Agenda Item G-1
July, 1980

MEMORANDUM

DATE: July 14, 1980

TO: Council, SSC, and AP Members

FROM: Jim H. Branson, Executive Director

SUBJECT: King Crab FMP

ACTION REQUIRED

Review draft FMP and recommend revision or release to the public. Time and place for Public hearings.

Background

The first draft of the king crab plan was reviewed by the Council in August, 1979. The plan drafting team revised the plan and submitted it to the Council at the meeting in Kodiak on May 22, 1980. The SSC subgroup met with the PDT to review the plan on June 19th, in Juneau.

Council recommendation is required on whether the document should be released for public hearings or whether it should be revised before being released to the public. Recommendations from the Council are also necessary on the time and location of public hearings.

Attachment: Summary of Plan

MD

2.0 SUMMARY

The Fishery conservation and Management Act of 1976 as amended, requires each Regional Council to prepare fishery management plans for all fisheries within its area of jurisdiction in the Fishery Conservation Zone (FCZ) from 3 to 200 miles. The purpose of the plan is to provide for an optimum yield of the resource to the fishermen and to the nation, while avoiding irreversible or long term adverse effects on the resource and the marine environment.

The king crab plan has been developed as a framework which provides the guidelines for the annual management of the king crab resource and fishery. A well established management process has been developed over the last 20 years by the State of Alaska Board of Fisheries and the Alaska Department of Fish and Game for both territorial and FCZ waters. The plan incorporates the current management regime and includes alternatives. It will be the basis for cooperative management by the Council, the Board of Fisheries, the Alaska Department of Fish & Game, and the National Marine Fisheries Service.

The plan describes the biology of king crab stocks and their fisheries and it reviews the history of management and its management varies from area to area. The procedures for describing MSY, ABC, and OY are outlined and the plan proposes management measures and options.

2.1 Management Objectives

The plan proposes the following management objectives:

1. To optimize annual physical and economic yield of the king crab stocks in the FCZ.

2. To promote full utilization of the king crab resource by the domestic fishery.

Optimum Yield

Optimum yield (OY) and Estimated Annual Catch (EAC) are concepts used in the plan to describe the "optimum" level of harvest on a long term basis (OY) and the estimated catch level for each year (EAC). OY is equal to MSY which is determined from the average annual catch (119 million pounds) for the Gulf of Alaska and the Bering Sea.

The Acceptable Biological Catch (ABC) is the annual estimate of the maximum biologically allowable level of catch. It is computed from the determination of the relationship of size of the female spawning stock to the reproductive success of males present in the adult population. A spawner/recruit relationship is assumed to exist below a certain threshhold level of stock size. The EAC is determined from the ABC by considering such socioeconomic factors as changes in the price/size relationship for example.

Management Strategy

The current management policy of the State of Alaska establishes a quota and size limits in order to maintain fishable crab stocks that are made up of several year classes. This allows the stocks several reproductive seasons before being recruited into the fishery. The objective is to reduce the dependency of the fishery on a one-year class and maintain a conservative level of exploitation.

In addition to the management strategy considered above, the plan proposes a management strategy applicable to healthy stock conditions, for example, in the Bering Sea. This management strategy is based on a stock recruit relationship and a yield per recruit concept whereby the size of recruits entering into the fishery is adjusted to achieve the greatest yield for a given level of recruitment and for a given stock size. This strategy would maximize the yield during healthy stock conditions.

Management Measures

a. Fishing Seasons

Option 1 - Alaska Plan. Seasonal openings in each district have traditionally been determined by the Board of Fisheries in consideration of biological and industrial needs. The opening and closing dates vary according to area (6 areas in the Kodiak and Bering Sea regions). The season generally lasts from mid-September to mid-January or the end of May for the Bering Sea area. Emergency orders are used to close several of the areas using in-season stock assessment information. Depending on the status of stocks, a second fishing season is opened in most areas for older age crabs.

Option 2 - Close the fishery during mating and molting seasons. This option considers only the biological basis for the season closures. The mating and molting period vary in each area but generally commence in spring and end in late summer.

b. Sex Restrictions

Option 1 - Alaska plan. No commercial harvest of female crab.

Option 2 - Allow a percentage of females to be taken if a surplus determined to be available. The surplus would be dependent on the amount of crabs above the threshold amount used in the spawners/recruit calculation of ABC.

c. Size limits

Option 1 - Alaska plan. The current size limit varies by area based on the combination of the need to maintain a multi-year fishable stock and industry requirements which have developed around a certain size of finished product. A second season to harvest the older crab, generally greater than 7½ inches carapace width, is currently allowed in most areas.

Option 2 - Annual variation in the limit based on size of stock and

level of recruitment, for example a size limit of 5.25 inches could be implemented under current stock conditions in the Bering Sea without adversely affecting the stocks.

d. Harvest quotas

Option 1 - Alaska plan. Quotas are established for each stock area, by estimating fishing mortality of a particular recruit class and appropriate exploitation rate.

Option 2 - All male crabs over a certain minimum size limit.

e. Registration

Option 1 - Alaska plan. Kodiak, Alaska Peninsula, Dutch Harbor and Bristol Bay are exclusive registration areas. The vessels may register for only one exclusive area during any one fishing season.

Option 2 - Registration by statistical area is necessary before the fishing season. There is no exclusive registration areas.

Option 3 - No vessel registration.

f. Gear Restrictions

Option 1 - Alaska plan. King crab can only be taken by pots and ring nets. The number of units of gear are also regulated in certain areas.

Option 2 - Pots and ring nets are the only legal gear for king crab. There is no restriction on the number of units of gear which can be fished.

g. Gear placement, gear storage, and vessel tank inspection

Option 1 - Alaska plan. After the fishing season, the king crab pots must be taken off the fishing ground and stored on land or at sea. The gear may be stored in 25 fathoms of water or in two designated pots storage areas. Tank inspections must be made before the opening of the season.

Option 2 - Pots must be removed from the grounds and stored in

designated areas. The vessel tank inspection requirements are eliminated.

Option 3 - Pot storage is provided on the fishing grounds. Vessel tank inspection requirements must be fullfilled.

h. Limited Entry

Option 1 - No limited entry until further studies are done.

Option 2 - No limited entry.

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NATIONAL MARINE FISHERIES SERVICE
Northwest and Alaska Fisheries Center
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cc/McCrary

July 16, 1980

F/NWC2 - RM

TO: NPFMC, Scientific and Statistical Committee

FROM: F/NWC2 - Rich Marasco, Member
SSC Groundfish Subgroup

SUBJECT: Review of May 1980 Draft of King Crab FMP

On June 19 and 20 Bud Burgner, Jerry McCrary (for Jack Lechner), Rich Marasco, Steve Pennoyer, and George Rogers met in Juneau with members of the AP and PDT to discuss the most recent draft of the Alaska King Crab FMP. The following is a summary of major comments made and questions posed at the meeting.

1. There is a need to define the term "framework plan". Further, a discussion is needed of the costs and benefits of a framework versus standard plan.

