BIOLOGICAL PERSPECTIVES ON CRAB MANAGEMENT IN ALASKA:

AN ORAL REPORT TO THE ALASKA BOARD OF FISHERIES

By
Gordon H. Kruse

Regional Information Report No. 5J93-02
Alaska Department of Fish & Game
Division of Commercial Fisheries
P.O. Box 25526
Juneau, Alaska 99802-5526

January 31, 1993

BIOLOGICAL PERSPECTIVES ON CRAB MANAGEMENT IN ALASKA:

AN ORAL REPORT TO THE ALASKA BOARD OF FISHERIES

By

Gordon H. Kruse

Regional Information Report[1] No. 5J93-02
Alaska Department of Fish & Game
Division of Commercial Fisheries
P.O. Box 25526
Juneau, Alaska 99802-5526

January 31, 1993

[1]The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. . These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries.

FORWARD

We thought that we would begin the Board meeting with an overview of biology and management of crabs in Alaska. This talk is similar to a presentation that I have given at a couple of recent scientific meetings. One meeting was the *International Symposium on Management Strategies for Exploited Fish Populations* in Anchorage during October 21-24, 1992, and the other was the annual meeting of the Alaska Chapter of the American Fisheries Society in Valdez, Alaska, during November 16-19, 1992.

The presentation is based on a scientific manuscript accepted for publication in the *Proceedings of the International Symposium on Management of Exploited Fish Populations* (Kruse 1992). This Regional Information Report constitutes a much less technical version of that scientific manuscript. In essence, it is meant to serve as a written transcript of the oral presentation delivered to the Alaska Board of Fisheries at its meeting in Anchorage during February 2-10, 1993. Copies of the presentation slides appear in the back of this report.

CRAB SPECIES

There are six primary species of crabs in Alaska that contribute to commercial landings [slide 1]. There are three species of king crabs: red *(Paralithodes camtschaticus)*, blue *(P. platypus)* and golden king crab, *(Lithodes aequispinus,* otherwise locally known as "brown" king crab). We have two species of the genus *Chionoecetes*: Tanner crab *(C. bairdi*, otherwise referred to as "bairdi") and the snow crab *(C. opilio*, otherwise referred to as "opilio"). You will sometimes hear the terms *bairdi* Tanner crab and *opilio* Tanner crab, but scientists prefer the "recognized" common names of Tanner crab and snow crab. Our sixth major commercial species is the Dungeness crab *(Cancer magister)*.

HISTORY OF FISHERIES

I'd like to give an overview of the history of landings for these six species. I'll be showing fives slides [slides 2-6]. In each case, I'd like to emphasize the trends in landings. Please note that the units of the catches vary in each slide.

In the first of these, red and blue king crabs have been plotted together, but bear in mind that red king crabs constitute the majority of these landings [slide 2]. Note for example, that the Kodiak red king crab fishery built to peak landings in the mid-1960s, declined significantly in the late 1960s, and then more or less stabilized at much lower levels until the 1980s when the fishery crashed. The fishery has been closed since the 1983-1984 season due to extremely depressed stock abundance.

Partly in response to declining landings in the Kodiak fishery in the late 1960s, the domestic fishery for red king crabs in Bristol Bay developed. Landings from this fishery built steadily through the 1970s and peaked at 60,000 tonnes (130 million pounds) in 1980. Then, catches declined very rapidly, and this fishery was closed for one year in 1983 due to low abundance. In recent years this fishery has been conducted, but catches have been maintained at relatively low levels.

Most of the fisheries for other stocks of red and blue king crabs were maintained over approximately a 20 year period before they, too, crashed. Most of these fisheries remained closed due to very low stock abundance.

The declines of fisheries for red and blue king crabs, in part, stemmed the growth of markets and fisheries for Tanner crabs [slide 3]. In most areas of the state, landings built through the mid- to late 1970s. Fisheries for these Tanner crab stocks experienced declining landings from the late 1970s through the 1980s. Many of these fisheries produce low landings today, and some are closed due to depressed stocks. One major exception to this is the Tanner crab fishery in the Bering Sea, which peaked at 30,000 tonnes (66 million pounds) in the late 1970s, declined with the other Tanner crab stocks, but rebounded toward the end of the 1980s.

