OVERVIEW - BITTER CRAB DISEASE

Alaska State Legislature

HOUSE OF REPRESENTATIVES

REPRESENTATIVE FRAN ULMER

MEMORANDUM

TO: Rep. Lyman Hoffman, Chair
House Finance Subcommittee on AFG&G Budget

FROM: Rep. Fran Ulmer

DATE: January 29, 1990

RE: Funding for monitoring program for bitter crab disease in Tanner crab

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I am requesting an addition of $78.1 to the Commercial Fisheries component in the ADF&G budget for two programs dealing with the bitter crab disease.

Hematodinium , or bitter crab, as it is more commonly known, is a disease which makes tanner crab very bitter in taste and unable to eat. It is estimated that 90% of all tanner crab in the Northern Southeast area including Lynn Canal is infected with this disease at this time. The mortality rate is 100% and the disease is very infectious, so many of our most productive crab fishing areas in Southeast are becoming barren wastelands. For many years, crab fishermen who discovered the disease in their catch, simply threw the bad crab overboard, many times in an area different from where the crab were caught. We now know that the disease can spread through these dead, raw carcasses to otherwise good crab stocks. An increment of $51.1 is needed to determine acceptable means of disposing of infected crab, and to address the issue of the seasonality of the disease to determine if a change in the harvesting season could significantly reduce the incidence of unmarketable crab.

District 4B — Juneau
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Alaska State Legislature

REPRESENTATIVE BILL HUDSON

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COMMITTEES:
Transportation
Resources
Foreign Trade

FINANCE SUBCOMMITTEES
DOT/PF
C&RA

May 23, 1989

The Honorable Steve Cowper
Governor of Alaska
P.O. Box A
Juneau, AK 99811-0101

Dear Governor Cowper:

I am asking for your help in identifying the extent of a significant disease now affecting the northern Southeast Alaska tanner crab populations.

Mr. Joseph Donohue of Sitka Sound Seafoods and the M/V STORM FRONT identifies the observed problem of the "bitter crab" disease quite well in the attached paper dated March 23, 1989.

I would appreciate the Department of Fish and Game making some effort to analyze this apparent growing infestation and seeking some solution.

I realize the legislature didn't adequately fund the department for this research Governor, but the spread of this disease may jeopardize this entire crab fishery unless we move now.

Any help you can give will be appreciated.

Respectfully,

Bill

Bill Hudson

cc: Senator Duncan
Senator Eliason
Representative Goll
Representative Grussendorf
Representative Ulmer
Commissioner Collinsworth
Mr. Joe Donohue

BH/klc

January 23, 1990

Representative Bill Hudson
Alaska State Legislature
P.O. Box V
Juneau, AK 99811

Dear Representative Hudson:

Joe Donohue, Chairman of ASMI's Quality sub-committee on Bitter Crab Disease contacted me about a meeting on Monday, January 29th at 8:30 a.m. with you to discuss the status on the problem of bitter crab. I hope that the attached material is helpful in providing you with some background on the subject.

I look forward to meeting you.

Respectfully,

Kevin O'Sullivan
Quality Program Coordinator

Alaska Seafood Marketing Institute
P.O. Box DX
Juneau, Alaska 99811-0800
(907) 586-2902

PROJECT DESCRIPTION:

a) IDENTIFICATION OF THE PROBLEM

The Tanner crab (Chionoecetes bairdi and C. opilio) fishery in Alaska is a multi-million dollar industry which, as a result of the decline of king crab populations, represents the primary crab fishery remaining in Alaska. In Southeast Alaska this industry nets an annual worth of about $4 million dollars per year. The Bering Sea component of this fishery is vastly larger.

Since 1985, an increasing number of Tanner crabs from S.E. Alaska have been found to be infected with a parasitic dinoflagellate similar to Hematodinium sp. (known to infect blue crab on the east coast of the U.S.). In 1988 and 1989 an increasing number of crabs from the Bering Sea have also been found to harbor the parasite. This dinoflagellate causes a syndrome known as Bitter Crab Disease. Crabs affected with the syndrome have a pink carapace, milky hemolymph, and chalky-textured meat which has a distinctly bitter aspirin-like flavor. Such animals are non-marketable.

