates that only one half the numbers of tagged females were recaptured that might have been expected. This agrees very closely with the difference between the 8.2 percent tag loss on males as contrasted with the 19.7 percent loss on females.

In conclusion it appears that the tag loss for females is twice as great as it is for males. The high tag loss on females is probably due to the mechanics of mating. Because the female must molt to mate successfully and the male retains possession of the female during this process, the tag probably gets torn loose and lost.

During the last seven trips to St. John's Harbor it was also noted whether crabs with missing tags had molted or not. Of the twenty-seven females recaptured with tags missing, nineteen had molted.

Population Estimates

Estimates of the St. John's Harbor crab population were made using the Peterson index method. The formula used was $\frac{a}{b} = \frac{c}{x}$ where

a = tagged crab recaptured
b = tags in population
c = tagged crab recaptured plus untagged crab captured
x = estimated population

The estimate was refined by subtracting dead tagged crab from the total tagged population and replacing tags on those crabs that had lost tags before releasing them again. These estimates were made after each trip to St. John's Harbor (Table 19) and are summarized below in Table 18.

By examining Tables 18 and 19 it can be seen that the estimate of the male population is fairly constant whereas that of the female population varies considerably. The fluctuation in the estimate of the total population is largely a reflection of the fluctuations in the estimated female populations.

Considering the high tag loss on females, the estimate of the female population, and consequently that of the total population, is probably unreliable using the Peterson method.

Table 18. Average population estimates and ranges from Table 19, excluding the first three observations.

	Average	Range
Male	4,152	2,601 - 5,847
Female	9,843	4,474 - 16,864
Total	12,491	9,306 - 21,471

Table 19. Population estimates - St. John's Harbor.

	Tags Recaptured		Tags in Pop.		Captured Untagged		Population Estimate		
Date	Male	Female	Male	Female	Male	Female	Male	Female	Total
5/15-16/67	3	0	70	10	156	145	3,710	--	8,106
5/21-22/67	4	5	204	155	203	137	10,557	5,952	15,915
5/30-31/57	9	4	404	339	277	315	12,838	27,035	35,322
6/5-6/67	24	9	642	607	142	157	4,440	11,195	12,565
6/15-17/67	35	26	773	764	187	373	4,903	11,724	15,647
6/21-22/67	56	30	946	1,130	98	344	2,601	14,087	12,745
6/28-29/67	52	60	1,041	1,472	116	240	3,363	7,360	10,500
7/11-12/67	85	48	1,147	1,710	117	247	2,725	10,509	9,667
7/21/67	98	79	1,164	1,853	125	244	2,648	7,576	9,306
8/9/67	96	89	1,159	1,848	202	248	3,597	6,997	10,321
8/22-24/67	81	69	1,155	1,848	219	138	4,277	5,544	10,150
9/21-22/67	94	38	1,355	1,964	236	86	4,425	6,408	11,915
10/18-19/67	53	26	1,558	2,042	107	58	4,703	6,597	11,118
2/14/68	3	0	1,552	2,038	8	2	5,691	--	15,556
2/20-21/68	24	4	1,551	2,038	30	23	3,490	13,756	10,382
3/5/68	13	2	1,577	2,059	18	7	3,760	9,265	9,696
4/10-11/68	28	6	1,593	2,065	50	7	4,437	4,474	9,790
5/14-15/68	23	7	1,631	2,070	42	18	4,609	7,392	11,103
5/21/68	38	18	1,659	2,088	59	61	4,234	9,164	10,705
6/26-27/68	44	11	1,639	2,142	56	49	3,725	11,683	10,999
7/9/68	62	31	1,678	2,183	61	125	3,329	10,985	11,583
7/24/68	51	38	1,725	2,283	74	136	4,227	10,453	13,465
7/30/68	29	35	1,797	2,410	34	147	3,904	12,532	16,104
8/5/68	22	26	1,812	2,509	49	92	5,847	11,387	17,013
8/14/68	32	30	1,738	2,491	61	75	5,042	8,718	13,505
8/21/68	22	9	1,793	2,564	32	14	4,401	6,552	10,400
8/27/68	22	12	1,824	2,578	36	61	4,809	15,682	16,961
9/10/68	21	28	1,857	2,638	37	151	5,129	16,864	21,741
10/25/68	54	22	1,856	2,635	38	60	3,162	9,821	11,839
12/5/68	31	12	1,849	2,628	47	30	4,652	9,198	12,493