Dungeness crab fisheries offer much more contrast to patterns in landings for king and Tanner crabs [slide 4]. Note, for example, that fisheries for Dungeness crabs in Southeast Alaska, Yakutat, and Kodiak have experienced pronounced cycles in abundance over time. Generally speaking, these stocks have remained rather healthy for more than 3 decades. However, landings have always been rather low in all other areas of the state. In some areas (e.g., lower Cook Inlet and most of Prince William Sound), fisheries have been closed due to depressed stocks. So, we have a rather wide range in abundance and landing trends in fisheries for Dungeness crabs as compared to king and Tanner crabs.

There are two crab species that are now producing significant landings. The first of these is the golden king crab [slide 5]. Fisheries for golden king crabs developed with the demise of fisheries for other king crab species. Recall that all fisheries for red and blue king crabs crashed in the early 1980s: this marked the beginning of the golden king crab fisheries. Thus, fisheries on golden king crabs have a very short harvest history.

The species currently producing the greatest landings is the snow crab [slide 6]. In part, this fishery grew in response to the decline of fisheries for Tanner crab. The snow crab fishery reached 74,000 tonnes (162 million pounds) by 1990, and grew further to 150,000 tonnes (328 million pounds) in 1991. This is the single largest crab fishery in Alaska and in the world today.

CRAB MANAGEMENT

Alaskan crab management can be divided into four types of strategies [slide 7]. There are those fisheries that we manage by *exploitation rate*. For such fisheries, we survey stock abundance, and generate a guideline harvest level (catch "quota") based on an exploitation rate policy. Another strategy that we use is *fishery performance*. Typically, in this case we do not have an abundance survey, but often we have other information on stock status from the catch data such as size distributions or even catch per unit effort as a measure of relative abundance. These might be fisheries that we manage with guideline harvest ranges that are based on fishery performance.

The other two types are *2-S* or *3-S*, where the S's refer to size, sex, and season, respectively. A 3-S fishery harvests males only above a certain minimum legal size during specified fishing seasons. In the case of 2-S management, there is no biologically-based prohibitions on fishing seasons.

I would like to give a few examples of fisheries that fit into these categories [slide 8]. Note that most of the red and blue king crabs fisheries are managed by exploitation rate strategies. Many fisheries for Tanner and snow crabs are managed in this way, as well.

Some of the red king and Tanner crab fisheries and a few golden king crab fisheries are managed by fishery performance. A few king and Tanner crab fisheries and some Dungeness crab fisheries are managed by a 3-S strategy. Most Dungeness and golden king crab fisheries are conducted during the molting and mating periods. Thus, they are regulated by 2-S management.

I would like to point out that, while we have four basic strategies, there are three common threads or cornerstones to our management programs for crabs in Alaska. These are the size, sex and season regulations [slide 9]. Even in the case of exploitation rate management or fishery performance, size-sex-season are used. Certainly, there are a variety of other measures that we use (e.g., legal gear, observers, thresholds), and I do not want to downplay their importance.

There is a rather long history of usage for size, sex and season regulations [slide 10]. For example, in the Kodiak red king crab fishery, sex restrictions that prohibited female harvest were in place since the start of that fishery in 1938. Size limits were first instituted in 1949: that is, males only above some minimum size can be taken legally. Since the 1960s, managers began using fishing seasons. In particular, fishing was prohibited during the "biological sensitive periods" that include molting and mating.

I would also like to point out that most crab research studies, i.e., investigations into biology and life history, have been done since the 1960s. So, it is rather ironic that we happen to have a situation in which the cornerstones (size-sex-season) to our management programs have been established prior to the conduct of most of the relevant research. Certainly, research has had effects on regulatory changes over time, but the cornerstones to crab management have remained virtually unchanged since their inception.

PURPOSE

With those observations in mind, I ask the following question: "How would we design crab management today, if we had all the benefits of this 30 years of crab research, without the impediments of being entrenched in these management frameworks [slide 11]?" In other words, if we had started from scratch, what kind of management program would we have built?

The goal of my talk is first to try to bring together some of the key biology and life history features of these crab species. And secondly, based on this synthesis, I then suggest some new directions and perspectives on fishery management [slide 12].

CRAB CLASSIFICATION

There is no need to go into all of the details of crab classification here. But, it is worth noting that not all crabs are created alike. There are two, basic "types" of crabs [slide 13]. There are brachyurans which are the "true" crabs. These include Tanner, snow and Dungeness crabs and these are grouped with other species such as the blue crab of the east coast.