Unfortunately, fishermen discovered early on that they could identify infected crabs by the pink carapace and such crabs were then thrown overboard. This practice has resulted in the spread of the disease throughout S.E. Alaska and the Bering Sea. Some areas in the S.E. have an incidence of this disease as high as 100%. In 1985 Bitter Crab Disease was only found in the upper Lynn Canal. In 1986 it had spread to some locations in the S.E.. In 1987 it had spread to numerous additional locations in the S.E. and those regions previously identified as positive had a much higher incidence. In 1988, the disease was found in the Bering Sea and still more new locations in the S.E. previously thought to be negative have been found to be positive for the disease. Several areas in the S.E. are already closed to commercial Tanner crab fishing due to heavy infection rates of the parasite. At the rate the disease is spreading, more areas could be closed down in the near future due to the disease. This is a significant problem as many fisherman have permits to fish for both king and Tanner crab and they already have lost the ability to fish for king crab in many areas.

Processors have suffered significant economic losses in the past few years as a result of purchasing tainted crabs and then not being able to sell them. Now the fishermen are suffering as the processors will not buy crabs with visible signs of the disease. The Alaska Department of Fish and Game Commercial Fisheries Division has found that as much as 40-80% of the Tanner crab brought to the processors this season by S.E. fishermen is unmarketable due to this disease. This has resulted in a significant loss of revenue for the fishermen and a decrease in the effective catch per unit effort. The ADF&G Commercial Fisheries Division has estimated a loss of over 80,000 lbs of crab worth over $220,000 this season due to Bitter Crab Disease. These values do not include the number of diseased crabs sorted out by the fishermen prior to going tc the processors. Some fishermen were throwing away over 50% of their catches. Consequently this

$220,000 value could increase substantially if the amount of crab sorted out by the fishermen was included. The economic impact this disease has had on the industry in recent years appears to be increasing along with the increased incidence of infected crabs.

Some preliminary work on the pathogenesis of Bitter Crab Disease has been conducted within the last year. However, for a management plan to be made by ADF&G, much more information is needed. Just a few of the questions which need addressing include: is there a seasonality associated with the disease; what is the geographic distribution of the parasite and is the parasite in S.E. the same as that in the Bering Sea; what is the life cycle of the parasite; are other species of crabs susceptible to the infection. Processors need to know if they can market low level infected crabs. Consequently, the compound causing the bitter flavor and meat deterioration has to be identified and a correlation made between the level of infection, concentration of the compound and the quality of the meat.

The purpose of this project is to conduct a study of the parasitic dinoflagellate which causes Bitter Crab Disease in Tanner crabs. The study will involve determination of: the mortality rates and seasonality of the disease in wild populations of crabs in S.E. Alaska; seasonal incidence and intensity of the disease in Bering Sea Tanner crabs; the oxygen carrying capacity, glycogen levels and osmoregulatory capability of infected hemolymph; the effect of stressors on exacerbating the disease; what compound causes the bitter flavor and what concentrations are necessary to do so; how do these concentrations correlate with the arbitrary 1+, 2+, 3+, 4+, 5+ designations for degree of infection in crabs; and is the parasite in the Tanner crab in the Bering Sea the same as that in S.E. Alaska.

This project should be considered in the Alaska Region priority section (E.1.e.) as it involves disease control of a commercially important species. If the concerns mentioned above are not addressed and nothing done to manage the disease then the Alaska Tanner crab fishery will soon go the way of the Alaska king crab fishery. Nothing can be done to protect this fishery until we understand more about the parasite and the pathogenesis of the disease.

B) PROJECT GOALS AND OBJECTIVES

The study will provide basic knowledge concerning the biology and pathogenicity of the dinoflagellate causing Bitter Crab Disease. This information will be used by ADF&G to make management decisions concerning ways to reduce the spread and the incidence of the disease without hurting the industry. The project will also provide the industry with a "yardstick" so that they will know what degree of an infection in a crab will result in an unmarketable product and how to test for it. Thus, trained individuals could monitor suspected crabs for the processors much in the way that fruit and vegetable canneries have people on line who monitor the quality of the products being canned or frozen.

This information will be provided by addressing the following objectives:

1. Determine the mortality rate due to Bitter Crab Disease in wild crab populations from two regions most similar to the S.E. Tanner crab fishing grounds, such as Auke Bay, and Eagle River, AK.

2. Determine the seasonal incidence and intensity of Bitter Crab Disease from the Bering Sea and from Auke Bay, and Eagle River, AK. and the geographic distribution of the agent.

3. Determine the oxygen carrying capacity, blood glycogen levels and osmoregulatory capabilities of infected vs non-infected crabs.

4. Determine the effects that stressors such as overcrowding, handling and increases in freshwater or saltwater have on exacerbating the disease.