2. The discussion in Section 4.1 should be broadened to indicate that the management unit is subdivided into six areas.

3. The estimate of MSY (119 million pounds) was questioned. It was suggested that the use of an average of the 1960-1979 catches was inappropriate. It was pointed out, for example, that historical catches for the Bristol Bay management area reveal that the MSY for the area is useless. Catches and CPUE's for the last several years indicate that MSY for this area could exceed 80 million pounds. MSY for the area is set at 48 million pounds. It was agreed that MSY should be defined in general terms; i.e., as a collection of ABC's for the period of time that the plan is in effect.

4. No mention is made of the incidental catch of halibut by crab gear. A suggestion was made to include a statement noting that the magnitude of the catch is not known and a joint ADF&G/IPHC study is being planned to determine the size of the incidental catch.

5. It was suggested that the discussion of the Kodiak fishery be reworked to give a more detailed description of the development and evolution of management of the fishery.

6. The definition of OY in the plan should be modified to read, "OY for this fishery is defined as a collection of annual catches which results from the implementation of ABC and EAC procedures defined in this plan."

7. The discussion of procedures to be used to determine ABC must be expanded. The method should be spelled out in more detail. Presentation of an example would be very useful.

8. It is important to point out that the proposed ABC procedure will be applied to individual stocks (areas) as defined on page 61. The ABC for the Management Unit, therefore, is the sum of the individual stock ABC's.

9. Modification of the EAC section was recommended. It was suggested that the second paragraph be dropped. The first sentence of the third paragraph should be changed to, "Analyses will be conducted to determine the economic impacts of alternative catches allowed by the ABC guidelines."

10. At some point in the plan there should be a description of how the proposed management framework will be implemented; i.e., timing, parties responsible, etc.

11. Objective 1 must be modified. The statement implies simultaneous optimization of conflicting goals.

12. The section that described various management options must be re-worked to be consistent with the ABC-EAC framework proposed. Harvest quotas and size limits will fall out of application of the framework. Table 25 should be modified to reflect this fact.

GAFFNEY
5/6/80

A PROPOSED METHOD FOR DETERMINING ABC AND OY FOR THE EASTERN BERING SEA KING CRAB FISHERY

by

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May 1980

A PROPOSED METHOD FOR DETERMINING ABC AND OY FOR THE EASTERN BERING SEA KING CRAB FISHERY

The methods proposed here are based on the concept that there is a minimum spawning stock of fertilized females required for reproduction. At levels of stock above this threshhold the amount of surplus stock dictates the ABC level and various combinations of minimum size limits and exploitation rates exist as options for determination of OY. As the spawning stock approaches and goes below the threshhold level, both the level of ABC and OY options are reduced. The threshhold level should be thought of as a point below which management options become reduced, rather than a biological extinction point.

The following discussion outlines the sequence of steps leading to ABC and some possible OY estimates. The first requirement in determining the ABC is to establish the minimum required level of female spawning stock based on spawner-recruit theory and application. The second step combines catch information and survey estimates of abundance along with certain assumptions on female copulation to determine the maximum catch level, or ABC, which still maintains, to the extent possible, the required spawning stock. Within the framework of ABC, various possible OY levels are then determined as minimum size limit/exploitation rate combinations to be selected from, based on socioeconomic considerations.

Determination of ABC

The ABC can be expected to fluctuate as the stock fluctuates. Under the proposed method an additional determinate of ABC is the position of the current spawning stock level in relation to the required or threshhold spawning stock. For example, under the assumption that copulation drops off as the size limit is lowered and/or the exploitation rate is increased, a certain fraction of barren females can be tolerated as long as the

spawning stock is high. When a decline in stock sets in, full female copulation becomes increasingly important as the threshhold level of spawners is approached, and the range of possible size limit/exploitation rate combinations becomes restricted. What follows is a discussion of how the threshhold spawning level is determined and how the current spawner abundance is assessed in relation to it, for the estimation of ABC.

Determination of required spawning stock

The threshhold spawning stock concept is based on the assumption that a spawner-recruit relationship exists, at least at lower ranges of possible stock sizes. When the stock is below this threshhold, then every effort should be taken to prevent further decline in reproductive capacity. If it happens that there is a spawner-recruit relationship at intermediate and high stock levels also, then the threshhold may represent some region of high probability that recruitment will be stronger than average. If, on the other hand, no relationship exists above lower stock levels, then the threshhold represents the lower bound on a region of spawning stock sizes where any recruitment (within limits of fecundity) is equally likely.

For illustration, the available spawner-recruit data for the southeastern Bering Sea red king crab stock, based on survey abundance estimates, are shown in Figure 1. Beyond the indication that recent strong recruitment emanated from a period of relatively low spawning stock (early 1970's), little can be said regarding the nature of the spawner-recruit relationship. However, from spawner-recruit theory (Ricker, 1954) it is evident that our basic choices are limited to two: (1) those curves which are dome-shaped, and (2) those that are flat over a substantial portion of spawning stock ranges. This latter possibility