Tanner Crab

Preliminary Evaluation of Bering Sea Tanner Crab Stock -- Mr. John Karinen

Catch data on tanner crab (*Chionoecetes bairdi*) collected during the 1968 fall cruise of the R/V MILLER FREEMAN were used in a preliminary analysis of the distribution of male and female crabs by depth and geographical location. These data were obtained and analyzed as described in the Conference reviews of BCF king crab research by Hoopes and Karinen. It should be noted that calculations for the bathymetric distribution of crabs were based on all trawls towed, including those where no crabs were taken. Because only small samples of the tanner crab catch were measured, results in this report should be considered preliminary.

Distribution of tanner crabs by 5 fathom intervals (Figure 27) did not show a distinct separation of crabs by sex or size. Male and female crabs were generally most concentrated at the mid-depths (30-50 fathoms) of their depth distribution range (15 to 60 fathoms). Both male and female tanner crabs of all sizes were most abundant at depths where the abundance of male and female king crabs was low (Figure 27 and Figure 5). Tanner crabs were up to 300 times more abundant than king crabs at stations where the depths were from 36 to 40 fathoms.

Relative abundance of male and female tanner crabs by geographical location are shown in Figures 28 and 29, respectively. Caution should be observed in interpreting these data because these population estimates and distribution figures are based on single tows of one hour duration in each 20 x 20 mile area. Densities of crabs within these areas could vary considerably. Sampling error alone may be as much as ± 40 percent.

Regardless of these limitations this information provides a first approximation of the distribution and abundance of tanner crab in the southeastern Bering Sea.

At the time of the 1968 fall cruise, male tanner crab were ubiquitous over the sampling area, with the greatest concentration occurring to the west of 163° W. longitude. Female tanner crabs were not as extensively distributed as the males and were also found mostly in the western part of the station pattern. Thus, the main body of tanner crab was distributed to the west and north of the greatest concentrations of king crab.

Amount of distributional overlap between the two species differed with sex. Distribution of male tanner crabs overlapped rather extensively with king crabs of both sexes. In contrast, female tanner crabs were most abundant in