5. Determine what the compound is that causes the bitter flavor.

6. Determine what concentrations of this compound are necessary to cause the off-flavors and how these concentrations correlate with the existing 1+ to 5+ designations used to describe the severity of infection.

7. Conduct quantitative tasting panels using meat from crabs variously infected with the parasite to determine the marketability of low level to moderately infected crabs.

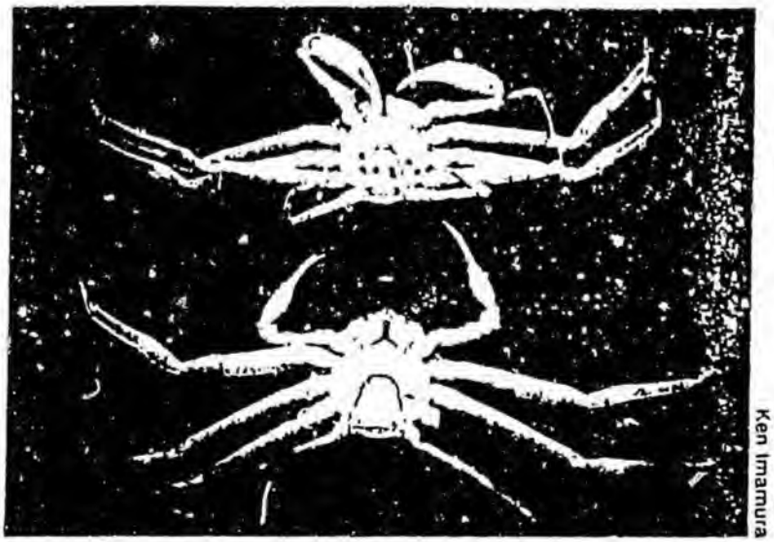
8. Determine if the parasite in the Bering Sea is the same as the parasite in the S.E.. This can be accomplished by simple DNA hybridization techniques.

It is difficult, if not impossible to assign any exact dates of results when experimenting with wild animals in a laboratory and when sampling animals in their natural habitat. Additionally, Bitter Crab Disease is a slow, chronically developing disease, not an acute one, consequently any work on such agents takes longer than with microbes causing acute diseases. Be that as it may, the dates listed should provide an approximate timeline to be used to evaluate the progress of the study.

The project should be completed 24 months after the start of the mark/recapture work in Auke Bay. The final report will be submitted within 2 months of completion of the project. The list below represents the work being conducted within that time:

Bitter Sweet Surprise

by Theodore R. Meyers



Ken Imamura

To some folks this title may suggest a recipe for a gourmet confection gone awry or perhaps an emotional tale of pleasure and woe. It is neither of the above but instead refers to a taste problem found in Tanner crab meats from certain harvest areas in Alaska's panhandle.

Some Southeast Tanner crab sport fishermen have had an unpleasant surprise when it came time to cook and eat their catch. At times the usual firm flesh with its sweet flavor has been replaced by a chalky meat having a bitter asprin-like aftertaste. Such crabs can be recognized beforehand by an exaggerated pink shell and milky appearing tissues and blood observed by cracking a walking leg.

The undesirable flavor and meat quality actually are clinical signs of "bitter crab disease" caused by a tiny single celled blood parasite belonging to the taxonomic group of microorganisms known as *dinoflagellates*. In general, dinoflagellates are a curious collage of organisms, most of which are photosynthetic and classified as algae. A few of these plant forms are also able to produce potent toxins responsible for "red tides" and paralytic shellfish poisoning. The Tanner crab dinoflagellate, however, is a rare parasitic type which is more like a protozoan than algae. Although distasteful, it is harmless if accidentally consumed by humans. Personnel from both the Fisheries Rehabilitation, Enhancement and Development (FRED) and Commercial Fisheries Divisions of ADF&G have been studying the bitter crab parasite for over a year to determine information about its life history and potential effect on Tanner crab populations.

The organism, although simple in appearance, has a complex life cycle involving three distinct forms: a vegetative stage and two different dinospore (or moving morphological) stages. The vegetative stage functions as a replicative form of the organism in the host and is a round nonmoving cell approximately two to three times the size of a crab blood cell. These vegetative stages cannot naturally infect other Tanner crabs but multiply to tremendous numbers within the blood of previously infected crab hosts. They eventually replace most of the blood cells and much of the normal crab tissues since crab blood normally travels some distance in open channels within all parts of the crab's body. Most Tanner crabs infected with the vegetative stages of the parasite die before the stages can develop into dinospores, a process called sporulation. When a crab host survives long enough to allow sporulation, all vegetative stages become transformed within a few days.