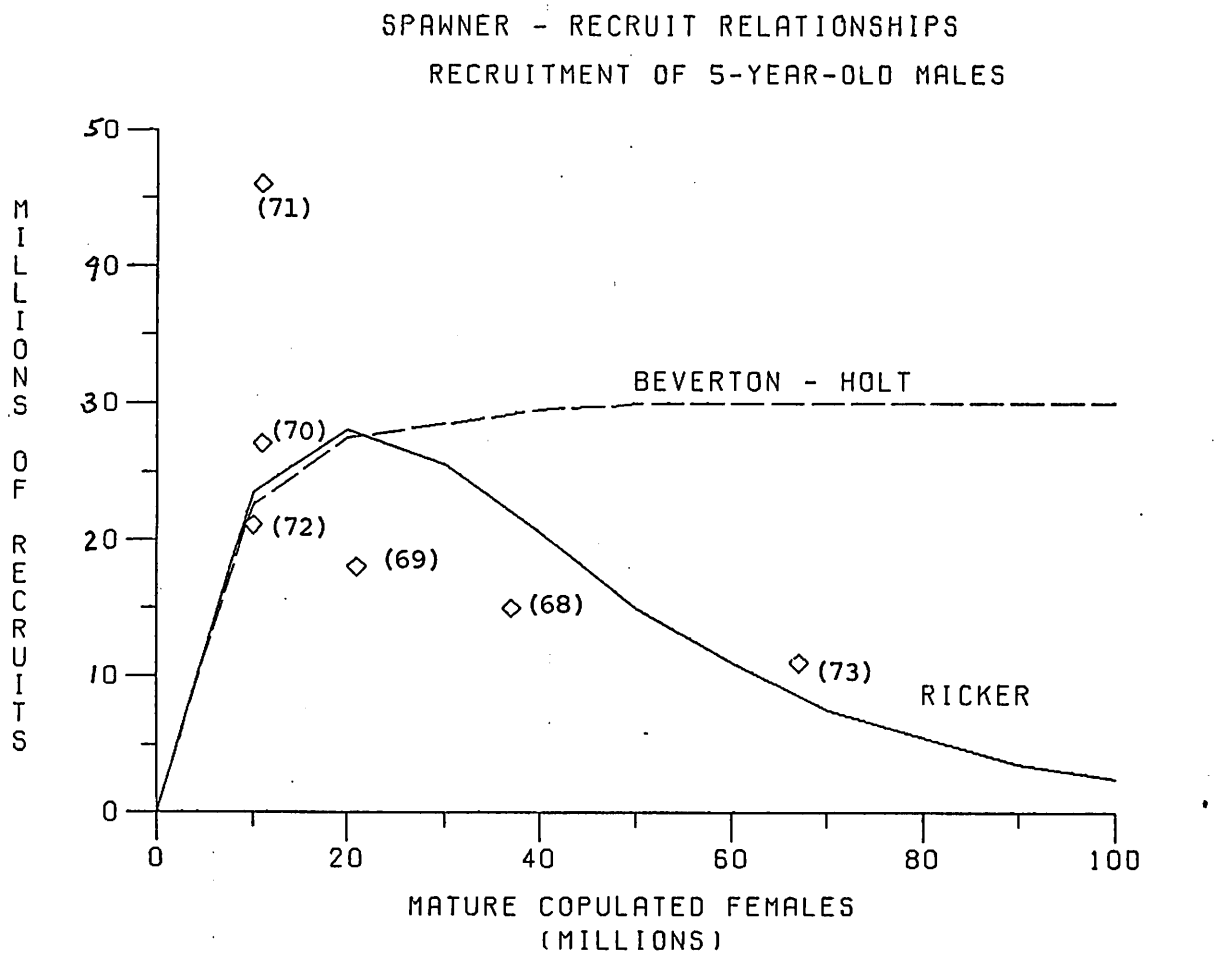

Figure 1.--Spawner-Recruit data and fitted curves for the southeastern Bering Sea red king crab stock. (Year of estimate of mature copulated females in parentheses)

translates into a situation of randomly changing recruitment over most spawning stock densities. In either event, a threshhold level in the mid-range of possible spawning stock densities appears to be appropriate, unless a maximum (in the case of a dome-shaped relationship) or a descending left-hand limb (in the case of a flat relationship) exists at less than intermediate stock levels. If this is the case, then a threshhold level at mid-region would be somewhat conservative. Conversely, a dome-shaped relationship which has its maximum at a stock level beyond the mid-region would necessitate a higher threshhold level. This last possibility appears the least likely in the presence of the available data. Thus, some region of mid-stock densities appears to be the best choice.

The current abundance of mature females (and males as well), has been on an increasing trend (Table 1), based on NMFS surveys. Further, analysis of future recruitment (Figure 2) indicates a decline in stock abundance, which will probably impact the fishery significantly in 1982. Thus, it can be concluded that the spawning stock is currently at a peak of abundance of around 120 million mature females and that a suitable threshhold level exists at around half this value, i.e., 60 million mature female crabs. It is to be strongly emphasized that this value represents a logical beginning point and will be subject to modification as additional annual points are added to those shown in Figure 1 via the NMFS survey.

Table 1.--NMFS survey estimates of the mature red king crab stock in the southeastern Bering Sea.

	Millions of Crabs	
YEAR	FEMALES	MALES
1968	37	26
1969	21	40
1970	11	17
1971	*	*
1972	11	22
1973	67	56
1974	61	67
1975	49	71
1976	61	109
1977	126	147
1978	117	115
1979	122	95

* limited survey; abundance estimates not calculated

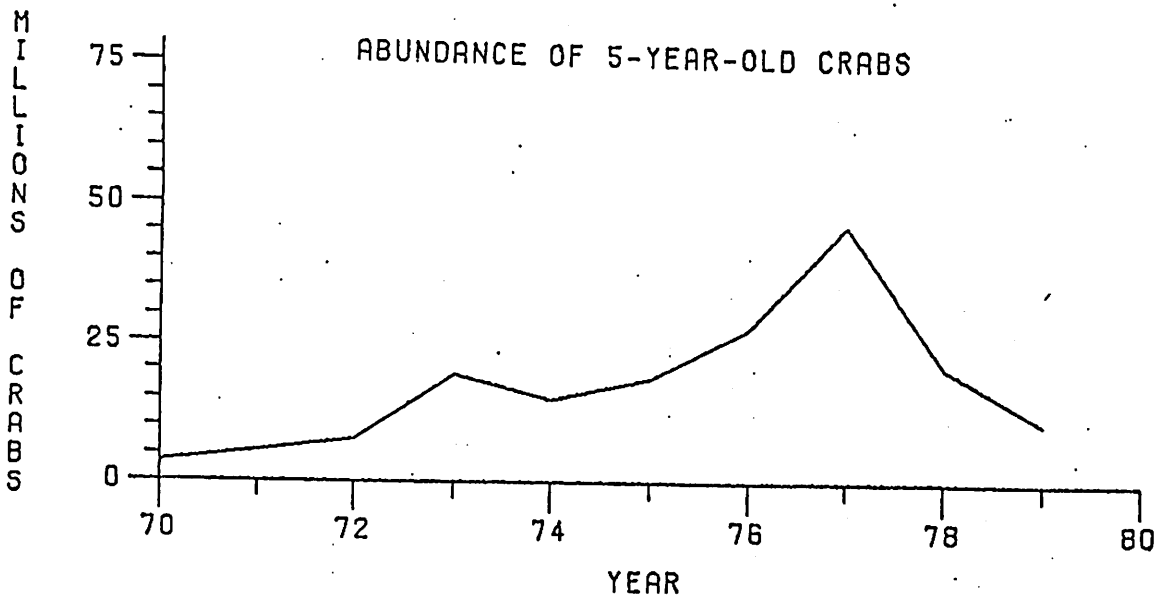

Figure 2.--Estimated annual abundance of 5-year-old male red king crab in the southeastern Bering Sea.

Determination of yield options

From consideration of survey abundance, catch, and natural mortality estimates by age or size for the current year, estimates of potential catches the following year can be developed. These potential catches can then be arrayed in table form as a function of various minimum size limits and exploitation rates for the purpose of OY selection as well as ABC determination. The value for ABC lies somewhere within this array and can be located based on reproductive considerations. If we are willing to make certain assumptions about how the relative size of mating males and females affect the rate of copulation of females (e.g., those used in Reeves and Marasco, 1980), then estimates of spawning stock size related to various size limit/exploitation rate options can be made and related to the estimate of minimum required spawning stock of females. From these computations, ABC can be estimated.

As an example of this procedure, data from the 1979 fishery and NMFS survey in the eastern Bering Sea are used in an illustrative sequence of calculations. In Table 2, the 1979 estimated age composition is adjusted for fishery removals, natural mortality, and growth to produce a projected estimate of the 1980 stock. From this projected stock estimate, an array (Table 3) is constructed showing yields for various combinations of minimum size and exploitation rate. The total expected abundance of mature females can also be calculated for the next year. The basic reason for these projections is to provide early information regarding ABC and OY levels. The projected table of yields would be subject to verification and correction prior to the season as the 1980 survey results become available.