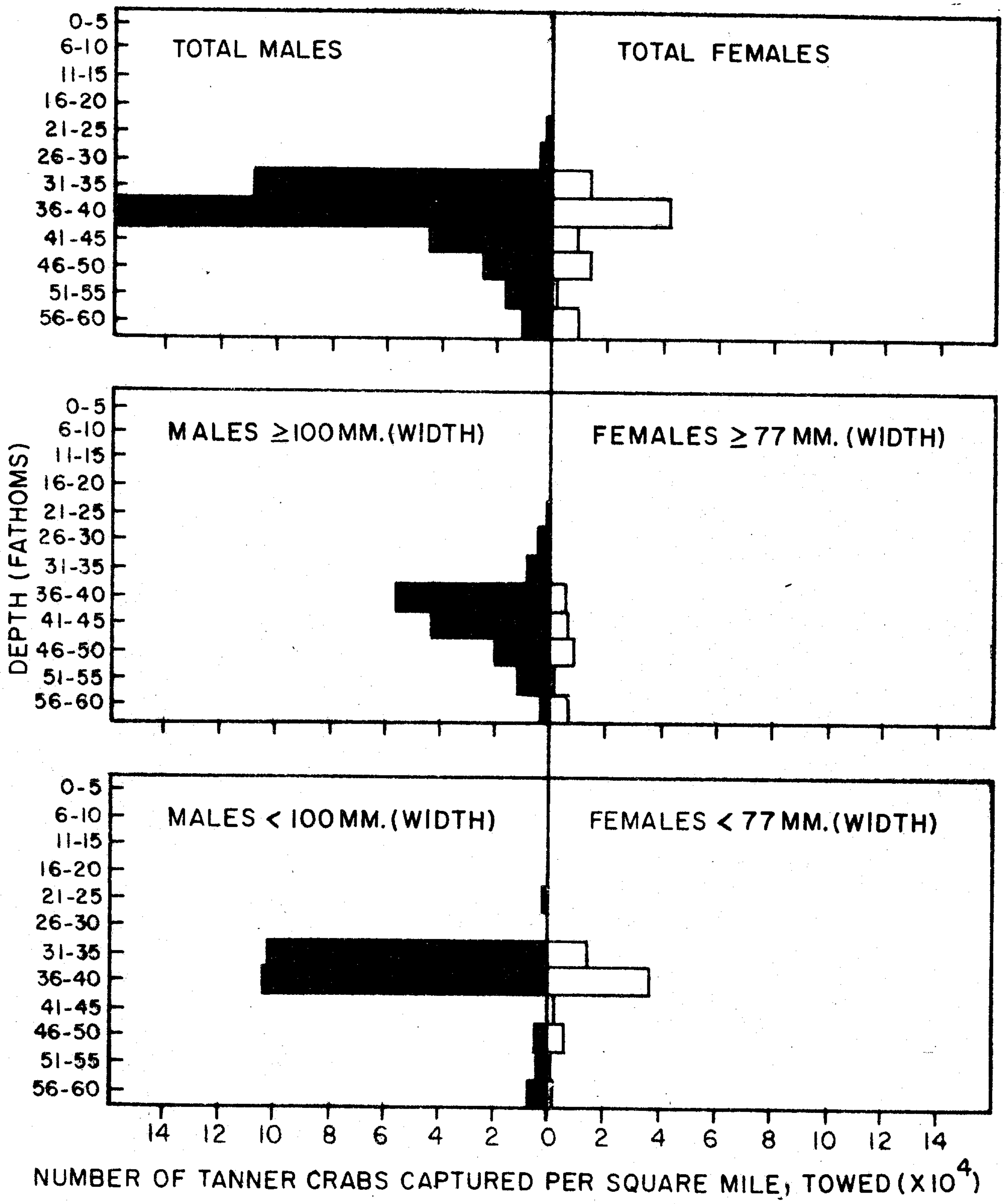

Figure 27. The distribution of tanner crabs by depth in the southeastern Bering Sea during September 1968, as determined from catch analyses of 75 trawl samples collected during Cruise 6809-10F.

