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10159 ADMINISTRATIVE REGULATION REVIEW

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Administrative Regulation Review Committee

AGENDA

Tuesday, March 20, 2001 2:45pm- 4:00pm, House State Affairs, Room 102

I. Kachemak Bay Closure to Bottom Mariculture (continued)

* This hearing will be teleconferenced

Comments on the Proposal Ban of On-bottom Shellfish Aquaculture for the Kachemak Bay Critical Habitat Area

By
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I received a request from the Alaskan Shellfish Growers Association (ASGA) to review the Alaska Department of Fish and Game (ADF&G) literature review titled "Ecological Considerations for On-Bottom Aquaculture of Littleneck Clams (*Protothaca staminea*) in Kachemak Bay, Alaska." ASGA requested me to address the merits of the scientific information that the ADF&G Habitat and Restoration Division is using as rationale to propose a ban on clam farming in Kachemak Bay. In a recent conversation with Claudia Slater of the ADF&G southcentral Region Habitat Restoration Division, she indicated that the rationale used to propose closure of the bay was taken from an ADF&G literature review on the environmental impacts of clam farming. This document is not intended as a position supporting the existing aquatic farming industry, but to evaluate the claims made by ADF&G in proposing a ban on clam farming

For the remainder of this document the I will refer to the ADF&G literature review as the literature review. My initial reading of the literature review caused me concern since the author states, "search for publication and information was not exhaustive or all inclusive ... Rather, this review is intended to provide an objective evaluation of readily-available literature... This statement is partially correct and glaring deficiencies are in the literature reviewed and in the selection of citations that do not apply to the aquaculture methods used or proposed to be used in Alaska. Selection of inappropriate documents in the literature review and application of many example species, locations, and circumstances gleaned from studies around the world are inappropriately applied to aquaculture in Alaska. A number of perceived important points are clearly erroneous. By the selection and interpretation of the information contained in the literature ADF&G Habitat and Restoration Division clearly reflects its bias in opposition to clam farming regardless of its ecological and socioeconomic merits.

The remainder of this paper is devoted to a point by point examination of the information and interpretations made in the literature review. I make these points, not as an affront to Dr. Hauser, author of the literature review, since I have a great deal of respect for his work within ADF&G. Dr Hauser has an esteemed career as a fishery biologist but is not a shellfish biologist with extensive experience in shellfish aquaculture nor is he knowledgeable about the current Alaskan shellfish farming industry. This is a primary shortcoming of this literature review in that a shellfish biologist familiar with shellfish ecology should have been the biologist assigned to write such a review, or the literature review should have been peer reviewed by shellfish biologists outside of the department to assure accuracy. This was not done, and the result is a highly flawed and unusable document on which to make regulatory decisions.

RaLonde Biological Report for Industry

Despite its shortcomings, the literature review does not recommend banning on-bottom clam aquaculture in Kachemak Bay. On this point, I am mystified as to how the ADF&G Habitat and Restoration Division can make the claim that the ADF&G literature review supports a ban. In fact, the report states emphatically that the decision to farm a beach should be made on a site by site basis; a position articulated by the Alaska Department of Law, and ADF&G Commission Frank Rue. The literature review contains the following direct statements.

- "Ultimately, the effects of on-bottom Mariculture on the organisms and habitats of Kachemak Bay ecosystem will depend on the locations, distribution and magnitude when operation may occur and the specific operational plans."
- "Candidate on-bottom clam mariculture sites must be evaluated to avoid areas of storm damage, log and sediment transport and freshwater inflow."
- "Potential sites should be located to minimize other potential conflicts with humans and the environment as well."

These are not statements mandating a ban on clam farming, but support a position the aquatic farmers have maintained during the entire debate over on-bottom clam farming, that farm proposals should be evaluated on a site by site basis.

Never the less, much of the literature review is flawed and contains statements that exaggerates the potential for environmental damage to Kachemak Bay. I will address the literature review section by section.

I. Introduction

The premise of the literature review is flawed from its very premise. The second paragraph of the introduction states,

> "The primary focus is the culture of the Pacific littleneck clam, on-bottom aquaculture techniques and potential ecological effects in Kachemak Bay, Alaska."

If this is the case, then why are examples from other species and regions used to infer supposed environmental damage to Kachemak Bay. Examples like:

- Oyster disease problems in France caused by importation of diseased oysters has no comparison in Alaska. In Alaska, the industry has imported Pacific oysters since the late 1970s and no oyster disease of significance has been transferred to Alaska. Ted Meyers, the ADF&G pathologist with an international reputation states that Alaska has "one of the most stringent disease policies", " We just have not found much of significance." In addition, Kachemak Bay WILL NOT be receiving any disease from imported clams since all the clams grown in Kachemak Bay will originate from the bay or closely adjoining region.

- Implying that spread of clam disease can be modeled after the whirling disease introduction to rainbow trout in the U.S. mountain states is unwarranted. The mechanisms of whirling disease will be discussed later, but the implication that culturing indigenous local stocks of littleneck clams poses the same level of potential disease introduction as whirling disease is ludicrous.
- Using the eastern hard clam (*Mercenaria mercenaria*) and the Manila clam (*Tapes japonica*) as surrogates for littleneck clams in assessing potential environmental damage should be done with caution. There are fundamental differences between the species to include:
    - Hard clams are predominantly a subtidal organism (Goodwin 1967; Walker and Rawson 1985) while littleneck clams in Alaska are intertidal (Feder and Paul 1973; Brooks 1996).
    - Hard clams inhabit sandy/silt substrate while littleneck clams prefer course sand, and gravel mixed with rocks and shell material (Chew and Ma 1987). Manila clams have a much wider substrate preference, venturing into muddy habitats in protected bays (Toba et al 1992).
    - Hard clams prefer slower moving water (7.4 cms/sec) while littleneck clams in Alaska prefer water velocities ranging from 77.1 to 154.3 cms/sec (Brooks 1996, Chew and Ma 1987).
    - Hard clams occupy warmer water with a range of 18° to 30°C (Loosanoff et al 1951) while littleneck clams are a colder water clam where temperatures range from 0° to 25°C is preferred (Chew and Ma 1987). Manila clams also are warmer water clams with a temperature preference of 23-24°C (Bardach et al 1972).

The point of this brief comparison is to show that using surrogate locations and species for comparisons can be misleading and can result in wrong conclusions. In the literature search, my assessment is that by using surrogate species, the author inadvertently inflates the presumed environmental damage of littleneck clam farming in Kachemak Bay.

II Background

The information on the life history of littleneck clams contains much of the pertinent information available from the literature. A few Alaska specific details are warranted (Refer to Brook 1997, 1999). The literature review cites (Chew and Ma 1987) in reference to preferred habitat locations as being "sheltered bay" while "quiet bays" are less productive.

The literature review refers to the substrate preference for littleneck clams as being "coarse sand and gravel". In our experience in Alaska shows that substrate types vary from sand and gravel (Feder and Paul 1973) to gravel and rock (Brooks 1997). One highly productive beach on the farm of Don Nickolson in southeastern Alaska is composed of large angular rock (Painter personal communication).

I assume that the statement that littleneck clams feed 95% of the time means 95% of the time while submerged in water. The pumping rate quoted as being greater than one liter per hour seems excessive and more comparable to the blue mussel (*Mytilus trossulus*), and pumping rates are a function of environmental conditions (Jorgensen 1990), and water temperature and body size (Widdows and Bayne 1971).

In context, the descriptions of the "typical" farm provided by Dewey (1996) and Mitchell (1996) are descriptions of their experiences as clam farmers in the state of Washington and British Columbia respectively. The farming activities described by Dewey and Mitchell differ significantly from practices proposed in Alaska.

- In Alaska farmers will not gravel beaches as practiced by Dewey and Mitchell. It must be emphasized that in Washington and British Columbia, Manila clams, an exotic species, is the clam being farmed. In the state of Washington, graveling is employed because the substrate in many locations is too soft for optimal growth, and farming occurs predominantly on private tidelands (Toba et al 1992). Since we will be farming native littleneck clams and adequate substrate is available, graveling beaches is unnecessary.
- Where Mitchell (1996) states that natural recruitment is a problem for his farm site, this is not the situation for many farm sites in Alaska where natural recruitment is welcome. Farmers will employ methods that encourage recruitment and survival by employing predator exclusion netting (Mitchell 1995) and plant supplemental hatchery seed when needed.
- The literature review stated that "labor intensive anti-fouling measures are needed to maintain the net (Mitchell 1996). The actual level of fouling is site dependant. Brooks (1999) found light fouling may be advantageous to survival of clams under predator netting and experience in southeastern Alaska has found that fouling of predator nets is a minor problem (Painter personal communication)
- The experience of Mitchell (1996) that his clams may be food limited may apply to some sites, but a number of factors will determine the productivity of a clam beach. For example, Rutz (1994) found that dense populations of clams on some beaches likely affect growth and recruitment.