In order to locate the ABC within the array (Table 3), some idea of

Table 2.--Data used to project abundance estimates one year ahead of a given set of survey estimates (millions of crabs).

Age	1979 Survey Estimate Males	1979 Survey Estimate Females	1979 Catch	Instantaneous Natural Mortality Rate Males	Instantaneous Natural Mortality Rate Females	1980 Projected Survey Estimate Males	1980 Projected Survey Estimate Females
4	13.9	20.1	0	.15	.58		
5	10.6	34.7	0	.13	.58	12.0	11.3
6	10.3	26.2	0	.12	.58	9.3	19.4
7	18.1	26.5	0	.08	.58	9.1	14.7
8	19.7	13.9	1.2	.08	.58	16.7	14.8
9	17.7	7.5	5.6	.11	.58	17.1	7.8
10	7.1	6.3	3.5	.23	.58	10.4	4.2
11	4.5	2.5	2.8	.50	.58	2.4	3.5
12	3.5	0.8	2.0	.57	.58	0.4	1.4
13	2.3	0.4	1.0	.61	.58	0.4	0.5
14+	1.3	1.6	0.5	.76	.58	0.4	0.2
Total ages 5-14+	95.1	120.4	16.6			78.2	77.8

Table 3.--Estimated yields for 1980, by minimum size limit and exploitation rate.

ESTIMATED 1980 YIELDS (millions of pounds)							
SIZE LIMIT	EXPLOITATION RATE .3	.4	.5	.6	.7	.8	.9
7.00"	38	51	63	76	89	101	114
6.75"	51	68	84	101	118	135	152
6.50"	63	84	105	126	147	168	189
6.25"	72	96	120	144	167	191	215
6.00"	79	106	132	159	185	211	238
5.75"	84	112	140	168	196	223	251
5.50"	86	115	144	172	201	229	258
5.25"	88	117	147	176	205	235	264

the impact of the various size limit/exploitation combinations on female spawning stock are needed. For this requirement, an assumed relationship between percent copulation and male to female size ratio is used (Figure 3). Any reduction in the average size of mature males due to increases in exploitation or lowering of the size limit beyond those now in effect would be reflected in a lowered rate of copulation of females. The assumption portrayed in Figure 3 leads to an array of copulation rates determined by size limit and exploitation rate combinations (Table 4). These rates, derived from computer simulations similar to those in Reeves and Marasco (1980), are then applied to the projected estimate of mature female stock abundance to give a corresponding array of female spawning stock sizes (Table 5). Using the predetermined estimate of threshhold spawning stock, a minimum required spawning stock boundary line can be drawn through the spawning stock array. When this boundary is overlayed on the estimated yields in Table 3, ABC can be determined as the maximum yield above the minimum threshhold spawning stock boundary. In this example, the ABC value is 189 million pounds, associated with a 6.5-inch size limit and an exploitation rate of 0.9. A range can be provided for any chosen value in Table 3, based on sampling error of the survey.

Determination of OY Options

Any yield value in Table 3 above the spawning stock threshhold boundary can be considered an OY option, the appropriate one to be selected based on socioeconomic considerations. Information on stock available the next season (e.g., 1981) at various minimum size limits could be provided for each OY option in a format as indicated by Table 6, to aid in the selection. In addition, there may be other criteria beyond size limit and exploitation

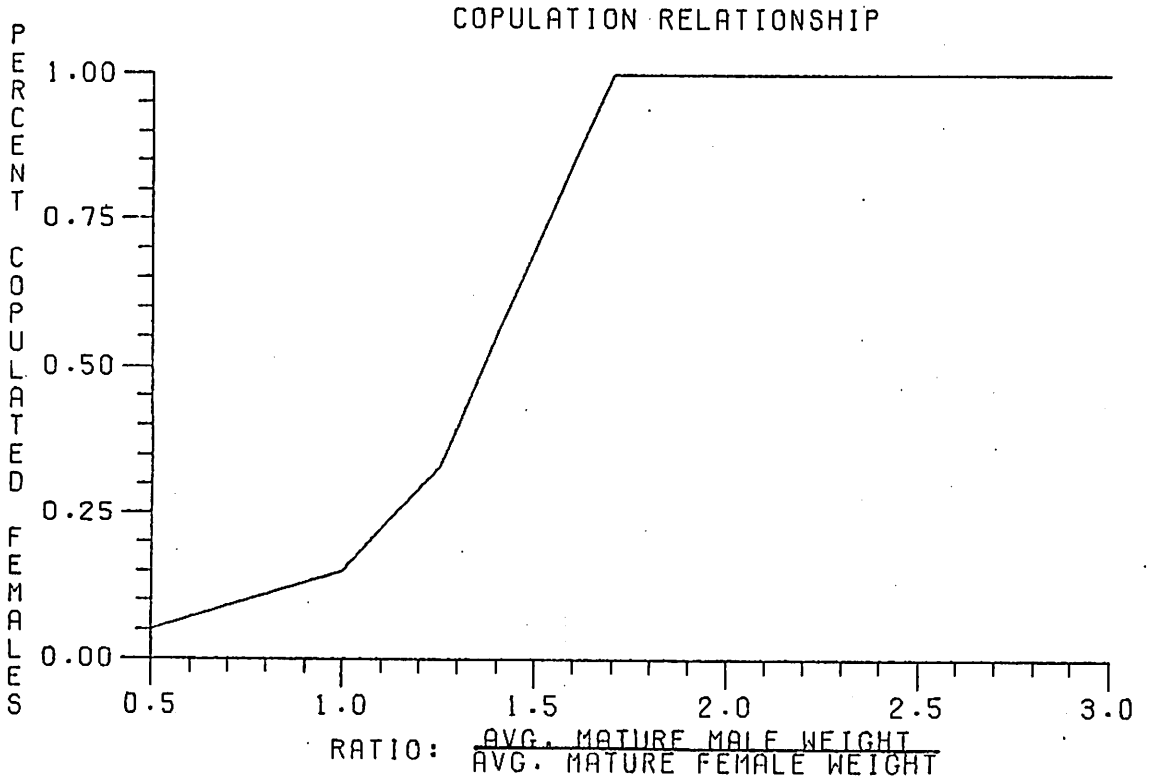

Figure 3.--Assumed relationship between percent copulation of females and the mature male-female size ratio during the spawning period (from Reeves and Marasco, 1980).

Table 4.--Simulated copulation rates for female king crabs, by minimum size limit and exploitation rate.

SIMULATED PERCENT COPULATED FEMALES							
SIZE LIMIT	EXPLOITATION RATE .3	.4	.5	.6	.7	.8	.9
7.00"	100	100	100	100	98	97	95
6.75"	100	98	97	95	92	90	87
6.50"	100	96	93	89	86	82	79
6.25"	93	89	85	81	78	74	72
6.00"	86	82	77	73	70	66	64
5.75"	81	77	72	68	65	62	60
5.50"	77	73	68	64	61	57	55
5.25"	72	68	63	59	56	53	51

Table 5.--Projected estimate of the 1981 female spawning stock by minimum size limit and exploitation rate.