On the contrary, the king crabs are anomurans and are grouped with other species such as the hermit crab. I will show later that this is a lot more than just semantics, and that there are some very fundamentally different biological and life history features that go along with classification into these two groups. Further, these features have some profound implications on fishery management.

BIOGEOGRAPHY

One aspect worth considering is biogeography [slide 14]. It is a basic principle of biogeography that animals tend to be most abundant in portions of their range that have optimal habitats. This has an important implication on fisheries. It follows that fisheries that occur on stocks that reside near the geographic limits of a range of a species tend not to sustain high harvest levels.

As you might expect, there are a number of Alaskan crab stocks that live near the geographic limits of the range of the species [slide 15]. These include Norton Sound red king crabs at the northern limits of the range for this species. Blue king crabs reside at the southern end of their range in Southeast Alaska. Dungeness crabs in Prince William Sound, lower Cook Inlet, and along the Alaska Peninsula and Aleutian Islands occur at the extreme northern and western limits of the range for that species. I will point out implications of these distributions later in my report.

r AND K SELECTION

There is an area of biology that has some general implications to fishery management. To discuss these, I first need to define r and K selection [slide 16]. Ecologists tend to think of species residing along a spectrum. The two ends to this spectrum are occupied by r-selected species and K-selected species. The r species tend to be those that are very opportunistic. They don't live very long, they reach small sizes only, they reproduce once, and they grow very rapidly. Good examples of r-selected species are most terrestrial insects.

On the other hand, we tend to think of K-selected species as being more competitive. These species tend to live longer lives, they achieve large sizes, they reproduce multiple times and often have complex reproductive strategies, and they develop slowly. Good examples of K-selected species are most terrestrial mammals, including humans.

There are a number of attributes of r- and K-selected species that have relevance to fisheries [slide 17]. Age at which animals mature, for example, tends to be young for r-selected species. These species also tend to have low maximum ages, high annual mortality rates, and high egg production or "fecundity." On the contrary, K-selected species tend to have the opposite attributes.

I considered these four features with respect to red king, Tanner, and Dungeness crabs in Alaska [slide 18]. Age of maturity is rather similar (6-7 years of age) for red king and Tanner crabs, but Dungeness crabs tend to mature younger -- around age 3. Maximum age ranges from no more than 8 years for Dungeness crabs to more than 20 for the red king crab. Red king and Tanner crabs experience similar, moderate levels of annual mortality, which perhaps averages around 26% per year. There is a wide range in estimates of annual natural mortality rates for Dungeness crabs, but the average mortality rate of Dungeness crabs is greater than those of red king or Tanner crabs. Red king and Tanner crabs similarly produce up to half a million eggs, whereas Dungeness crabs produce up to 2.5 million eggs.

These attributes were considered in terms of r and K selection [slide 19]. I would place red king crab at the K end of the spectrum, Dungeness crab at the r end of the spectrum, and Tanner crabs somewhere in the middle. While I have not explicitly considered blue and golden king crabs nor snow crabs here, I would say the other king crab species would probably reside toward the K end of the spectrum with red king crabs, and snow crabs would fall somewhere in the middle with Tanner crabs.

It is important to realize that these r and K determinations are all very relative. Red king crabs are not nearly as K selected as, say, the Pacific Ocean perch that live to very old ages. Likewise, the Dungeness crab is not nearly as r selected as, say, the Atlantic blue crab that live to ages 2-4 only.

There are some general implications of r and K selection on fisheries [slide 20]. Generally, r-selected species tend to be very tolerant of very high fishing mortality, and yield per recruit (i.e., pounds per crab corrected for survival) tends to be maximized at a young age. Fisheries on these stocks tend to be productive, and stocks often recover quickly from overharvest.

The opposite it true for K-selected species. These tend to tolerate only low levels of fishing mortality, and yield per recruit tends to be maximized at older ages. Last, these stocks are much more vulnerable to overfishing and they recover slowly.

REPRODUCTION

Crab biologists consider three different measures of maturity for males [slide 21]. There is a *physiological maturity* which is the size at which they first begin to produce spermatophores. *Morphometric maturity* occurs at the size that a large chela (claw) is developed which may play an important role in reproduction. *Functional maturity* occurs at the size at which males first begin to participate in reproduction in the natural environment.