When describing clam farming in Alaska, keep in mind that clam farming for commercial sale is only being done on three farms in southeastern Alaska, farming techniques are being developed, and best management practices will be ultimately be developed to suit the specific environmental conditions of the site.

I am very concerned about the method ADF&G uses to compute the total littleneck clam habitat available in Kachemak Bay. The review explains that the theoretical maximum habitat available is 1,500 acres. What determines the "theoretical maximum habitat?" The review continues with a statement that "approximately half contains unsuitable habitat." If the theoretical maximum habitat also contains the unsuitable habitat, why is it included in the theoretical maximum and why is it later excluded? Within Kachemak

Bay, there is also considerable confusion about the location and area of clam habitat. For example, in the Kachemak Bay Critical Habitat Plan identified clam habitat locations are considerably different than documented in a 1885 ADF&G publication by Reed (1985) "The role of wild resource use in communities of the central Kenai Peninsula and Kachemak Bay, Alaska", and Stanek (1985) "Patterns of wild resource use in English Bay and Port Graham, Alaska." In both of these publications Seldovia Bay is specifically identified as a prime clam harvest location, but it is not identified in the Kachemak Bay Critical Habitat Plan. In my contacts with the Seldovia Native Community, their traditional knowledge also supports the position that littleneck clam populations were at one time more wide spread.

The literature review states that the Alaska Board of Fisheries reduced the harvest quota from 29,510 kg (65,000 lbs) in 1992 to 18,160 kg (40,000 lbs) in 1994 (Trowbridge et al 2000). This analysis, however, does not reveal the entire story. Since 1992 a general population reduction trend has been documented in both legal and sublegal size classes. Reductions of legal size clams reflect the removal of harvest and reduced recruitment is indicated by the reduction in sub-legal size clams in the sampling location (Trowbridge et al 2000). In response the commercial hard shell clam limit was reduced again in 1997 to (11,364) kg (25,000 lbs.).

In addition, to the commercial fishery data, clam inventory data supports the appearance of an overall reduction of harvestable clams and recruitment from 1992-1999 (Trowbridge 2000). I have also maintained a position in a number of my reviews that the clam harvest in Kachemak Bay does not adequately account for illegal and over-quota harvest of commercial and private clam harvest in Kachemak Bay. Traditional knowledge in the area supports the premise that much more harvesting is occurring than is documented. The premise of my concern in past comments to ADF&G is that undocumented illegal harvest, supported by Trowbridge (2000) occurs in Kachemak Bay, and the degree of occurrence is a matter of the source of data and opinion. My opinion, supported by a number of unpublished public sources, is that undocumented harvest is substantial.

Population survey data confuses the situation in Kachemak Bay. Bechtol and Gustafson (1998) indicated a 54% reduction in population size (from 7.2 to 3.3 million clams) at Chugachik Island from 1992 to 1995 that resulted in a closure of the commercial fishery in 1995 and 1996. The closure was apparently successful and resulted with a nearly 64% increase in population size to 5.4 million clams in 1996. A population increase of 64% can hardly be considered modest considering the general poor recruitment that occurs on Alaska beaches. Because of the one year closure, one would expect that a 64% increase in population size would be the result of recruitment since this is the only way a population size can increase. As a consequence of including the younger recruits into the 1996 survey a decrease in the individual average clam weight of the population should occur between 1995 and 1996. However, the average individual clam weight in the 1996 population is actually heavier that the average weight in 1995. I would like someone to explain this to me.

The clam survey data for 1996-97 contains a large number of zeros in the data set indicating that legal size and/or sublegal size clam were not found during sampling. These zero values indicate that the distribution of clams was very uneven and exposes evidence that local populations unevenly distributed and depressed, likely caused by harvest. The surveys generated a population estimate and 95% confidence interval around the estimate; however, the 95% confidence limits are often greater than the population estimate. The cause of the large confidence likely originates with too few samples being collected, which according to the state of Washington should be at lease 11 samples per acre, a sample number not met by the ADF&G surveys. The large number of zeros may also contribute to the large confidence intervals. These discrepancies call into question the accuracy of the clam survey data.

I again call to question, and have not received an adequate response, why ADF&G believes that the populations of littleneck clams in Kachemak Bay are doing fine when all the evidence I see shows a constant decline in the population and the commercial and recreational harvest.

III Literature Review

Seeding adjacent beds, recruitment mechanisms and stock selections

The literature review discounts the potential long drift patterns of bivalve larva as a means of recruitment to more distant beaches and that "there is no evidence to the extent that this occurs." In the literature, one only needs to look at the progressive invasion of the green crab from San Francisco to British Columbia in about 10 years to show that marine currents have a significant role in the spread of marine invertebrate larva (Estelle 2000).

Clam population restoration efforts in the Port Graham area provide a specific example of successful establishment of quality habitat by enhancement of the beach with clam seed. Brooks (1999) reported that in Murphy's Slough contained available littleneck clam habitat but no established population existed in 1995, in 1996 clam seed 9-12 mm in length were plant at 350 clams.m^2 (Brooks 1999). By the spring of 2000, a population of clams at Murphy's Slough averaging 33 mm in size and an enhanced beach reached a population density of nearly 300 clams mm per square meter established (Jeff Hetrick personal communication).

The reference to littleneck clam larva not being found in the Kachemak Bay plankton study authored by Wing and Hoffman (1976) may not be unusual. In their research Wing and Hoffman indicated that sampling was at times sporadic resulting in weekly and monthly sampling periods. The research appeared to be focused on finding crustacean larva, did not identify the bivalve larva captured in the samples, and the data was qualitative rather than quantitative. Consequently, the statement that bivalve larva were "not frequently found" has little meaning. Having done considerable zooplankton sampling to specifically locate bivalve larva and predict their setting time (RaLonde 1997) my experience is that bivalve larva abundance is sporadic and can change from one sample to another. My studies required consistent sampling at least twice each week to obtain an adequate profile bivalve plankton.

Genetic integrity

I collaborated with ASGA and ADF&G in the developing of the current shellfish transport policy and regulations. Promulgated in part on a study by RaLonde (1993), the current shellfish transport policy was developed around the larval drift concept. Essentially, the larval drift argument supports the fact that ocean currents can transport marine zooplankton substantial distances; and with respect to bivalve larva, a three week drift time can widely distribute the progeny of a specific breeding population. Consequently, the ASF&G shellfish transport policy divides the state of Alaska into three transport zones: southeast, southcentral (Prince William Sound to Cook Inlet, and Kodiak Aleutian. As indicated in the literature review, the genetics policy dealing with shellfish transport is now under review. A shellfish transport permit is likely more scrutinized in Alaska than in any other coastal state. The opportunity for ADF&G personnel to examine the permit application is substantial.

The literature review documents some of the complexities of shellfish genetics, and the brief scrutiny provided hardly supports an argument that genetic impacts can be significant, particularly when placed in the context that Alaska has a regional transport policy. In development of a new genetics policy, compliance with the current regional transport regulations is reasonable in the short term pending any research that would support its modification. Additional measures can also be employed to provide some security to the genetic integrity of local clam populations particularly as they apply to hatchery seed supplementation. The following suggestions originate from personal communications with Dr. Stan Allen, shellfish geneticist from Aquaculture Genetics and Breeding Technology Center, Virginia Institute of Marine Biology.

1. Continue the regional transport protocol and maintain separate isolated broodstock to produce seed for each region.
2. Add and remove a portion of the captive hatchery broodstock at approximately 10% per year to maintain the genetic diversity of the seed production.
3. To increase the genetic variability of the seed and the likelihood of individual clam contribution into the seed production, eggs will be pooled from a number of females and individual males will be used to fertilize the pooled eggs.

In follow-up discussions with Qutekcak Shellfish Hatchery manager Jon Agosti, he indicated that such conditions were reasonable, and he is actually implementing them into the hatchery operational plan.

Any biologist could raise the genetics issue for any fishery management and aquaculture venture, and in Alaska we could devastate the Alaska fishery and prevent any aquaculture development.

Effects on habitat

Trampling of the intertidal bed will be minimal since the predator netting is deployed on the beach, and the bed remains undisturbed until harvest. In fact negative effects of trampling are likely to be more evident on commercial and recreational harvest beaches where harvesters are repeatedly trampling the substrate.