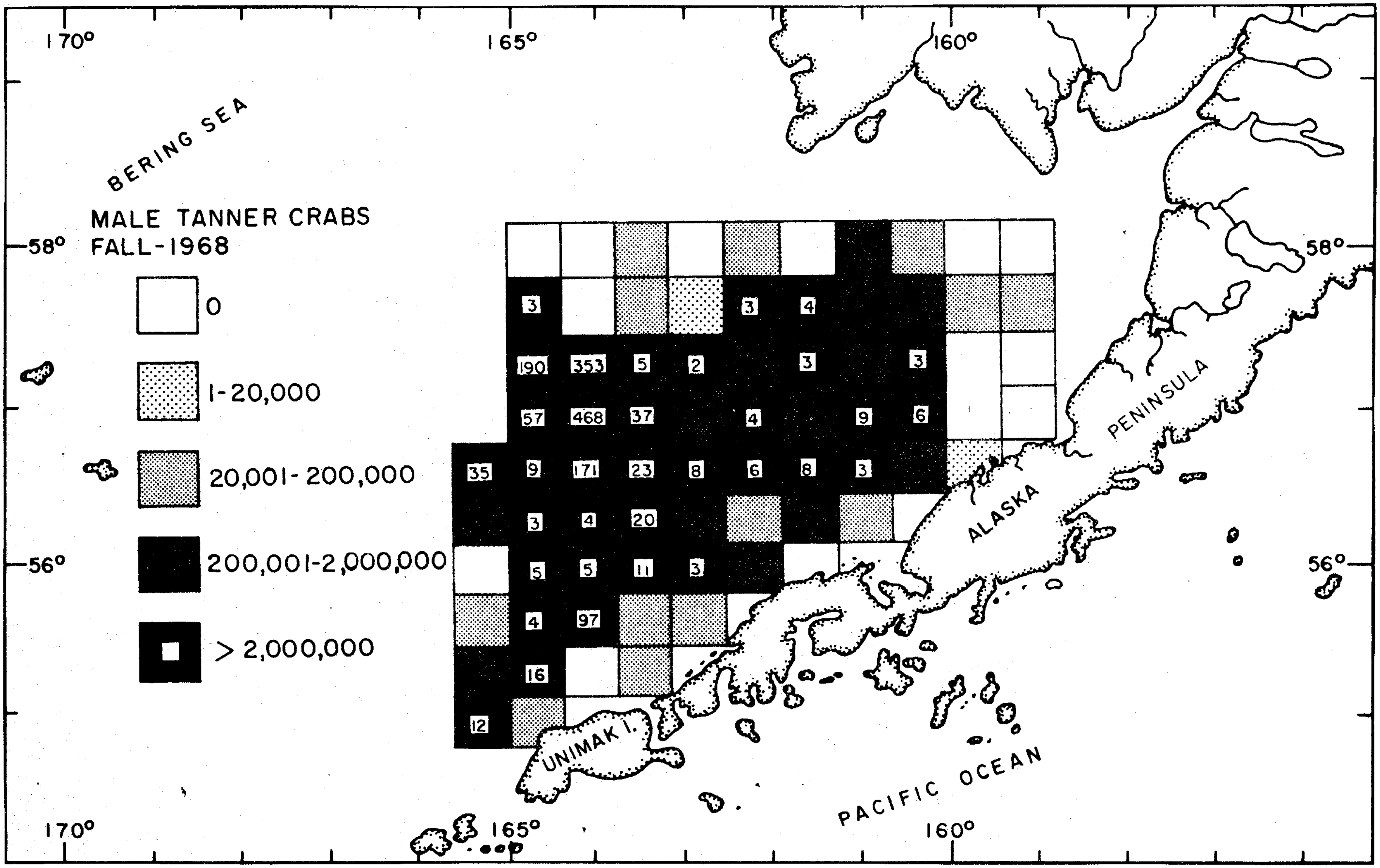

Figure 28. Relative distribution and abundance of male tanner crabs in southeastern Bering Sea during September 1968, based upon trawl catches made during Cruise 6809-10F. Numbers within squares indicate estimated population to nearest million.