There are some reproductive benefits of large size [slide 22]. We know, for example, that functional maturity is always larger than physiological or morphometric maturity. We do not necessarily understand why this is, but the point is that it is the large males that tend to be most significant in reproduction. So, there is some advantage bestowed to large males, because they don't necessarily reproduce once they begin to produce sperm nor when they first develop a large claw.

In some species, females may require large males for reproduction. These large females may simply go unmated if there aren't large males available. Large males may mate with multiple females, whereas the small males may not be able to do so effectively. In addition, small males may have difficulty fertilizing a female's full egg clutch.

How many opportunities do males have to mate? I already pointed out that functional maturity is larger than morphological maturity. Also, I want to point out that, in the past, it has been the Board's desire to set the legal size limit at 1-2 molts above size of maturity. One problem is that these have generally been based on morphological maturity. However, if we consider maturity to be functional maturity, then we find that, for red king crabs, legal size is nearly the same as size of maturity [slide 23]. So, a functionally mature red king crab off Kodiak does not have any opportunities to mate prior to becoming vulnerable to fishing. On the other hand, for Tanner and Dungeness crabs there is a "safe window" within which males become functionally mature and yet still have to molt once more before they become of legal size.

So, how many mating seasons are afforded to these crabs before they become harvestable size? There are none for red king crabs, because functionally mature crabs are already of legal size. But, additionally, red king crabs molt annually up to legal size. On the other hand, once Tanner and Dungeness crabs become mature, they tend to skip-molt or miss a year or more before molting again to legal size. So, males of these two species might have an extra year as mature, sublegal crabs before being recruited to the fishery, and they may have some added breeding chances compared to red king crabs.

There is another reproductive feature that is traceable to crab classification. This feature is sperm storage. We find that female brachyurans (e.g., Tanner and Dungeness crabs) possess abdominal receptacles that allow them to store sperm. Thus, males can inseminate them, and the females can save that sperm for use in subsequent egg extrusions to fertilize eggs up to two years later. On the other hand, with respect to anomurans (e.g., king crabs), males must be physically present when the female extrudes eggs in order for fertilization to take place. So, sperm storage capacity seems to be another advantage bestowed to the brachyurans compared to the anomurans.

GENETIC SELECTION

Another aspect deserving of attention is genetic selection [slide 24]. Recall that we have size limits for males, and in some cases we have rather high harvest rates on those large males. These two features are the ingredients for genetic selection to occur. When we use a size limit, we have the potential to selectively remove the fastest growing crabs from the population. When we have a high harvest rate, we increase the rate of selection. Obviously, crabs that grow faster (larger growth increments or higher molting probabilities) reach legal size sooner, and so they will be vulnerable to more years of fishing pressure.

It turns out that growth has a genetic component, so we can actually genetically select against fast growth and for slow growth. Additionally, growth tends to be linked to other features, such as fecundity and maturity. The main point is that fisheries with high harvest rates and size limits can actually select for population characteristics that lead to low productivity through time. That is, we can actually change the long-term productivity of our crab populations through genetic selection.

CAPTURE AND HANDLING EFFECTS

Capture and handling effects are important considerations in crab fisheries [slide 25]. I'm not going to go into this in any great detail, but the topic deserves serious attention. Again, recall that we have size limits and sex restrictions. Yet, our pot gear tends to capture crabs of various sizes of both sexes. These animals interact in the pots, and the pots get retrieved to the surface aboard the vessel. The females and sublegal males get sorted on deck and tossed overboard. This sequence of events can create a variety of lethal and sublethal effects that may influence the productivity of our fisheries. I term *catching mortality* as those deaths that occur within the pots prior to retrieval, *ghost fishing mortality* are deaths that occur in lost pots, and *handling mortality* are deaths that occur due to stress or injuries incurred during the sorting/discarding process. Sublethal effects include limb loss, reduced feeding rates, reduced growth, and loss of vision. So, it could well be that size and sex restrictions are causing some adverse effects on our crab stocks.

RECOMMENDATIONS

With that brief overview, I offer some recommendations. The first of these is that management should probably be most conservative for king crab fisheries and could be most liberal for fisheries on Dungeness crabs [slide 26]. To a large extent, this is based on our review of r and K selection. That is, king crabs, being most K selected, are probably least likely to tolerate high harvest rates. Whereas, Dungeness crabs, being most r selected, can probably better tolerate higher rates of exploitation. Recall the persistent cycles in Dungeness crab landings [slide 4]. Such cycles suggest some resilience of these stocks to overharvest.