A number of prominent errors are evident in the effects on habitat section that need to be clarified beyond question.

No graveling of the beaches will occur. The Kachemak Bay clam farming applicants will not be modifying substrate as is described in the literature review. The type of substrate modification described in the literature review is done in Washington (Dewey 1996) and British Columbia (Mitchell 1996) and only on soft substrate. Alaskan beaches suitable for clam aquaculture are substantially firmer than the Manila clam beaches. Any references in the literature review that refers to environmental damage caused by substrate modification of the local beach should be taken in context of the ecosystem at large (Simenstad et al 1991; Simenstad and Fresh 1995).

Clam harvesting with suction dredges and any mechanical digging or dredging device will not be used to harvest Alaska littleneck clams. Only hand digging to a depth of approximately 10 cms is required to harvest littleneck clams. When digging clams the farmers return the substrate to the open hole, a practice not regularly done by commercial and recreational beaches. Any reference to mechanical or dredge harvesting is not appropriate and should be removed from the literature review. The experience of Washington clam farmers is that a modest level of digging actually improves the substrate and increases recruitment of benthic organisms (Cheney personal communication).

The discussion on the effects of predatory netting increasing sedimentation does not include any information from Alaska. Reference to Kaiser et al (1996) as a study proving increased sedimentation rates is inappropriately applied to Alaska since the study was conducted in a high silt area in the United Kingdom. Spencer et al (1997) reports that temporary removal of the netting quickly washes away sediment accumulation. As I indicated earlier, Alaska littleneck clams inhabit beaches with higher water velocity than beaches occupied by Manila and hard clams. Using these species as surrogates exaggerates the effect of sedimentation. Recent research in Alaska by Brooks (1999) showed no significant collection of fine sediments occurred on beaches protected by predator nets for a period of three years at study plots at Passage Island, Murphy's Slough, and Tatitlek, Alaska.

The literature review cites Spencer et al (1997) reporting that community diversity is increased with addition of predator exclusion netting, and that exclusion of the predators was the cause. Spencer also indicated that in other sites and environmental conditions and other factors may be more important that predation exclusion. The causes of community diversity are far more complex than mere exclusion of predators (Dame 1996; Simenstad and Fresh 1995; Peterson 1975; Peterson 1977).

The issue of community scale alteration of the benthic and epibenthic biota caused by aquaculture is best explained in the context of the scale of potential clam farming in Kachemak Bay. While 10-20 acres of tidelands can reap substantial economic benefit, the scale of benthic and epibenthic community changes are minimal. The environmental impacts of clam aquaculture to Kachemak Bay best fits the description by Simenstad amd Fresh (1995):

> "On a community scale, responses to chronic, low intensity or infrequent, intermediate intensity disturbances tend to be within the scope of behavioral or ecological adaptability of the flora and fauna."

<u>Ecological interactions/biodiversity/food chain effects:</u>

The topic of ecological interactions is far too large and complex to be addressed adequately by a review of "readily available" literature. Innumerable books have been written on the topic of marine ecology, food chains, and biodiversity, yet the literature review covers the topic in less than two pages and nineteen citations with only one applying specifically to Kachemak Bay. This feeble effort hardly confirms any of the interpretations generated from the literature review.

In the past three decades, Kachemak Bay has experienced extreme ecosystem wide changes with the demise of the shrimp, king crab, and Dungeness crab fisheries. The halibut fishery has moved further off shore, and the littleneck clam fishery appears to be declining. Identifying Kachemak Bay as a critical habitat area has not contributed to restoring the integrity of the ecosystem. Asserting that a modest level of clam farming will cause significant changes in biodiversity, food chain, and ecological interactions is a deficient attempt by ADF&G to prohibit an activity that has such innocuous effects opn the ecosystem. Spencer et al (1997) states that, "Our results suggest that the biotic and abiotic changes caused as a result of clam cultivation are relatively benign compared to other forms of marine cultivation..." I would go even further and state that clam aquaculture in more benign that the harmful effects of commercial fishing that are well documented by Dayton et al (1995).

Of a more specific nature, the literature review reports that "dense populations of adult bivalve feeder can be and are a major cause of mortality for settling larva." This is indeed true. An examination of data from Rutz (1995) shows that recruitment is poor within a dense population of clams However, the intent of shellfish aquaculture is to not allow the beds to become so dense the recruitment is reduced. In the Rutz study, the clam population on one beach was 97 clams per square foot, far too dense for optimal growth and recruitment survival. Aquaculture of clams will likely reach a maximum density of between 30-40 clams per square foot.

Simenstad (1995) provides a prospective that local human impacts need not lead to widespread changes in an ecosystem. The degree of impact is proportional to the scale of the farming activity and the size and complexity of the ecosystem affected. For example, interpreting Peterson and Quammen (1982) research that removing littleneck clams from nipping by fish will upset the energy flow is an oversimplification by inferring that a local beach will cause ecosystem wide changes. What is left out of the argument in the literature review is that if fish have a choice within an ecosystem, they prefer bivalves from softer mud/sand habitat that are more easily preyed upon rather than clams inhabiting course substrate like littleneck clams (Peterson and Quammen 1982).

Citing of Bourne (1984) as evidence of scoter predation is not the best choice of documentation since Bourne states clearing in his publication that his estimate is crude because a feeding study on scoters had not been done. Before asserting that clams are removed from the food web, critics should consider that clams protected by predator exclusion netting still experience 40-60% mortality, much of it caused by predation within and on the substrate. The larger 12 mm mesh size of the predator exclusion netting, actually allows shore birds to feed through the netting. Simenstad and Fresh (1995) argues that food webs are more often shifted than stopped. Where large Dungeness crabs may be excluded from their prey, a healthier epibenthic community may provide more food for juvenile salmon that can swim in and out of the predator net web. But again, the shift is on a local beach level and not ecosystem wide. Controlling the scale and siting of clam farms will help to mitigate any potential problems.

The statement that removal of highly productive clam beds will affect the animals that feed on them. This statement is misleading because 1) What is a highly productive clam bed? and 2) some predators will actually benefit from clam culture and the predator exclusion netting that allows them to compete for food over other predators (Simenstad and Fresh 1995).

Brady (1996) defined a production clam bed as one having 115 or more clams per square meter. Clam population estimates of proposed clam farm sites indicate that clam abundance varies between 9-54 clams per square meter. These beaches hardly fit the definition productive clam beds.

In conclusion, the food web ecosystem interaction information is very sketching and provides no conclusive evidence of direct damage of littleneck clam farming on Kachemak Bay. The supporting documentation in this section is anecdotal at best.

Predator exclusion nets:

The literature review found no evidence of bird or marine mammal entanglement in predator netting. However, the author implies that no evidence also raises the question non-reporting of entanglement. Such an argument has no merit. Either evidence exists or it does not. An interesting comment is the fact that salmon gill nets do entangle birds and mammals and can do so within the critical habitat area. Perhaps ADF&G should consider a ban on set net fishing for salmon within the critical habitat area since it is inconsistent with protection of marine mammals and birds.

The positive contribution of bivalves to the marine environment is explained briefly. The literature review repeats an unwarranted argument by using Gibbons and Blogoslawski (1989) as a source that "tabulated numerous diseases, parasites and pests that take advantage of bivalves" and but in the paper did not mention littleneck clams specifically in this statement. The literature review also cites Gibbons and Blogoslawski (1989) as a source of evidence of disease infestation of clams cultured at "high uniform densities"; however, the publication identifies a single "undescribed" coccidian parasite (Morado et al 1984).

In reference to derelict gear, the literature review provides no evidence throughout the entire West Coast clam aquaculture industry of derelict gear causing any problem. Cheney (personal communication) informed me that predator net can be damaged, but Washington farmers quickly respond with repairs. Alaskan aquatic farmers are required to post a cleanup bond prior to farming to ensure that derelict gear is removed by the farmer or the state of Alaska. Again, commercial fishing contributes an enormous amount of derelict gear to the ocean each year. In the north Pacific, 30-40,000 kms of drift netting is lost (Eisenbud 1985) and in 1990-91 over 31,600 king crab pots were lost in the Bristol Bay king crab fishery (Kruse and Kimker 1993).

Introductions of diseases, parasites or other organisms

Of all the section within this literature review, this section is the most irresponsible in the manner in which information is presented. This section contains absolutely false statements that cannot be dismissed as merely as interpretations of the research results.

The literature review does not address the life stage that diseases occur in bivalve, but in fact most of the disease problems are in the larval phase, and most of the documentation is on diseases of oysters (Figueras and Fisher 1988).