Two types of dinospores can occur but not both within the same crab host. One spore type is large and slow moving, while the other is a much smaller rapidly swimming spore. Both are propelled by two flagella (organ of movement). Dinospores are the end stages of the parasite and function to perpetuate its life cycle by escaping the old host and penetrating a new one. Once inside the new host, the spore(s) would conceivably germinate into a vegetative stage, thus completing the circle of life. A mystery yet remaining is whether both dinospore types are infectious. They may instead represent male and female cells which must first unite with each other outside the crab host to form the infectious stage of the parasite. In either case, sporulation kills the surviving crab host within one to two days, allowing escapement of dinospores into seawater when crab tissues decay.

Laboratory experiments have shown that all parasitized Tanner crabs die. However, the progression of the disease and host death may take from 6 to 10 months, a process which may be prolonged further by colder seawater temperatures. Consequently, some crabs may survive for more than one season in colder waters; and distribution of the parasite might be limited to the warmer latitudes in southeast Alaska.

The seasonality of bitter crab disease is still being investigated and it is not yet certain whether the life cycle of the parasite is completed within one year. As suggested by laboratory experiments, sporulation of vegetative stages and infection of other crabs by dinospores may occur in August and September when seawater temperatures average above 7°C. Vegetative stages developing from dinospores multiply within crab tissues producing the chalky meat and bitter flavor. By the following February or March commercial crab fishermen are able to detect visually those crabs affected by the disease. Some parasitized

Facing page: Tanner crabs infected with the bitter crab dinoflagellate exhibit an exaggerated pink shell color (bottom) when compared to healthy crabs (top).

A photomicrograph taken by a scanning electron microscope at high magnification shows droplets of an extracellular substance exuding from nonmoving vegetative stages of the parasite (left). These vegetative stages later sporulate into either the large (right) or small type (bottom) of biflagellated dinospore.

crabs would have to survive until August and September to allow sporulation to renew the cycle.

The parasite, while in the process of reproducing and feeding on crab host tissues and fluids, causes muscle fibers to break down, producing poor meat quality. Flavor becomes bland as a result of tissue degradation. The bitter aftertaste is most likely a result of extracellular substances produced by the vegetative parasite or organic materials within the actual parasite cell. The severity of both poor meat quality and off flavor is directly proportional to the progression of the disease and the numbers of the parasite within the crab host.

Commercial fishermen and seafood processors in southeast Alaska have been aware of chalkiness and bitter flavor in Tanner crabs for at least the past several years. In most instances affected meat lots are considered losses. Such losses are minimized by sorting the pink and milky crabs from the catch on the fishing grounds and at the processor boats or facilities.

The bitter crab dinoflagellate probably evolved within southeast Tanner crab populations long before man began exploiting the resource. However, it may have gone unnoticed when seasons for harvest occurred earlier in the life cycle of the parasite during late fall or early winter and when the market product in demand was meat rather than sections. Low meat yield and off-flavor are more noticeable in the latter market form. If the dinoflagellate parasite has an annual life cycle, meat deterioration and off-flavor would become more noticeable as the disease progresses into February and March. Changing to a commercial season during the earlier stages of the disease might allow all crabs to be marketable and make sorting of affected crabs unnecessary. This alternative is speculative and needs further investigation. Sorting can be an additional hazard in spreading this disease to healthy Tanner crab populations when infected crabs are transported then culled and released into distant waters near the seafood plants or from processor boats. An important realization is that any naturally occurring disease has the potential to negatively impact wild animal populations when human intervention proceeds without necessary precautions. These are common sense approaches which include maintaining the status quo by not overharvesting and not disseminating the disease, either of which or both would tip the balance in favor of the disease agent.

Many questions remain concerning bitter crab disease and include the distribution of infected Tanner stocks and whether other Alaskan crab species can become infected. Recent laboratory studies have shown that red king crabs are immune to infection by the parasite. Continued investigation and prudent managment of Tanner crab populations should allow this disease and resultant problems in meat quality to be controlled.

Theodore R. Meyers is Principal Fish Pathologist, FRED Division, Juneau. He holds a Ph.D. in veterinary medicine from Cornell University and a Master's degree in fish pathology from Oregon State University.