1981 FEMALE SPAWNING STOCK (millions of crabs)							
SIZE LIMIT	EXPLOITATION RATE .3	.4	.5	.6	.7	.8	.9
7.00"	78	78	78	78	76	75	74
6.75"	78	76	75	74	72	70	68
6.50"	78	75	72	69	67	64	61
6.25"	72	69	66	63	61	58	56
6.00"	67	64	60	57	54	51	50
5.75"	63	60	56	53	51	48	47
5.50"	60	57	53	50	47	44	43
5.25"	56	53	49	46	44	41	40

Table 6.--Format for presentation of fishable stock by minimum size limit for various OY size limit/exploitation rate options.

	FISHABLE STOCK UNDER OY OPTIONS																			
SIZE LIMIT	7.00" SIZE LIMIT							6.75 SIZE LIMIT							• • •	5.25" SIZE LIMIT						
	.3	.4	.5	.6	.7	.8	.9	.3	.4	.5	.6	.7	.8	.9		.3	.4	.5	.6	.7	.8	.9
7.00"																						
6.75"																						
6.50"																						
6.25"																						
6.00"																						
5.75"																						
5.50"																						
5.25"																						

rates which will determine OY.

The values used for percent copulation can have a significant effect on the location of the spawning stock threshhold boundary, which acts to separate out the OY options from the entire yield array. These values are derived from an assumed, albeit possibly conservative, relationship between copulation rate and male-female size ratio. One solution to this problem would be to venture below the threshhold boundary of Table 3 to select an OY value which would test the assumption regarding copulation rate. For example, a 6-inch minimum size limit and a 0.6 exploitation rate corresponds to an OY value of 159 million pounds (Table 3). Under our assumption, a copulation rate of 73 percent (Table 4) would be expected during the spawning season following a fishing season where this OY was achieved. The resulting expected spawning stock would be 57 million females (Table 5). The actual copulation rate observed from the next survey could be used to update the information in Table 4. If the survey data indicated a rate lower than the table value, OY options would be reduced in the next fishing season. Conversely, if a value equal to or greater than the table value is obtained, then further experimentation is warranted. It should be noted that because the female spawning stock is currently high, a copulation rate of 73 percent does not lower the expected spawning stock much below the threshhold level established earlier.

Literature Cited

Ricker, W. E. 1954. Stock and recruitment. Jour. Fish. Res. Bd., Canada. 11:559-623.

Reeves, J. E. and R. Marasco, 1980. An evaluation of alternative management options for the southeastern Bering Sea king crab fishery. NWAFC Processed Report 80-6, 85 p.

ILLUSTRATIONS

FOR

A DISCUSSION OF MANAGEMENT

MEASURES FOR THE BRISTOL BAY

KING CRAB FISHERY

Presented by

J. E. Reeves and R. Marasco*

to the

NORTH PACIFIC FISHING VESSEL OWNERS ASSOCIATION

June 18, 1980

Seattle, Washington

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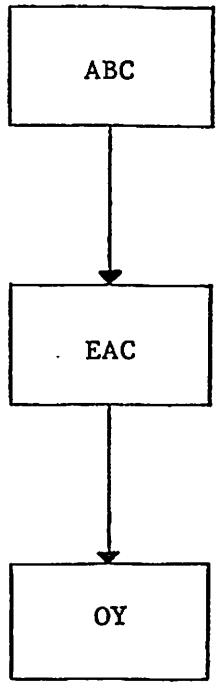
Seattle, WA 98112