Dames (1996) documents devastating diseases that affect natural bivalve populations in the normal course of living. Figueras and Fisher (1988) argue that diseases and parasites do exist in wild populations but that the diseases causing the greatest problem with epizootics are found in oysters not clams. Elston (1990) documents few parasites in clams, a fact that is supported by Ted Myers, ADF&G pathologist (Personal communication). Myers describes the Alaska shellfish disease problem by saying that of the 150 shellfish transport permits processed each year in Alaska, 0-3 might be refused, and generally for reasons other than pathology. Littleneck clams have been identified with parasite infestation in wild populations in Alaska, but Meyers asserts that these parasites are endemic with nearly all populations in the state.

Again I must repeat, Alaska has a regional shellfish transport policy that requires broodstock for a given region must originate from the region. All shellfish, both broodstock and seed from the hatchery must also be certified disease free upon transport and transported only to the region where the broodstock originated. There will not be any exotic species of shellfish imported into the state other than certified disease free oysters less than 20 mm in shell length. Shipment of oyster seed from Washington hatcheries is also diminishing since construction of Qutekcak Shellfish Hatchery where 100% of the clam seed will be produced for state needs.

The literature review cites a disease problem, documented by Meyers and Short (1990) that occurred on the farm site of Canoe Lagoon Oyster Company in southeastern Alaska. The outbreak of this parasitic infestation was the result of warm water temperature, utilization of outdated growout technology, and poor food supply during the summer months that stressed the oysters to the point where an infestation occurred. Once the problem was identified, the gear type was changed, the growout site moved, and problem corrected.

The literature review cites disease problems found in fin fish, particularly infectious hematopoietic necrosis (IHN) in Alaska sockeye salmon and whirling disease (*Myxosome cerebralis*) that infests salmonids. Any reference to fish diseases has no merit to shellfish and should be excluded from the ecological impact.

One of the clearest indications of bias in the literature review is the appearance of deliberate distortion of information obtained from Meyers (1981). The literature cites the Meyers publication for evidence of disease problems using eastern oysters (*Crassostrea virginica*) in New York. I am mystified as to what disease problems in eastern oysters have to do with Alaskan littleneck clams, accept that if someone needing evidence of a serious disease problem, eastern oysters would be the example I would use. But the application of such information to Alaska has no merit.

Of greater concern; however, is the distortion of Meyers (1981) in the literature review with an interpretation that Meyers "identified numerous diseases and parasites endemic to culture shellfish stocks in New York." The actual publication has two significant statements to say about the research results

1. "Organisms causing disease were found in low prevalence and were not associated with mortality in either age class of the two oyster populations examined."

And in respect to clams that were included in the study but excluded from the literature review.

2. "Hard clams had a lower diversity of parasitisms and histologic abnormalities none of which provoked any host response or had any pathological significance."

The literature review also interprets Hines et al (2000) research as evidence that four or five exotic species were imported into Alaska with shipments of unclean oyster seed from Washington hatcheries. This interpretation is an exaggeration. What Hines et al (2000) actually documented was that the Pacific oyster is the only exotic species where definitive evidence documents its introduction. The oyster shell burrowing sponge (*Cliona thosina*) is a "probable" introduction with the ecological impact of "oyster shell damage". Two other species of microalgae were found on buoys on the Tatitlek oyster farm site, which should not be used as evidence the oyster seed was the vector of introduction.

The introduction of diseases, parasites or other organisms is replete with errors and misinformation and should be excluded from any consideration on environmental impacts to Kachemak Bay.

Site selection and loss of productive clam beds

Site selection for aquatic farm sites is an important issue well addressed during the permit review process. The Alaska Department of Nature Resources has on its web site, descriptions of sensitive sites that should be avoided. All permit applications are reviewed for their suitability and feasibility to succeed and minimize damage to the marine ecosystem. Each permit application goes through an enormous amount of scrutiny from governmental agencies, special interest groups, and private citizens in public hearings. Permit applications are only submitted during January-April of odd numbers years to facilitate reviews and assess the potential for cumulative impacts on any particular marine system. This intense review, generally requiring over 9 months to complete, ensures that Alaskans have adequate opportunity to examine each aquaculture enterprise.

All of this activity assures that the public process is not circumvented and that siting of the farm plot is appropriate to the marine system into which it is place. As a result, implementation of a ban provides no more protection to a marine system than is currently available in regulation.

In fact, a case can be made that clam farming is consistent with the special harvest area provisions. According to the Kachemak Bay Critical Habitat Plan, and activity is permited if:

1. "Protection of the resource, habitat and use of the resource" is assured. This document provides evidence that environmental impact is far less damaging than implied in the literature review, and the case of current permit application, clam farming will actually improve the clam population of the farmed beaches.

2. Restriction and interference with pubic use and enjoyment of the resource

Clam farming does not restrict access to the beach. Even if predator netting is deployed, the netting is resistant to trampling. Since farming occurs in the +2 to -2 tidal level, clam farming poses no navigational hazard.

Some public comments assume that allowing clam aquaculture on available beaches will cause widespread clam culture and privatization of beaches. This concern is a non-issue since the vast majority of the high quality clam beaches are already set aside in Kachemak Bay State Park and Wilderness Areas and are unavailable for aquaculture.

As indicated earlier, farming on the over-exploited beaches can hardly be construed as an undue restriction to commercial or recreational harvest of the beaches. The very small acreage requested (less than 20 acres) is not a significant removal from the 222,000 acres of tidal and subtidal lands in the bay. All of the beaches within the Kachemak Bay State Park, being over 90% if the south shoreline length of Kachemak Bay, will continue to be accessible for public harvest of clams.

3. The "Adverse effects of the activity on fish, wildlife, and their use must be mitigated."

Clam aquaculture can mitigate for any potential damage to the resource in a number of ways. As stipulated in 5 AAC 95.900, mitigation is easily applied in the following sections.

- (1) Permit conditions can be applied to aquaculture leases to prevent habitat damage, and many existing oyster farms already have permit specifications as part of their lease agreements.
- (b2) Clam aquaculture is flexible enough to enable immediate changes in operation if needed to minimize the adverse impacts on the habitat.
- (b3) Clam aquaculture techniques are easily modified, and any damage can be promptly corrected.
- (b4) A tidelands lease requires the operator to maintain the farm or risk having the lease revoked. Farmers must also post a cleanup bond that will be used to correct any damage done if the farm is abandoned or the lease revoked.
- (b5) In areas were the clam resource is already damaged due to over harvest, aquaculture will enhance the existing population.
- (b5) Since clam seed is available, farmers have proposed application of seed to increase clam populations on public harvest beaches.
- (b5) The reproductive contribution of the clams from farmed beaches will assist in rehabilitating clam populations on depleted beaches.

Evidence showing the benign effects of clam farming on habitat, the positive impacts to existing clam resource, the insignificant impact on public access, and the ability to mitigate for any potential damage caused by farming; indicates that the modest level of clam farming proposed is consistent to the Kachemak Bay Critical Habitat Plan.

Consideration should also include the economic impact of prohibiting on-bottom aquaculture in the plan revision. Prohibition will have major economic consequences since a single acre of clams can provide $35,000 annual income to the farmer, and local seafood restaurants and retailers will benefit from the farm production. Alaska Native villages, that wish to pursue subsistence aquaculture, will also be excluded from beach enhancement if aquaculture prohibition in included in the revised plan.

<u>Conclusion</u>

In conclusion, I find little merit in using this literature review as a supporting document to ban clam aquaculture in Kachemak Bay. The implications of a ban on clam farming are deeper than an environmental, but economic as well. With a ban of clam farming, the Kenai Peninsula will not have an opportunity to expand the region's economic base. Evidence shows from personal interviews with Lands End Resort and His Catch Seafood in Homer that local demand alone requires more that triple the current commercial harvest, and Favco (a primary seafood wholesale enterprise in Anchorage) indicated the local market exceeding one million pounds annually.

British Columbia is pursuing a shellfish culture growth plan to reach $100 million annual by 2015 (Coopers and Lybrand 1997). Florida trains, supplies startup funding, and guarantees state tidelands for startup farmers. The Florida clam culture program is a model for re-employment of displaced commercial fishermen through a partnership program between the state, university, and industry; and in the process, has created a $30 million industry in less than 10 years. Meanwhile, ADF&G debates non-issues like environmental impacts of shellfish aquaculture. Every professional contact I have made and article I have reviewed shows that responsible shellfish aquaculture is one of the most environmentally sensitive and responsible industries that can occur in a coastal area.