Yet, management should probably be somewhat more conservative for Dungeness crab fisheries in Alaska than for Dungeness crab fisheries along the Pacific northwest coast. This is due to geographic variation in those key life history parameters. For example, Alaskan Dungeness crabs mature later, live longer, and probably have lower annual natural mortality rates than their counterparts to the south. So, they might tend to be somewhat more K-selected and more vulnerable to overfishing than stocks of

Dungeness crab residing along the Pacific northwest.

Management should be most conservative for fisheries on stocks of crabs that are at or near the geographic limits of the species' range. These include Norton Sound red king crabs (northern limits), blue king crabs in Southeast Alaska (southern limits), and Dungeness crabs in Prince William Sound, lower Cook Inlet, and along the Alaska Peninsula and Aleutian Islands (northern and western limits).

We should re-evaluate size limits [slide 27]. To do so, I argue that we need to consider size of functional maturity not morphological or physiological maturity. As I pointed out earlier, in the past it's been the Board's desire that legal size limit shall be 1-2 molts above size of maturity. But, because size of maturity has often been based on morphology, we have not necessarily provided a 1-2 molt buffer to those males that actually participate in reproduction.

Growth increment and molting probability are also important in considering size limits. How much does a crab grow each year, and does it grow every year? How much time does a crab spend as a mature crab before it molts to legal size? As we've seen with the Dungeness and Tanner crabs, species that begin to skip molt just prior to attaining legal size may have additional mating opportunities beyond those afforded to the king crabs.

Sperm storage appears to bestow reproductive advantages. This capability is one of the features that separates the brachyurans which have it and the anomurans which don't. We should consider the benefits of large body size, and the very real possibility that it is the largest males that are the most valuable to reproduction. Also, genetic selection needs to be considered when we re-evaluate size limits.

We should consider the merits of a female harvest. To do so, we should evaluate what effects our single-sex fisheries are having on sex ratio, and the implications of altered size distributions of spawning stocks. What happens to the largest mature females during fisheries for large males? Can they find mates?

Gear modifications should be made to reduce the catch of non-legal crabs so that we can minimize capture and handling effects [slide 28]. There are a number of options, and the Board will be hearing about some of these things a bit later in the meeting. As an alternative, we might even consider a very different management approach: abandon size and sex limits altogether, and institute a "keep what you catch" policy. I certainly would not advocate this for fisheries managed by 2-S or 3-S strategies. But, in cases where we have good abundance estimates, this may be a possibility worth considering. It may be a way to virtually eliminate capture/handling effects, and reduce genetic selection. If an exploitation rate policy is maintained, we could actually increase the abundance of large males thus better preserving the natural size structure and sex ratio of the population. Certainly, such a change in management strategy would need to be very carefully weighed. Not only are there biological considerations, but economic factors (e.g., market effects) are very important.

Just as we have done for the king, Tanner and snow crabs, we should seriously consider seasonal closures for Dungeness crab fisheries during the molting and mating periods. This is a very sensitive period in the life history of Dungeness crabs when they are most vulnerable to handling mortality and cannibalism in pots.

Lastly, as we begin to reconsider some of the bases for our management of crabs, research needs to play a very integral part in these changes. Handling effects and genetics should be further investigated. Also, there are some very important features that regulate stock productivity that we really don't know much about, including annual mortality and growth. It is rather distressing that the two species (snow crab and golden king crab) that currently sustain some of our most significant fisheries are the same species that we know the very least about. Can we avert crashes of these stocks?

At present, we're working on some of these areas of crab research. So, we hope to be able to come forward with some concrete proposals for management changes in the not-so-distant future. We want to seriously consider fishery management alternatives, because of the long history of crab fishery collapses with past strategies and because we want to promote the healthiest fisheries possible for many years to come.

LITERATURE CITED

Kruse, G.H. 1992. Biological perspectives on crab management in Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Professional Paper 071, Juneau.

BIOLOGICAL PERSPECTIVES ON CRAB MANAGEMENT IN ALASKA

COPIES OF PRESENTATION SLIDES

Gordon H. Kruse
Alaska Department of Fish and Game
Juneau, Alaska U.S.A.