KING CRAB
Management measures

→ Minimum size limit
→ Harvest quota
Fishing season
Sex restriction


ABC
EAC
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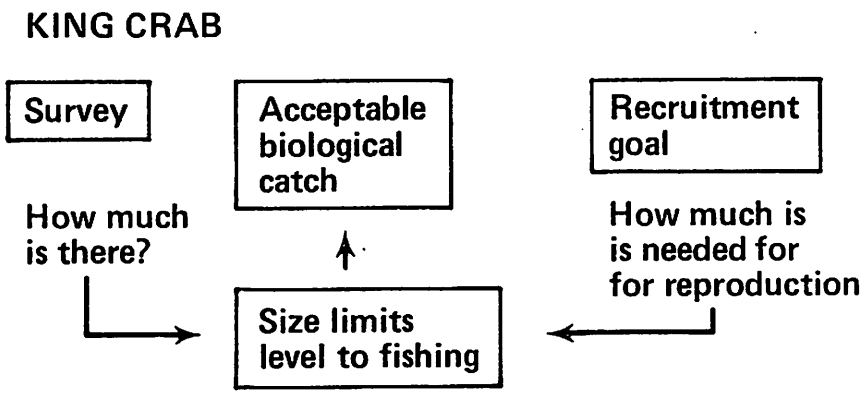
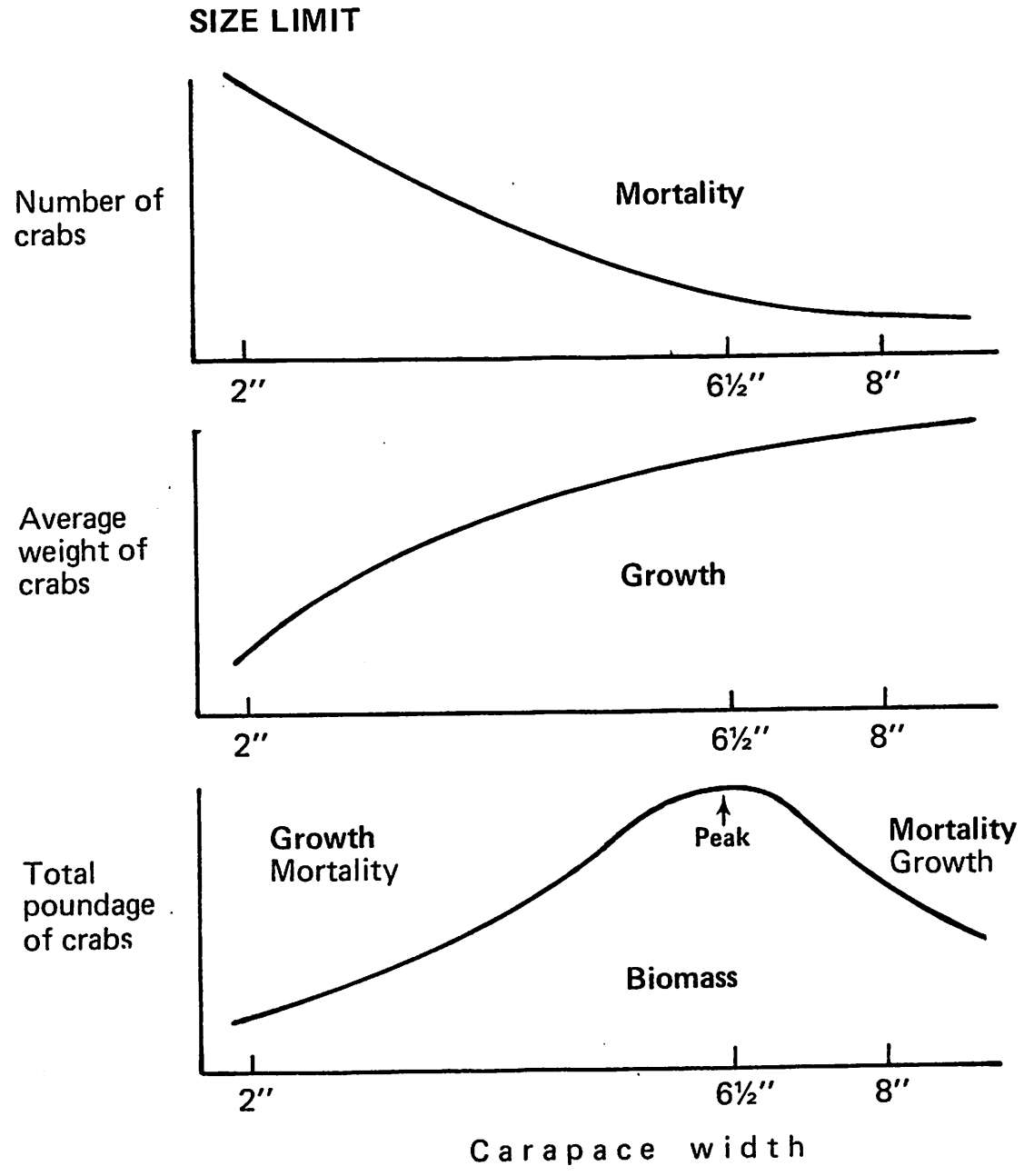
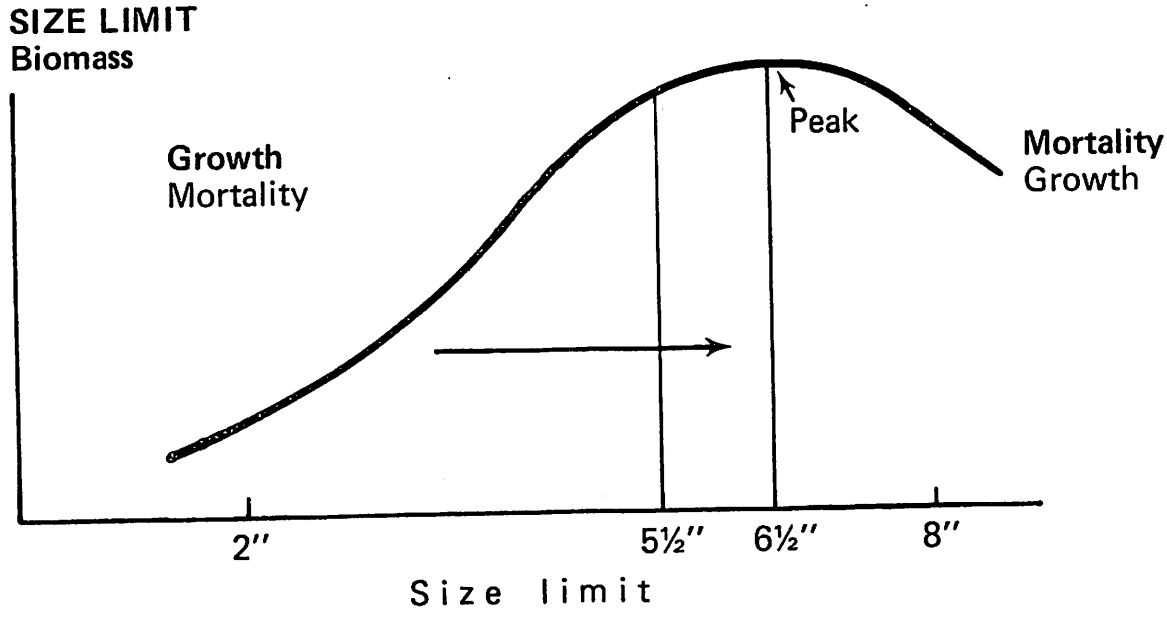


- Several factors go into determining the annual catch.

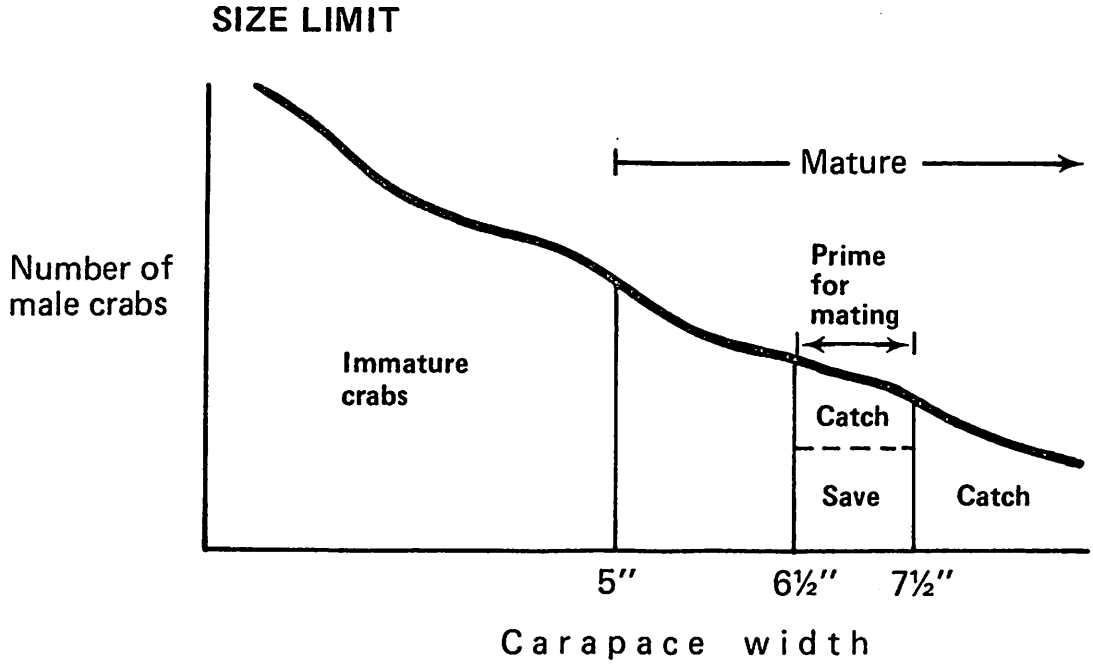


- Size limits may also serve to increase total poundage of catch.

- The biomass of recruits peaks at the size where the growth rate equals the mortality rate.