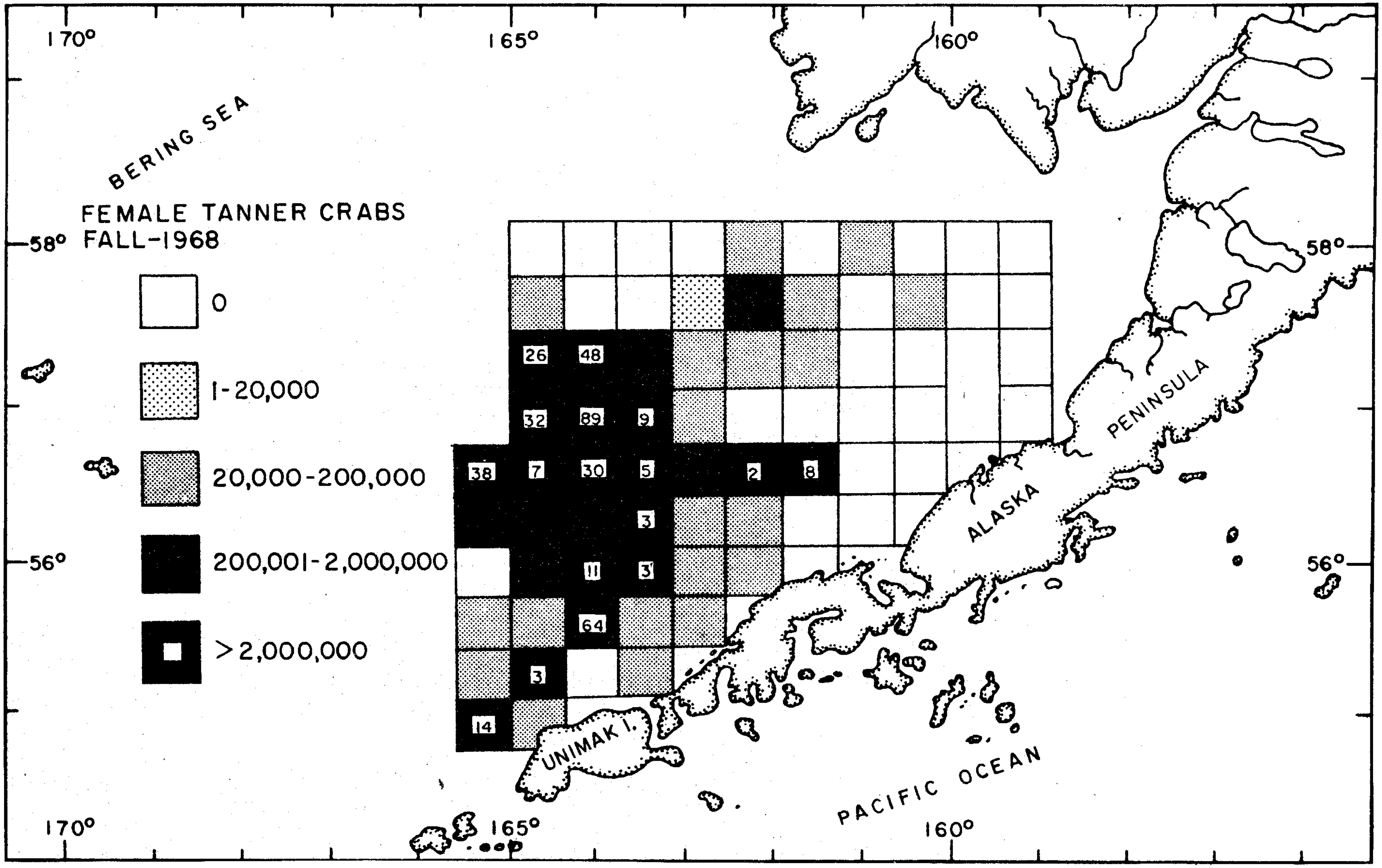

Figure 29. Relative distribution and abundance of female tanner crabs in southeastern Bering Sea during September 1968, based upon trawl catches made during Cruise 6809-10F. Numbers within squares indicate estimated population to nearest million.

areas where no female king crabs were found.

Physical factors (i.e. water temperature, salinity, bottom sediments etc.) may be influencing the distribution of both king and tanner crab. The greatest concentrations of female tanner crabs were present in areas where the bottom temperature ranged from 1° to 5° C. Female king crabs were concentrated in areas where the temperature ranged from 5° to 7.5° C. Male tanner crabs were present in significant concentrations over this entire temperature range (1° to 7° C).

<u>Observations on Tanner Crab During F/V VIKING QUEEN Charter -- Mr. Carl Lehman</u>

During the F/V VIKING QUEEN survey off Cape Fairweather in early May 1968, many tanner crab were caught in the scallop dredges. Carapace width of 112 individuals from a single haul were measured. Most of the crabs were females carrying newly spawned eggs. The females ranged in size from 59 mm to 125 mm carapace width; most of them were between 90 mm and 105 mm. All the females larger than 79 mm (except one at 84 mm) were carrying eggs. All but two of those carrying eggs were new-shelled. The two females that were old-shelled also carried eggs; this implies that it may not be necessary for a female tanner crab to molt prior to spawning eggs.

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