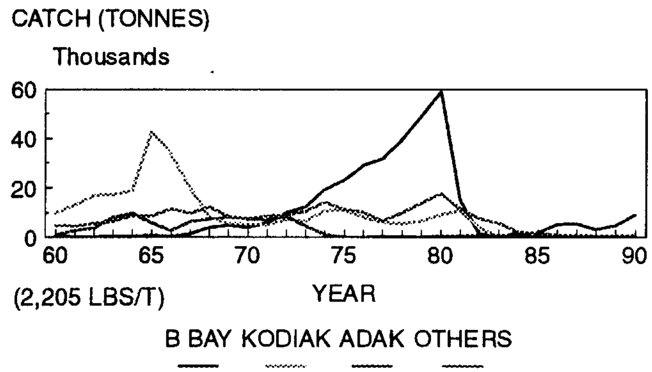
1

MAJOR COMMERCIAL SPECIES

Red King Crab (PARALITHODES CAMTSCHATICUS)
Blue King Crab (PARALITHODES PLATYPUS)
Golden King Crab (LITHODES AEQUISPINUS)
Tanner Crab (CHIONOECETES BAIRDI)
Snow Crab (CHIONOECETES OPILIO)
Dungeness Crab (CANCER MAGISTER)

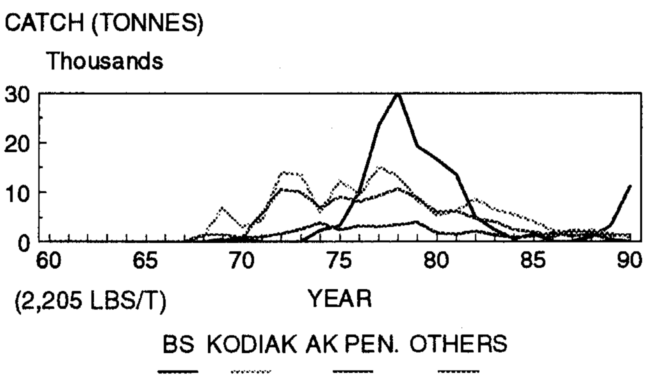
2

RED & BLUE KING CRABS



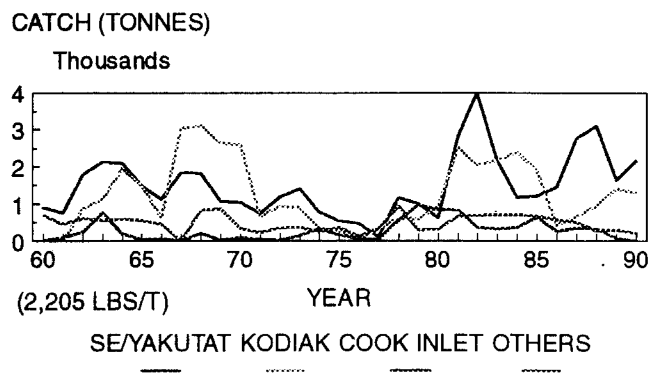
3

TANNER CRAB



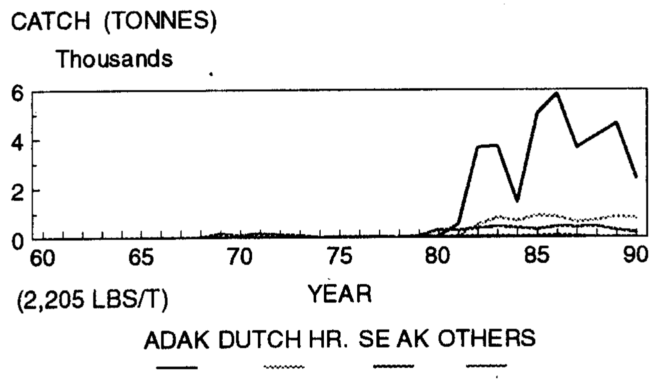
4

DUNGENESS CRAB



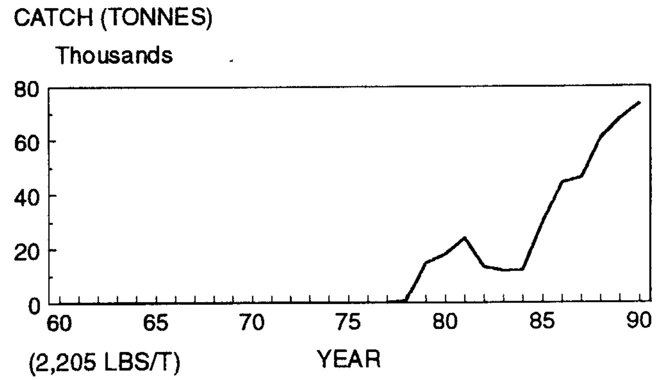
5

GOLDEN KING CRAB



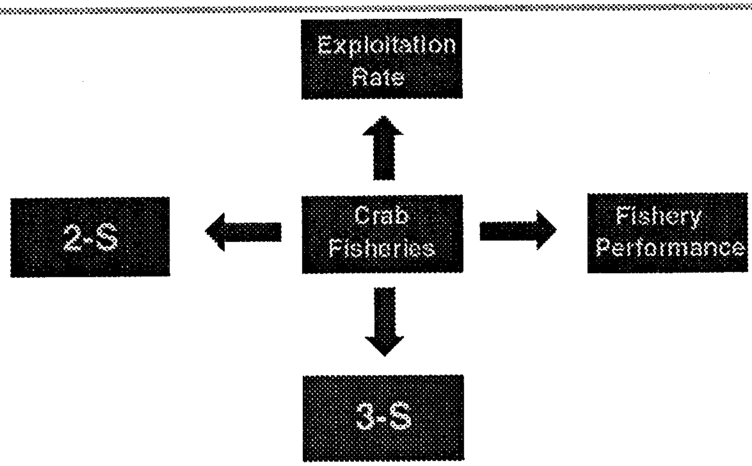
6

SNOW CRAB



7

CRAB MANAGEMENT STRATEGIES



8

CRAB MANAGEMENT STRATEGIES

EXPLOIT. RATE:

- Many Red King Crabs
- Many Blue King Crabs
- Many Tanner Crabs
- All Snow Crabs

3-S:

- Few Red King Crabs
- Few Tanner Crabs
- Some Dungeness Crabs

FISH. PERFORM.:

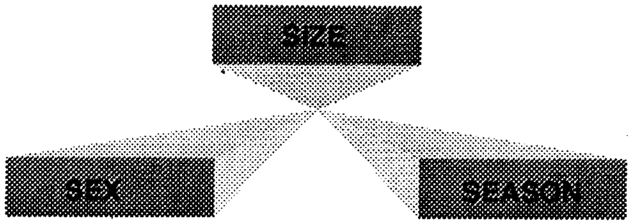
- Some Red King Crabs
- Some Tanner Crabs
- Few Golden King Crabs

2-S:

- Most Dungeness Crabs
- Most Golden King Crabs

9

MANAGEMENT MEASURES



OTHERS: LEGAL GEAR, OBSERVERS, POT LIMITS, GUIDELINE HARVEST LEVELS, THRESHOLDS, ETC.

10

MANAGEMENT PRECEDENCE

Kodiak Red King Crab Fishery:

- 1938 - Sex Restrictions
- 1949 - Size Limits
- 1960s - Fishing Seasons

11

QUESTION: ?

How would we design crab management, if we had the benefits of 30 years of crab research without the impediment of entrenched management frameworks?

12

GOAL

1. Synthesize Key Biology and Life History Features of Alaskan Crabs
2. Suggest New Directions and Perspectives on Fishery Management

13

CRAB CLASSIFICATION

BRACHYURANS:

Tanner Crab

Snow Crab

Dungeness Crab

Blue Crab

ANOMURANS:

Red King Crab

Blue King Crab

Golden King Crab

Hermit Crab

14

BIOGEOGRAPHY

PRINCIPLE:

Animals are most abundant in portions of their range with optimal habitats.

RELEVANCE TO FISHERIES:

Fisheries on stocks near the geographic limits of a species tend not to sustain high harvests.