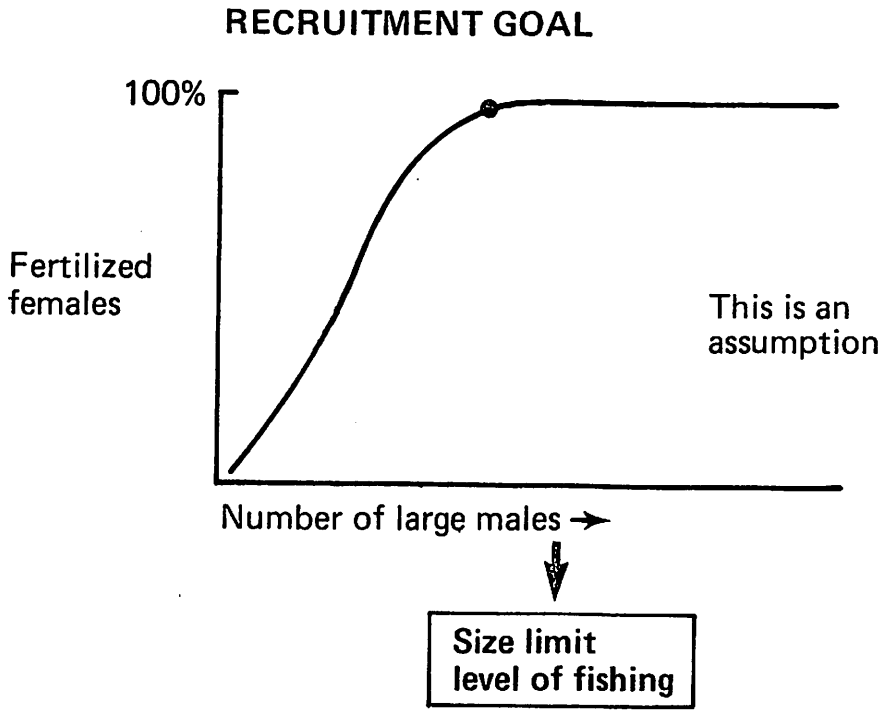


Setting the size limit at the peak of biomass requires a very high fishing level. When the fishing level is not high, a lower size limit should be set.



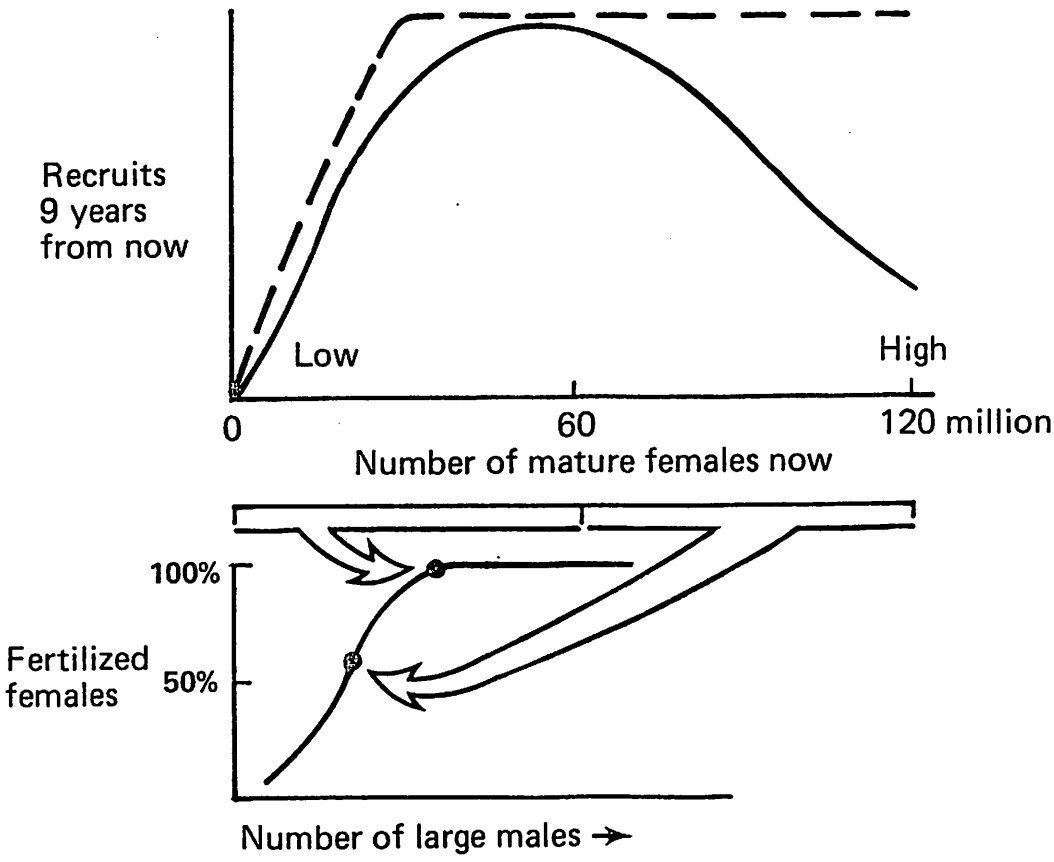
Size limits may serve to protect reproduction.

The assumption here is that recruit male crabs are vital to the mating process.

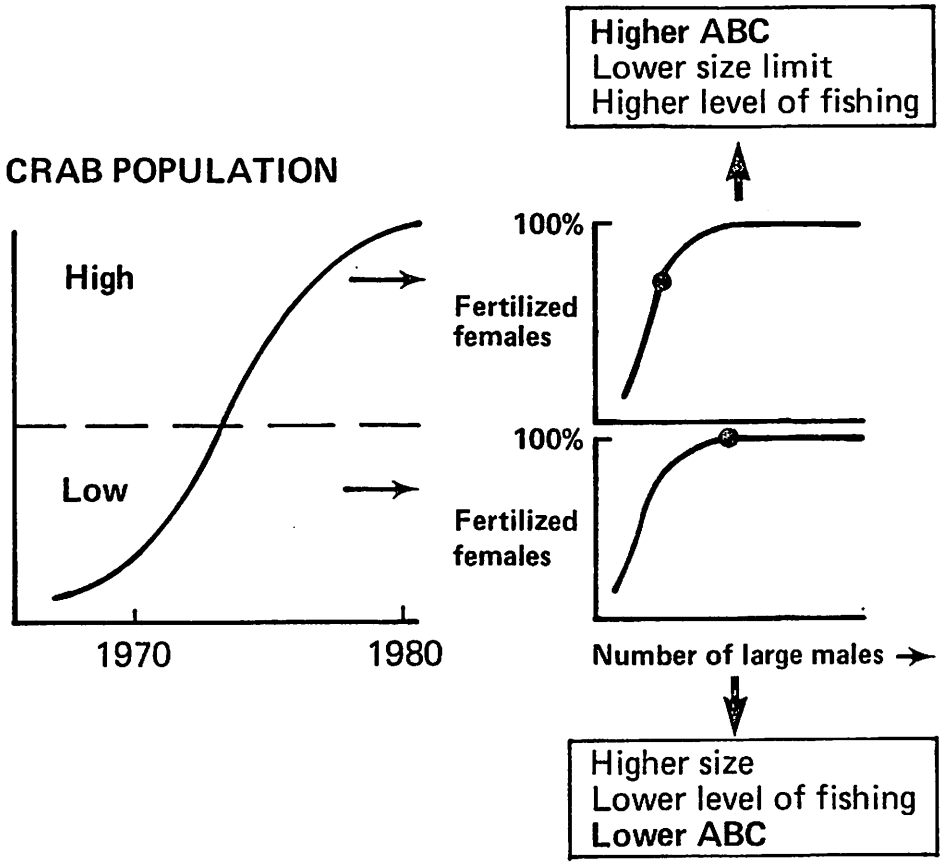


Here the goal is to maintain the largest possible number of fertilized females.