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Ecological Considerations for On-Bottom Aquaculture of Littleneck Clams (*Protothaca staminea*) in Kachemak Bay, Alaska

A Literature Review

by
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I. Introduction

Shellfish have been harvested from the tidelands of Kachemak Bay in Lower Cook Inlet by subsistence, recreational and commercial users since before statehood and there is evidence of human use since the last ice age. In addition, in recent decades, shellfish mariculture has been performed with suspended gear (Simpson 2000; Trowbridge et al. 2000). Presently, proposals are being considered for on-bottom culture of littleneck clams (*Protothaca staminea*) in several locations within Kachemak Bay as well as other regions of Alaska (Simpson 2000). Consequently, a variety of concerns have been expressed during public and agency reviews about this activity.

Purpose of this report:

The purpose of this report is to review scientific literature that has been published about clam mariculture practices, ecological implications and potential effects on the environment. The primary focus is the culture of the Pacific littleneck clam, on-bottom culture techniques and potential ecological effects in Kachemak Bay, Alaska. Reports from studies performed outside of Kachemak Bay and related, analogous species are needed however, to provide pertinent supporting information. The search for publications and information was not exhaustive or all inclusive (approximately 120 publications were reviewed; some, of which, have not been peer-reviewed; and, a few personal communications were used). Rather, this review is intended to provide an objective evaluation of readily-available literature related to salient topics raised by public comments regarding potential ecological effects of on-bottom clam farming in Kachemak Bay.

There are four sections in the body of this report including the Introduction. The Background section is intended to provide general information about littleneck clams and Kachemak Bay. The Literature Review section relies on published materials to discuss topics that were derived from public comments; and, the Conclusions are brief interpretations from this Literature Review regarding potential ecological effects of on-bottom clam farming in Kachemak Bay.

Hauser Biological Report for F&G

II. Background

Setting:

Kachemak Bay includes, for this report, those marine waters, tidelands and submerged lands inside a line from Anchor Point to Point Pogibshi. This area was designated the Kachemak Bay State Critical Habitat Area in 1974 "to protect natural habitat crucial to perpetuation of fish and wildlife (especially, shellfish, crab, and fish)." The commercial clam fishery management districts, however, include only shores east and south of a line from Fritz Creek to Barabara Point (excluding the Homer Spit). The Alaska Department of Environmental Conservation has certified only beaches on the south side of Kachemak Bay between Bradley River and Barabara Point (Trowbridge et al. 2000).

Common Littleneck Clam Life History - Overview: There are several common names for the common littleneck clam (Chew and Ma 1987). This report will use the term "littleneck clam". Littleneck clams are found on the Pacific coast of North America from the Aleutian Islands to the tip of the Baja Peninsula, but they are most abundant north of Oregon (Chew and Ma 1987). The littleneck clam is one of the most widely distributed hardshell clams of the Pacific Northwest and the Gulf of Alaska. It occurs in the intertidal zone of sheltered areas and estuaries. Typically, these areas are readily accessible; therefore, it is readily harvested by commercial, recreational and subsistence users (Chew and Ma 1987).

Most littleneck clams are found along the low tide level - between about -0.75 to +1.0 meters (-2.5 to 3.3 ft mean low low water) (Amos 1966; Nickerson 1977; Paul and Feder 1973; Rodnik and Li 1983), however, Goodwin (1973) found them as deep as 18.3 meters (60 ft). The best beaches for littleneck clams have a substrate of coarse sand and fine gravel. Littleneck clams are found up to 15 cm (6.0 in) below the surface of the substrate (Amos 1966; Chew and Ma 1987; Paul and Feder 1973; Rutz 1994) although Paul and Feder (1973) often found 10 mm (0.4 in) littleneck clams on or near the surface on beaches in Prince William Sound.

Time of spawning for littleneck clam depends on water temperature (Chew and Ma 1987). Specific information is not available for Kachemak Bay, however, in Prince William Sound, spawning begins in late-May when the water temperature is about 8°C (46.5°F). The spawning period may last four months, although males appear to be ripe most of the year (Feder et al. 1979; Nickerson 1977). Eggs and sperm are discharged into the water column and synchronized mass fertilization occurs (Quayle and Bourne 1972).

The fecundity of clams, including littleneck clams, is considered to be enormous but no published documentation of the fecundity of littleneck clams was found. Jon Agosti (Manager, Qutekcak Shellfish Hatchery, personal communication), however, estimated that the fecundity of littleneck clams may be up to 2 million eggs per average-sized female. Eversole (1989) summarized information about fecundity of the hard clam (*Mercenaria mercenaria*). He reported that the fecundity of the hard clam varied greatly among sizes and populations though there was a trend of increasing fecundity with increasing size. Hard clams that ranged from 42 to 74 mm (1.7 to 2.9 in) averaged 1.4 million eggs; 60 mm (2.4 in) females produced up to 3 million eggs. This huge reproduction potential is offset, however, by high larval and presettlement mortality in the order of 0.001 to 0.0001% of fertilized eggs that eventually settle (Dame 1996).

Larval development is pelagic and, depending on the water temperature and food supply, this "veliger stage" requires about three weeks (Quayle and Bourne 1972). During metamorphosis, the veliger develops a foot, becomes a pediveliger and settles to the bottom. After the larvae settle and start forming a shell, they are called "spat".

Nickerson (1977) reported that littleneck clams in Prince William Sound start to become sexually mature at three years and 13 mm (0.5 in) in length, but Fraser and Smith (1928) and Quayle (1943) found that they matured at about 22 to 35 mm (0.9 to 1.4 in). The maximum age and size reported for littleneck clams was 16 years (Paul, et al. 1976) and 63 mm (2.5 in) (Chew and Ma 1987). Beaches near strong tidal currents favor littleneck clams while the heads of quiet bays are often less productive; however, growth is highly variable, depending on substrate and tidal velocity (Chew and Ma 1987). Recent reports suggest that aging methods for littleneck clams may underestimate the growth rate (RaLonde, University of Alaska. Marine Advisory Program, unpublished data). The minimum legal harvestable size in Alaska is 38 mm (1.5 in) (Bechtol and Gustafson 1998).

Littleneck clams may spend as much as 95% of the time feeding by siphoning and filtering the water at a rate of more than 1 liter/hr (0.26 gal/hr). Phytoplankton is the most important food item, however, zooplankters, mollusk veliger larvae, detritus, and bacteria are also ingested (Rodnik and Li 1983).

Clam Farming:
A description of a "typical" littleneck clam mariculture operation was not found, however, a "typical" Manila clam (*Tapes japonica*) farm in Washington State begins with substrate enhancement that may include addition of four inches of washed fine gravel (Dewey 1996b). After seeding, operations may include deployment of predator exclusion netting and surveys to determine size and abundance of clams. Apparently, each bed includes three age classes of clams. Harvesters dig annually and remove harvestable-sized clams (Dewey 1996c; Smith 1996). Another 2.2 hectare (5.5 acre) "typical" farm was also enhanced by gravel additions and rock removal and employed seasonal use of a double layer of protective netting to prevent predation by scoters (Mitchell 1996). Labor-intensive, anti-fouling measures are needed to maintain the netting. Beaches are monitored and seeding or culling is used to adjust the rearing density to about 500-600 clams/ sq meter (47 to 56 clams/ sq ft). Harvest rate is about 9,808 kg (20,000 lb) per year (he area harvested was not given) (Mitchell 1996). Apparently, natural recruitment is variable between years and within the farmed area, but "wild" clams only interfere with the operation of the farm because they disrupt the uniform size and density of seeded clams (Mitchell 1996). Mitchell (1996) also commented that "Manila clams are food limited" and he presumed that "littleneck clams in Alaska will be as well". The average size of clam farms in British Columbia is 4.8 hectares (12 acres) (ranging from "backyard size to 50 acres" (20 hectares)) (Christie 1996).

Oceanography of Kachemak Bay:
The coastal current from the Gulf of Alaska flows generally northerly and westward past lower Cook Inlet (Favorite 1970) and the circulation patterns in Kachemak Bay and lower Cook Inlet are quite complicated (Burbank 1977). There are two large, strong gyres in both inner and outer

Kachemak Bay during the summer (Burbank 1977) which persist but weaken during the winter (Gatto 1981). These generalized descriptions are influenced and modified seasonally and annually by winds, tidal exchanges, storms and freshwater runoff (Dames and Moore 1975; Burbank 1977; Gatto 1981).