The author and three co-authors, Tim Keoneman and Cathy Botelho of the Commercial Fisheries Division, and Sally Short of FRED Division, have treated this subject more thoroughly in an extensive paper to be published in late 1987. Ken Imamura, also with the Commercial Fisheries Division, has participated in this study.

BITTER CRAB DISEASE
Hematodinium sp.

Steps that management has taken:

JANUARY 1987 During the February 15 to March 25, 1986 Tanner fishery, the fleet found a significant percentage of unmarketable crab in waters adjacent to Sullivan Island. In order to protect the remaining stock in that area and to reduce the potential for transportation of infected crab to other locations, an EO was written to close all waters of Lynn Canal north of the lattitude of Point Sherman Light and south of the lattitude of the southermost tip of Point Seduction, and all waters of Chilkat Inlet north of the lattitude of the southern tip of Point Seduction for the January 15, 1987 Tanner fishery.

JANUARY 1988 Areas closed during the January 1987 fishery were reopened for the January 1988 fishery because samples collected between seasons suggested a lessening of the severity of the incidence of the disease. However, populations were found to be at low levels, possibly as a result of the infection.

FEBRUARY 1989 A news release issued in response to public inquiries regarding disposal of bitter crab. In some areas the organism was detectable in more than 80 percent of all sizes and both sexes of Tanner crab. When crab such as these are retained and transported from areas with high rates of infection to areas of low infection there is risk to healthy stocks.

1. Most effective disposal: sanitary landfill
2. Less effective, in order of probable effectiveness:
   a: cooking followed by approved grinding and marine discharge
   b: killing the crab and retaining in leakproof containers
   c: least desirable AND MOST FREQUENTLY EMPLOYED METHOD: over board dumping of newly dead or live infected crab. THe potential exists for healthy crab either consuming or contacting infected crab and becoming infected themselves.

JANUARY 1990 A staff proposal to allow flexible season openings in areas with known high incidence of the disease to possibly maximize utilization of infected crab is presented for consideration by the Board of Fisheries. The progression of the severity of infection in individual crabs seems to be from a low level in late summer or early autumn to a higher level in winter and early spring. Earlier openings in areas of known high incidence could allow harvest of infected crab before the full development of bitter taste associated with the later stages of infection.

When did the disease first appear?

"What we now recognize as signs and symptoms of infected crab has been prevalent in various geographic locations since 1974. At that time the season extended from September through April, progressed at a slow rate with fewer vessels."

In March 1985, a southeastern processor purchased and packed crab which proved to be bitter. They suffered both significant money and market losses.

In February 1986, this same processor discontinued buying Tanners from upper Lynn Canal because of quality control problems...a bitter taste evident in crab from a "pre-molt stage". They took a loss of $40,000 to $50,000 from crab purchased the prior year and feared a medical claim against them. Vessels normally delivering from Lynn Canal to them, took their catch elsewhere. Port samplers

in Juneau brought some of the "molting" crab to Dr. Ted Meyers to validate the suspicion that the bitter taste was associated with more than a biochemical change prior to molting. The body of knowledge on Hematodinium has slowly grown since.

What have the fishermen lost?

Not all fishermen are sorting their catches on the grounds, either because they are unable to identify the diseased crab visually or they are keeping their entire legal catch for the processor to sort. On one delivery last year, a fishermen was quoted as saying "didn't seem to notice it (bitter crab)". From his catch during rough weather in the canal, 1,346 pounds were accepted; and 1,243 pounds of his delivery rejected. Until this past season, not all processors provided deadloss information as required.

Those that are sorting on the grounds are most often having to return their catch to the sea. Others have kept the diseased crab on deck to freeze and then dumped them overboard; others have actually disposed of their bad crab on land. Most of these figures, of course, have not been reported as deadloss to the department.

Deadloss estimates are very conservative. As the industry has learned to visually sort for this disease and generally become more informed about this disease, the accuracy of reporting has also improved. There is some debate whether the noted increase in reported pounds of rejected crab is due to better reporting or a spread and intensification of the disease. Historical fish ticket information on Tanner deadloss delivered to the dock follows:

	Unmarketable Lbs.	% of Total Catch	$ Value
1985/86	454	0.05	568.00
1986/87	4,416	0.40	7,286.00
1987/88	25,625	2.00	57,656.00
1988/89	80,188	5.20	220,517.00

What research/sampling is being done?

Surveys:

a: Samples have been collected from various bays in SE during the past four years while conducting the red king crab research cruises.
b: A limited amount of mark/recapture data is available from a naturally diseased population in the Sullivan Island area.
c: Some directed test fishing monies have allowed us to take samples in the Sullivan Island area.