RECRUITMENT GOAL--NEW ELEMENT
Spawner—recruit curve



- Here the goal is to maintain the required number of fertilized females.



- Size limits and level of fishing will change as the population changes.

POSSIBLE QUOTAS (millions of pounds)

		Level of fishing (percent mortality)			
		20	**40**	**60**	**80**
Size limit	7″	30	50	75	100
	6.5″	45	85	125	170
	6″	55	105	160	210
	5.5″	60	115	170	230
	5″	65	120	180	240

- The enclosed quotas are unacceptable because reproduction may be impaired.

POSSIBLE QUOTAS

High population

		Level of fishing			
		20	**40**	**60**	**80**
Size limit	7″	30	50	75	100
	6.5″	45	85	125	170
	6″	55	105	160	210
	5.5″	60	115	170	230
	5″	65	120	180	240

Low population

Size limit	7″	30	50	75	100
	6.5″	45	85	125	170
	6″	55	105	160	210
	5.5″	60	115	170	230
	5″	65	120	180	240

- Choices of possible quotas will increase or decrease as the population increases or decreases.

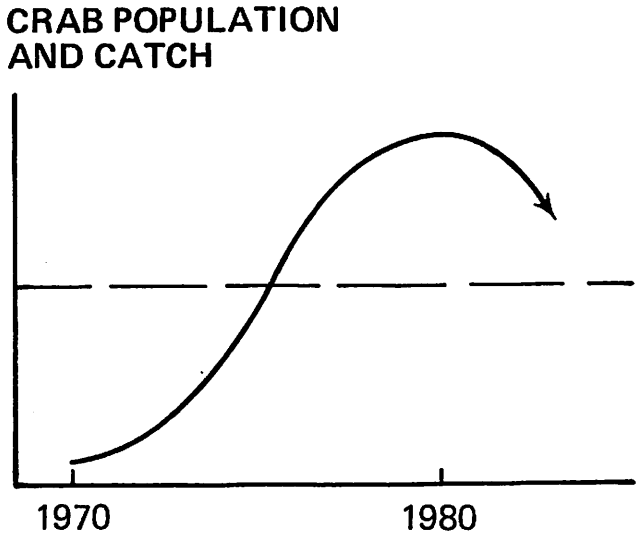
POSSIBLE QUOTAS (millions of pounds)

		Level of fishing 20	40	60	80
Size limit	7″	30	50	75	100
	6.5″	45	85	125	170
	6″	55	105	160	210
	5.5″	60	115	170	230
	5″	65	120	180	240

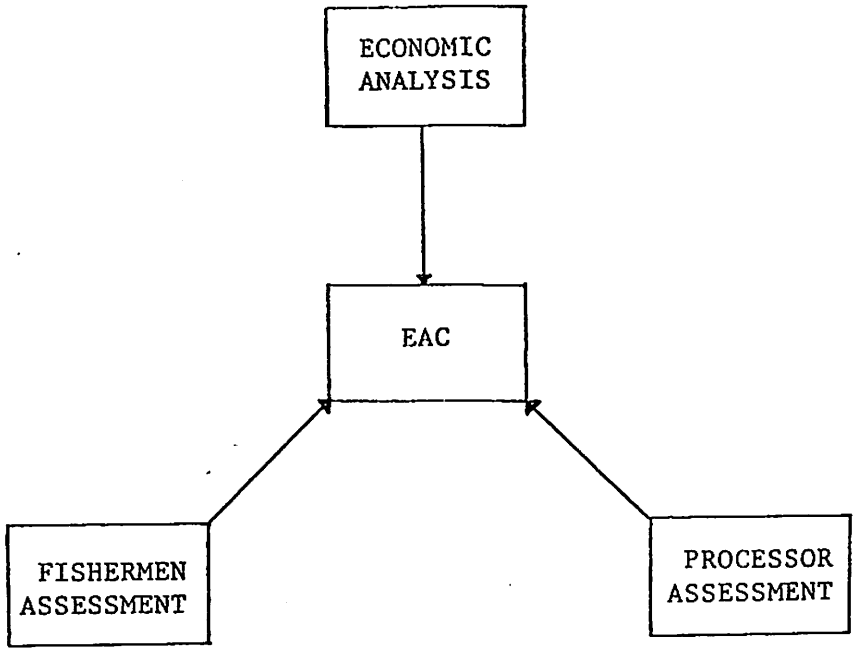
SEASON CPUE (crabs per pot-lift)

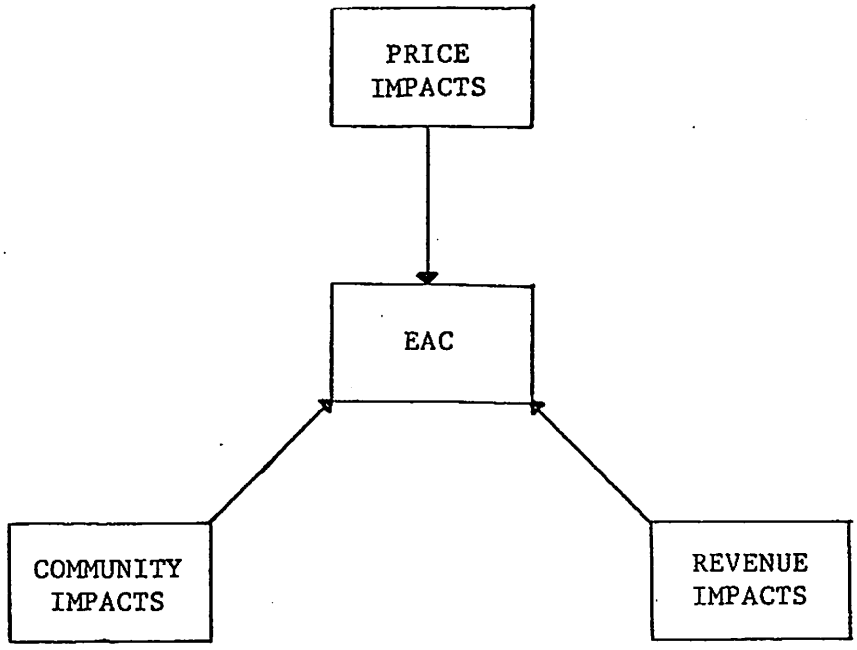
Size limit	7″	31	22	18	13
	6.5″	46	37	30	23
	6″	56	45		
	5.5″				
	5″				

CPUE information may aid in deciding the actual quota for any year.



- Survey data indicate the red king crab population in Bristol Bay will decrease in the next two years.


ECONOMIC ANALYSIS
EAC
FISHERMEN ASSESSMENT
PROCESSOR ASSESSMENT


PRICE IMPACTS
EAC
COMMUNITY IMPACTS
REVENUE IMPACTS