Littleneck clam resources in Kachemak Bay:

Gustafson (1995) provided an assessment and a summary of littleneck clam resources on certified beaches in Kachemak Bay. Considering that most littleneck clams are found along the low tide level, between about –0.75 to +1.0 meters (-2.5 to 3.3 ft) (Nickerson 1977; Paul and Feder 1973; Rodnik and Li 1983), the estimated theoretical maximum amount of littleneck clam habitat in Kachemak Bay is about 1500 acres (W. Bechtol, ADF&G, Homer, personal communication). Of this, approximately half contains unsuitable habitat and half may have sufficient habitat to support beds of littleneck clams.

There was some commercial harvest of clams from Kachemak Bay prior to statehood, but the recent commercial littleneck clam fishery began in 1986 when the Alaska Department of Environmental Conservation (DEC) certified the Chugachik Island beach for commercial harvest (Gustafson 1995). As commercial harvests increased, DEC increased certified areas until, in December 1994, DEC certified all waters south of a line from the Bradley River to Barabara Point, with the exception of some localized closure areas or seasons.

Commercial harvests of littleneck clams from the management area ranged from 1,180 to 30,282 kg (2,600 to 66,700 lb) during 1986 to 1999 (Trowbridge et al. 2000). Beginning in 1994, the Alaska Board of Fisheries directed the Alaska Department of Fish and Game to manage the commercial hardshell clam harvests for no more than 29,510 kg (65,000 lb) annually.

Recreational harvests of all hardshell clams ranged from 19,794 to 102,649 kg (43,600 to 226,100 lb) during 1981 to 1998, with recent data suggesting that littleneck clams comprise 54 and 86% of recent recreational harvests (Trowbridge et al. 2000). Regulations for the recreational harvest of littleneck clams include: a minimum legal clam height of at least 38 mm (1 ½ in) and a daily bag limit of 1,000 clams. The Alaska Board of Fisheries responded to several proposals for regulatory changes in 1997 by establishing a 72,640 kg (160,000 lb) Guideline Harvest Level (GHL) for the recreational fisheries while reducing the commercial GHL to 18,160 kg (40,000 lb). Subsequent to this resource allocation, ADF&G has set the commercial GHL for individual beach areas and districts based on assessments conducted the year prior to the district being opened for harvest. In an effort to provide for long-term sustained yield, ADF&G, using survey results, has managed for less than the full resource allocation that was established by the board.

Average sizes from several beaches that were surveyed between 1992 and 1994 ranged from 34 to 47 mm (1.3 to 1.9 in) and average ages ranged from 5 to 9 years. Densities of total clams ranged from 18 to 174 clams per sq meter (1.7 to 16.2 per sq ft). Littleneck clam populations on Chugachik Island beach in Kachemak Bay were studied between 1992 and 1996 (Bechtol and Gustafson 1998). Densities ranged from 53 to 118 clams per sq meter (4.9 to 10.1 per sq ft) and the total annual abundance ranged from 3.3 to 7.2 million clams. The average annual recruitment was 9.9%. Few clams recruited to the legal size of 38 mm (1.5 in) before age 5 and only 50% were recruited before age 7.

Public Comments about on-bottom Clam Farming: Key biological, ecological and management-related issues that were raised in public comments include:

- Seeding adjacent beds, recruitment mechanisms and stock selection
- Genetic integrity
- Effects on habitat
- Ecological interactions/ biodiversity/ food chain effects
- Entanglement in predator exclusion nets
- Introduction of diseases, parasites and other organisms
- Site selection and loss of productive clam beds

III. Literature Review

1. Seeding adjacent beds, recruitment mechanisms and stock selection:
Mitchell (1996), reported that seed from cultured Manila clam beds provided larvae to repopulate adjacent non-farmed areas in Puget Sound, however, he offered no evidence to support this. RaLonde (1993), however, postulated that the pelagic larval stage may be transported long distances by sea surface currents away from the broodstock, but there is no evidence to the extent that this actually occurs. These represent different views of how broodstocks contribute to recruitment. A pelagic larval stage is an important dispersal mechanism for a sessile organism if the species is to continue to exist (Dame 1996), however, up-current broodstock would soon become extinct if all larvae are carried away. Dame (1996) points out that the dynamics of stock integrity and recruitment are poorly understood and complex but that population properties must depend on interactions both within and between groups, patches and sub-populations of broodstock.

Littleneck clam recruitment varies greatly between areas within years and between years for an area (Chew and Ma 1987; Daisy et al. 1999; Goodwin 1973; Goodwin and Pease 1989; Paul and Feder 1973; Paul et al. 1976; Rodnick and Li 1983; RaLonde unpublished report). Apparently, recruitment depends more on local habitat conditions and seasonal and annual environmental conditions at the time of settlement rather than the number of larvae (Chew and Ma 1987; Feder and Paul 1973; Paul and Feder 1973; Paul et al. 1976; Rodnick and Li 1983; RaLonde unpublished report). Clams are highly fecund and individual beds of littleneck clams in Prince William Sound were reported to have standing stocks of 0.07 to 1.2 million clams (Feder and Paul 1973; Nickerson 1977) and beds in Kachemak Bay may include 1.8 to 7.2 million clams (Gustafson 1995; Bechtol and Gustafson 1998). These may produce sperm and billions of eggs from May through September (Nickerson 1977; Feder et al. 1979; Rodnick and Li 1983; Chew and Ma 1987). Individual clams that may mature as early as 3 years (Nickerson 1977) and may survive to age 15 or 16 (Paul and Feder 1973; Paul, et al. 1976; Nickerson 1977), may spawn as many as13 times.

After eggs are fertilized, the planktonic larval stage is usually about 21 days (14 to 38 days), depending on water temperature (Rodnick and Li 1983; Chew and Ma 1987; Daisy et al. 1999), although Daisy et al. (1999) reported that competent littleneck clam larvae were produced in 14 to 18 days in the Qutekcak Shellfish Hatchery at Seward, Alaska. The larvae drift with the tidal movements and currents and, when metamorphosis is complete, the larvae ("spat") settle out from the water column and have little lateral movement for the remainder of their life (Peterson 1977; Peterson 1982; Chew and Ma 1987). Consequently, the substrate type at the settling site is one of the most important factors that will affect the survival and growth of the littleneck clam (Feder and Paul 1973; Paul and Feder 1973; Goodwin 1973; Nickerson 1977; Rodnick and Li 1983).

Water current circulation patterns in both inner and outer Kachemak Bay are complex (Burbank 1977; Dames and Moore 1975; Gatto 1981) and the flushing and mixing that occurs with the 8.2 meter (27 ft) tidal range in most of the minor, peripheral bays and passageways must be substantial. Burbank (1977) reported that there is an input of saline water into Kachemak Bay from the southeast; an addition of freshwater from precipitation and runoff and a net output of fresher water along the north and west margin of the bay. There are two gyres in both the inner and outer bay that retain water and entrain organisms that may result in unequal distribution of organisms (Haynes and Wing 1976; English 1978; Paul 1984). Burbank (1977) did not determine the full residence times of the water in the gyres of the inner bay, however, some drogues were retained up to 15 or more days. The circulation patterns of lower Cook Inlet and current interactions near the mouth of Kachemak Bay add to the complexity (Burbank 1977; Dames and Moore 1975).

The circulation patterns are modified annually and seasonally by changes in freshwater runoff, prevailing winds, storms and tides (Dames and Moore 1975; Burbank 1977; Gatto 1981). The complex nature of the circulation patterns with the interaction of tidal mixing in Kachemak Bay create potential for retention of pelagic larvae to reseed habitat within the Bay, as well as dispersal of larvae to other locations. Wing and Hoffman (1976) found that bivalve veligers were not frequently found in qualitative zooplankton samples, but they were most abundant in June and July in the vicinity of Kasitsna Bay in Lower Cook Inlet. Coyle and Paul (1990) reported that bivalve larvae in Auke Bay, Alaska, reached maximal densities in May or June and there were significant differences between years. They suggested that potential causes for the interannual variations included food availability, transport mechanisms and temperatures. Jamieson and Armstrong (1991) also concluded that recruitment for Dungeness crab (*Cancer magister*) (another benthic species which has a long pelagic larval life stage) is highly variable and dependent on oceanographic and meteorological conditions. Crabs and clams have different larval development, but both rely on a pelagic larval lifestage.

Many other factors will also affect survival of clams after settling; including: frequency and duration of freshwater exposure, mechanical disturbance from storm surges and crushing by driftwood, freezing weather during low tides and predators (Hartwick et al. 1981; Peterson 1982; Rodnick and Li 1983; Kraeuter and Castagna 1989; Bower 1992; Brooks 1997a). Peterson (1982) and Kraeuter and Castagna (1989) indicate that predation is the most important cause of mortality after settling. Grosz and Yocum (1972) and Bourne (1983), for example, demonstrated that the rate of clam predation by scoters can be substantial.