15

SELECTED RANGE LIMITS

RED KING CRAB:

Norton Sound

BLUE KING CRAB:

Southeast Alaska

DUNGENESS CRAB:

Prince William Sound, lower Cook Inlet, Alaska Peninsula, Aleutian Islands

16

r AND K SELECTION

- r SELECTED SPECIES -
  - OPPORTUNISTIC LIFESTYLES (SHORT LIVES, SMALL SIZE, ONE-TIME REPRODUCTION, RAPID DEVELOPMENT
  - E.G., INSECTS
- K SELECTED SPECIES -
  - COMPETITIVE LIFESTYLES (LONGER LIVES, LARGE SIZE, MULTIPLE REPRODUCTIONS, SLOWER DEVELOPMENT)
  - E.G., MAMMALS

17

ATTRIBUTES OF r AND K SPECIES

	r	K
AGE OF MATURITY	Low	Hi
MAXIMUM AGE	Low	Hi
ANNUAL MORTALITY	Hi	Low
EGG PRODUCTION	Hi	Low

18

BIOLOGY & LIFE HISTORY TRAITS

	RKC	TC	DC
AGE OF MATURITY	Old (7)	Old (6-7)	Med (3)
MAXIMUM AGE	V Old (>20)	Old (12-15)	Med (8)
ANNUAL MORTALITY	Med (26%)	Med (26%)	Hi (18-92%)
EGG PROD. (MILLIONS)	Med (0.004-0.5)	Med (0.005-0.4)	Hi (0.7-2.5)

19

SPECTRUM OF r & K SELECTION

K		r
Red King Crab	**Tanner Crab**	**Dungeness Crab**

20

r & K IMPLICATIONS

r Selected:	K Selected:
Tolerate high F	Tolerate low F
Max. Y/R @ young age	Max. Y/R @ old age
Productive fisheries	Vulnerable to overfishing
Rapid stock recovery	Slow stock recovery

21

WHAT IS MATURITY?

- PHYSIOLOGICAL MATURITY -
  - SPERM PRODUCTION
- MORPHOMETRIC MATURITY -
  - LARGE CHELA (CLAW)
- FUNCTIONAL MATURITY -
  - MATING PARTICIPATION

22

REPRODUCTIVE BENEFITS OF LARGE SIZE

- Size of functional maturity larger than sizes of physiological or morphometric maturity.
- Large females may require large males.
- Large males may mate with multiple females.

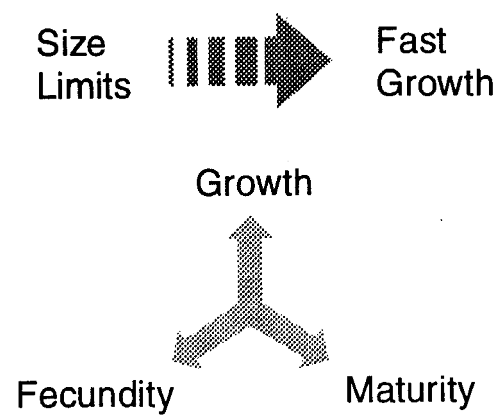
23

MATING CHANCES BETWEEN MATURITY & RECRUITMENT

	RKC	TC	DC
Molts to Legal	0	1	1
Mating Seasons	0	2	2
Sperm Storage	NO	YES	YES

24

GENETIC SELECTION



25

CAPTURE & HANDLING EFFECTS

LETHAL:	SUBLETHAL:
Catching Mortality	Leg Loss
Ghost Fishing	Reduced Feeding
Handling Mortality	Reduced Growth
	Loss of Visual Acuity

26

RECOMMENDATIONS

- Management: conservative for king crabs and liberal for Dungeness crabs.
- Management: more conservative for Dungeness crab stocks in AK than stocks in WA, OR & CA.
- Management: conservative for NS red king crab, SE AK blue king crab, and Dungeness crab in PWS, LCI, AP & AI.

27

RECOMMENDATIONS

- Size limits should be re-evaluated for:
  - Size of functional maturity
  - Growth increment & molt frequency
  - Sperm storage capability
  - Benefits of large body size
  - Genetic selection
- Consider female harvest
  - Sex ratio
  - Size of mating pairs

28

RECOMMENDATIONS

- Gear modifications to minimize catch of non-legal crabs or drop size/sex limits and institute "keep what you catch" policy.
- Create seasonal closures for Dungeness crab fisheries during molting and mating.
- Research on important unknowns: M, growth, handling effects, genetics, etc.

The Alaska Department of Fish and Game operates all of its programs and activities free from discrimination on the basis of race, religion, color, national origin, sex, or handicap. Because the department receives federal funding, any person who believes he or she has been discriminated against should write to: O.E.O., U.S. Department of the Interior, Washington, D.C. 20240.