Dockside:

a: Samples (100 per delivery) have been taken from catches delivered from a specific fishing location.
b: Since the 1985/86 season limited information has been collected from dockisde interviews at the processing facilities in SE.

How has the research/sampling been "funded" to date?

Dr. Ted Meyers has read all slides on a "time available" basis, as an additional task to his regular duties.

Sample collections and slide preparation has been accomplished during red king crab cruises and utilized time, slides, syringes, stain kits and other supplies purchased with population estimate and test fishing funds.

What work needs to be done?

1. Dissemination of information to the fleet and processors. Document and emphasize the severity of the disease to the health of the resource, suggest means of minimizing spread of disease from areas of high incidence to areas with little or no reported incidences of the disease.
2. Implement reasonable and appropriate measures for disposal of diseased crab. Implement measures to minimize transport of diseased crab by fishermen and tendering vessels.
3. Research to understand the impacts of the disease on Tanner crab stocks and on their management.
   a. Determination of life history, infectivity, seasonality, and other biological and physiological parameters associated with Hematodinium.
   b. Analysis of the relationship between the progressive stages of infection and catchability and marketability of the diseased crab. That is, determine the relative seasonal availability of the crab (changes in CPUE) and relative seasonal meat recovery and marketability (fullness, organoleptic and asthetic testing). Standardize criteria for testing acceptability of crab.
4. Continue collection of crabs for Hematodinium sampling during shellfish cruises. Provide for periodic sampling from Sullivan Island or alternate area for seasonality studies. As available, provide crab to industry for quality testing.
5. Support, to the extend possible, on-going and new programs studying various aspects of the organism.

COMMERCIAL FISHERIES

NEWS RELEASE

ALASKA DEPARTMENT OF FISH & GAME

STATE OF ALASKA
Department of Fish and Game
Don W. Collinsworth, Commissioner

Ken Parker
Director

Southeast Regional Office
P.O. Box 20
Douglas, Alaska 99824

Contact: Ken Imamura
Tim Koeneman
(907) 465-4250

FOR IMMEDIATE RELEASE

February 5, 1990

RECOMMENDED DISPOSAL METHODS FOR UNMARKETABLE TANNER CRAB

Juneau . . . . In response to public inquiries, the Alaska Department of Fish and Game is providing, as it did last season, the following information regarding the recommended disposal methods for unmarketable Tanner crab.

A significant number of Tanner crabs in some areas are infected with the bitter crab organism. In some areas, the organism is detectable in more than 80 percent of all sizes and both sexes of Tanner crab. When infected crab such as these are retained and transported from area with high rates of infection to areas with no detectable rates or low rates of infection, there is a risk to currently healthy stocks of crabs.

The safest method of disposal of infected crabs is assumed to be an approved method of land disposal such as in a sanitary landfill. This measure will totally isolate the infected crab and the causative organism from healthy populations of crabs.

Another disposal method that is probably as effective as isolation in landfills involves cooking the infected crab to industry sanitation standards prior to disposal by approved grinding methods and marine discharge.

Killing infected crab and retaining them in leak-proof containers for prolonged periods to kill the infective organism before marine disposal is less desirable from sanitation and aesthetic considerations. The infective organism is known to be extremely hardy and can remain active for days, long after the death of its host crab.

Simple grinding and marine disposal is even less desirable because of the potential for healthy crabs ingesting or contacting fragments of infected crabs and contracting the infection. The least effective means of disposal is probably overboard dumping of freshly killed or living infected crab from tenders or fishing vessels. The risk of spreading or intensifying the infection is greatest with this last method of disposal.

Unfortunately, although disposal methods are improving, much crab disposal in the past has employed the last and least desirable method. More effective methods require considerably more handling, staff involvement, and costs than simple dumping. However, the long-term consequences of unsafe dumping of infected crab could very easily mean spreading or intensifying the infection to such an extent that a commercial fishery will become much less tenable. The industry is asked to do what it can to prevent the spread of bitter crab infection.

Any questions can be directed to Timothy Koeneman, Cathy Botelho, or Ken Imamura at the address or phone number on the letterhead. In addition, Ted Meyers, the staff pathologist for the department, may be contacted at 465-3577 for technical or detailed information regarding this disease.

Phone numbers for the area offices are Juneau 465-4250, Sitka 747-6688, Ketchikan 225-5195, Petersburg 772-3801, and Wrangell 874-3822.