These reports from the literature indicate that production of pelagic larvae by littleneck clams can be enormous. Contribution to annual recruitment may be highly variable and unpredictable from any particular spawning population in any particular year. Annual recruitment will probably depend on a complex interaction of annual variation in water mixing, dispersion and retention of larvae in a water mass, substrate quality when and where settlement occurs, local environmental conditions at the time of settlement, and predation rate.

2. Genetic integrity
The Alaska Department of Fish and Game, Commercial Fisheries Division is expected to complete a Genetic Policy for Shellfish during 2000. This Genetic Policy for Shellfish will be modeled after the Finfish Genetics Policy that is designed to maintain diversity and minimize genetic risk to wild stocks. Aspects of the new policy may include identification of research priorities to better define the genetic structure of Alaskan stocks and produce triploid stocks for use in Alaska (J. Seeb, Alaska Department of Fish and Game, Anchorage, personal communication) (Simpson 2000). This literature search for this report precedes that effort but it may provide some basis for discussions leading to the new policy.

Humphrey and Crenshaw (1989) reported that very little genetic research has been conducted with the various species of clams, however, they and Newell (1991) reported that there were several research efforts underway to use genetic manipulation and selection procedures for broodstock to improve shellfish stocks. Substantial research has been done to develop sterile triploids for shellfish mariculture in other states (Allen and Bushek 1992; Allen et al. 1998; Allen et al. 1982; Allen et al. 1986). Sterile shellfish sometimes have production advantages over diploids (Allen and Downing 1991) and genetic concerns about stock transfers are obviated. The review by Humphrey and Crenshaw (1989) did include one study that found little or no gene flow between Atlantic and Gulf coast populations of the clam (*Mercenaria campechiensis*). Koehn and Hilbish (1987) summarized results from genetic studies of blue mussel (*Mytilus edulis*) that demonstrate complex patterns of genetic relationships. Some studies confirmed extensive gene flow among populations of blue mussel while others found striking differences in genotype frequencies over short distances. Oceanic populations of blue mussels have a different genetic makeup from estuarine populations and the genetic makeup of estuarine populations changes progressively as the salinity changes. This suggests that the oceanic populations of blue mussel – which, like the littleneck clam, have a sessile adult lifestage and a pelagic larvae larval lifestage -- are genetically more uniform than the estuarine populations and there is a genetic selection for ability to survive in less saline water. RaLonde (1993), however, proposed that a shellfish transport policy for southcentral Alaska based on a generalized larval drift pattern may have merit.

Larval littleneck clams may enter Kachemak Bay from the Gulf of Alaska, but the complex circulation patterns in the bay also operate to retain some locally-produced larvae. Jamieson and Armstrong (1991) also concluded that stocks of Dungeness crab (which also has a long pelagic larval life stage) in Georgia Strait and Puget Sound are distinct from stocks of the open outer coast and that these are the product of the oceanographic features of the area.

Considering the complex patterns of salinity and circulation in estuaries and nearshore waters, it is not unreasonable to expect either complex patterns of genetic makeup or, a more homogenous pattern; or, both. It will be challenging to prepare a comprehensive but conservative Genetic Policy for Shellfish in the State of Alaska during 2000 because published information is limited and some is seemingly contradictory. Local hydrographic studies are equally limited. The definition of what constitutes a shellfish broodstock in southcentral Alaska will not be simple, however, it should not be taken lightly.

3. Effects on habitat:
On-bottom clam farming could have various impacts on habitat and other species depending on what mariculture techniques are employed; such as, substrate cultivation and preparation, harvesting, and predator exclusion.

During the preparatory phase of clam farming, trampling of adjacent areas and access paths could compact the substrate and crush some organisms (Kaiser et al. 1996; Kaiser et al. 1998). Siting of the operation will be important. In some areas, for example, productive eelgrass beds have been disrupted by clam farm operations (Brooks 1996). Substrate modifications could include removal of large particles and addition of fine material to improve conditions for clams. Brooks (1996) and Kaiser et al. (1998) report that this is detrimental to polycheate worms but beneficial to amphipods and nemertean worms. Mojica and Nelson (1993), however, found no consistent differences in the benthic community of farmed sites compared to non-farmed sites in Florida. Simenstad et al. (1991) found changes in the characteristics of the substrates and changes in the associated fauna, but no clear-cut results. Simenstad et al. (1991) also pointed out that any observed changes in the biota from addition of gravel will depend on the characteristics and fauna of the original undisturbed area and the amount of gravel coverage and the age of the plot. The "numerical taxonomic diversity" index which they used for their study was reduced when a natural sandflat area was covered with gravel to improve clam habitat, but the diversity index improved where the gravel was added to a mudflat. Simenstad and Fresh (1995) also found that the effects of adding gravel depended on the specific conditions before the gravel was added.

Harvesting will disrupt the substrate and associated animals; however, some harvest methods may be less disruptive than others. Kaiser et al. (1996) pointed out that suction dredging removed the sediment and inverted or removed the infaunal community but hand raking was less disturbing because it left the sediment *in situ* and did not affect all of the animals. Recovery of the substrate and fauna after harvesting depended on the type of substrate, current velocity and the harvesting method. Kaiser et al. (1998) reported that the benthos recovered 54 days after hand raking but dredged areas took 3 to 7 months to recover. Kaiser et al. (1996) reported that it was not possible to differentiate the numbers of individuals and species between harvested and control areas seven months after harvest. Spencer et al. (1998) reported that although dredging immediately reduced the mean numbers of species by 82% and the numbers of individuals by 87%, after 12 months, it was no longer possible to distinguish between treatment and control areas. Nickerson (1977) reported that areas in Prince William Sound that were disturbed by a hydraulic harvester were clearly visible after one year, but barely visible after two years. Hall and Harding (1997) found that most of the effects of harvest by suction dredging were lost after 56 days, but they cautioned that the effects of repeated seasons of harvest as well as seasonal timing of harvest must also be evaluated. The harvest disruption was less severe during winter when there was little active recruitment by the organisms. The effects would be different if the harvest occurred during a highly productive season than during a period of normal seasonal decline (Hall and Harding 1997; Kaiser et al. 1998). Spencer et al. (1998) also point out, however, that both the scale of the disturbance and the location (i.e., effects of wave or current action) will have important implications on the recolonization rate.

Cultivated clam beds are often covered by netting to minimize predation (Brooks 1996; Dewey 1996a,b; Gibbons and Blogoslawski 1989; Kaiser et al 1996; Kaiser et al 1998; Malouf 1989; Mitchell 1996; RaLonde, unpublished; Spencer et al. 1992). Survival of unprotected clams at experimental locations in Port Graham and Nanwalek, near Kachemak Bay, and Prince William Sound ranged from 0 to 20 % while the survival of protected clams ranged from 30 to 60% (Daisy et al.1999). Brooks (1996) and Spencer et al. (1997) reported that the netting reduced the current at the sediment surface. This resulted in deposition of fine materials and Kaiser et al. (1996) and Spencer et al. (1996) pointed out that the habitat inside a cover is stabilized because of protection from wave action and lower current. This also causes an increase in the food supply for the clams. Spencer et al. (1997) found that netted areas had more clams as well as more species and numbers of other animals under the protection of the netting because predators were excluded. Clams protected by placement in bags apparently had little effect on the invertebrate community (Kaiser et al. 1998).

Less complex substrates often have a less complex associated biotic community. Kaiser et al. (1996) reported that variation between samples in cultivated areas was lower than other areas. Spencer et al. (1997), however, found more species and numbers of animals may occur under the protection of netting because these areas exclude predators. Although the size of sediment particles was smaller in a farmed area, Mojica and Nelson (1993) found no consistent differences in nutrients, oxygen, benthos or phytoplankton in farmed areas compared to controls. Simenstad, et al. (1991) compared plots that were modified with the addition of gravel and found that the treatment enhanced the biota of a mud flat but the "numerical taxonomic diversity" index was reduced in a natural sandflat. Results from various reports seem inconclusive. It appears that the effects of clam farm operations on species relative abundance may actually be ambiguous depending on the original substrate, associated communities and the scale, intensity and practices of the operation.

Derelict gear – rope, bags, netting - may also be a problem related to the operation of clam farms (Brooks 1996). The magnitude of this problem will depend on the vigilance of the operator and the exposure of the site to storm actions.

4. Ecological interactions/ biodiversity/ food chain effects:
Adult clams are sessile, benthic, filter feeders that live in the substrate and perform a number of ecological functions. Clams filter phytoplankton and suspended particulate matter from the water and transport those nutrients and shells to the sediments as biodeposits or remineralize them into forms that are readily utilized by phytoplankton (Dame 1993; 1996). In addition, clams function to aerate and mix the substrate by their limited vertical movements (Levinton 1995). The sessile adult stage is vulnerable to many types of predators and the larval planktonic lifestage have a different suite of predators. While the most common predators of larvae are jellyfishes and ctenophores, adult clams may also have a role in their predation (Dame 1996). Adult clams inhale water and nutrients which are brought by the currents and those nutrients may include clam larvae. Dame (1996) and Gibbons and Blogoslawski (1989) reported that dense

beds of adults may reduce settling rates and he concluded that dense populations of adult bivalve feeders can be and are a major cause of mortality for settling larvae. Other filter feeders will also ingest the larvae (Gibbons and Blogoslawski 1989).

Adult clams are victimized by many other animals. Gibbons and Blogoslawski (1989) tabulated numerous diseases, parasites and pests that take advantage of bivalves, however, actions of larger invertebrate and vertebrate predators are generally better understood. Invertebrate predators of littleneck clams in Alaska may include starfish, gastropods, crabs and giant Pacific octopus (*Octopus dofleini*). Moon snails (*Euspira lewisii*) starfish and seastars consume littleneck clams (Brooks 1997b; Chew and Ma 1987; Feder and Paul 1974; Gibbons and Blogoslawski 1989; Quayle and Bourne 1972; Rodnick and Li 1983) but the extent of this predation is not well documented. Hemingway (1973) described the attack of a snail on a mollusk and the effects of their toxin. Hartwick et al. (1981) reported that octopus is an important predator on littleneck clams which made up 16% of their diet in British Columbia, but the prey of different individuals may depend on the proximity of their dens to prey concentrations.

Vertebrate predators, including fish, birds and mammals also feed on clams (Gibbons and Blogoslawski 1989). Although some fishes (e.g., skates and rays) consume adult clams, most predation by fish on clams is non-lethal nipping of the siphon tips by fish such as sculpin, flounder and halibut (Chew and Ma 1987; Gibbons and Blogoslawski 1989; Peterson and Quammen 1982). Peterson and Quammen (1982) discovered that siphon nipping can result in reduced clam biomass and that the nipping rate varies between seasons and between different substrate types but this form of predation makes a substantial contribution to the energy flow in the ecosystem. Flounders may consume large numbers of small clams (Gibbons and Blogoslawski 1989). Scoters readily prey on littleneck clams (Chew and Ma 1987; Gibbons and Blogoslawski 1989). Bourne (1983) estimated that 200 scoters could consume 5 to 14.5 metric tons (5.5 to 16 tons) of littleneck clams in 6 months and Grosz and Yocum (1972) reported that, in northern California, mollusks – mostly littleneck clams – were in 85% of white-winged scoter stomachs and comprised 81% of the total volume of food. Littleneck clams that averaged 13.6 mm (0.5 in) in size consistently made up nearly a third of the diet of white-winged scoters in Kachemak Bay from January through April, 1998 (Sanger and Jones 1984). Other birds, including gulls, geese, ducks, eiders, oystercatchers and crows, are known to eat clams (Bellrose 1996; Chew and Ma 1987; Crow 1978; Gibbons and Blogoslawski 1989). Never the less, Raffaelli and Melne (1987) found no evidence that birds and large flounders affect the densities of estuarine invertebrates. These predators did, however, affect the size structure of the populations because energy needed to regrow the siphons was diverted from body mass.

Aside from humans, the primary mammalian predator of littleneck clams is the sea otter (Chew and Ma 1987; Gibbons and Blogoslawski 1989). Mollusks were the most important diet component (81% of occurrence) of sea otters in Prince William Sound and littlenecks were the frequently eaten species. Consumption rates for clams were over one per minute for one male and a female and pup just under one per minute. Clams 30 to 50 mm (1.2 to 2.0 in) were eaten intact and some clams over 100 mm (3.9 in) were occasionally cracked by the teeth (Calkins 1977). Kvitek and Oliver (1987) reported that clams are the most important prey of sea otters in the Bering Sea and the Alaska Peninsula. Sea otters locate clams by straining the substrate with their paws or by digging pits up to 15 to 45 cm (6 to 18 in) across and up to 50 cm (20 in) deep

(Calkins 1977; Kvitek and Oliver 1987). Although the diet of sea otters is almost exclusively macroinvertebrates the observed diet will be determined in part by the relative abundance of prey species and the length of time that an area has been occupied by sea otters (Riedman and Estes 1987).

Predation rates will vary seasonally and predation rates on early year classes of clams are probably higher than reported because the shells may be consumed or broken and unnoticed. Never the less, clams are food for many consumers and are important in a marine ecosystem in many ways. Dame (1996), in fact, states that bivalves can be considered a keystone species in numerous ecosystems. The keystone ecological role of bivalves includes trophic, substrate mixing, nutrient recycling, structural integrity; and, they serve as monitors and indicators of changes to their environment. The models of energetics, carbon and nitrogen flow and cycles and food webs are extremely complex. Peterson and Quammen (1982) pointed out that littleneck clams made a substantial contribution to the energy flow of the ecosystem of Mugu Lagoon in southern California. It is most likely that clams and other shellfish are a critical element of the food web of Kachemak Bay Critical Habitat Area. If a highly productive location is selected for a farm site and covered to exclude predators, it will remove that feeding area from those animals. Ultimately, the effects of on-bottom mariculture on other species and the habitat will depend on the particular site selected, size and the operational plan

5. Predator exclusion nets:
This literature search did not discover any information on wildlife entanglement in mariculture predator netting. While no recorded incidents of entanglement were found, it also appears that this aspect of mariculture practices has never been studied. Never the less, fouling of organisms in the protective netting has been raised as a concern. Although Rotterman and Simon-Jackson (1988) documented instances of sea otter mortality from entanglement in fishing gear, entanglement in clam predator netting may not be a problem; or, entanglement of organisms may not be reported. Predator netting is commonly deployed to protect against predators other than sea otters which are common in Kachemak Bay. The outcome of an interaction of a sea otter with netting is unknown, but if a netting is properly deployed (i.e., closely to the substrate) and maintained, it should present minimal danger to most swimming organisms. If the typical deployment is disrupted, it could possibly entangle the animal and cause it to drown. Also, derelict netting or netting that has been loosened by a storm or an animal would present a greater hazard to birds, mammals and fish.

6. Introduction of diseases, parasites or other organisms:
Clams are commonly cultured at high, uniform densities, providing opportunities for predators and for infection by pathogens (Gibbons and Blogoslawski 1989). Gibbons and Blogoslawski (1989) proceeded to list disease organisms, parasites, pests and predators of shellfish and to document specific outbreaks as well as preventive and treatment measures. Meyers (1981) identified numerous diseases and parasites endemic to cultured shellfish stocks in New York and Farley (1978) listed viruses of shellfish. Dame (1996) commented on several disease epidemics that devastated natural and cultured bivalve populations and discussed the implications that disease and parasites may have on the individual, population and ecosystem levels. Kraeuter and

Castagna (1989) discussed diseases that have been found in clams after seeding and a disease outbreak among razor clams in the Pacific Northwest.

Sub-lethal pathologic conditions with added stressors may become critical to host organisms and cause indirect mortality. Meyers and Short (1990) determined that a high mortality of oysters at an aquatic farm in Alaska resulted from an invasion of parasites after the stocks became stressed by warm waters and changing salinities. Morado et al. (1984) reported that littleneck clams infected by a parasitic infection of the kidney or by larval tapeworms could not maintain their position in the substrate and became exposed as "kick-outs" and more vulnerable to predators.

Introductions or transport of fish and shellfish within Alaska are governed by permitting procedures that have been instituted to protect wild stocks. (The Pacific oyster is the only shellfish that is allowed for import into Alaska.) These safeguards include Policies and Guidelines for Shellfish Health and Disease Control (Meyers et al. 1988), the Shellfish/Aquatic Plant Transport Permit and the Fish Transport Permit (McGee 1995). Known shellfish diseases are categorized based on their relative risk and if they are indigenous to Alaska. If stocks are diagnosed with diseases not found in Alaska, they are prevented from entry into the state or destroyed. Broodstocks or their progeny cannot be possessed or transported without a Fish Transport Permit which requires that a stock disease history be developed. Before a Fish Transport Permit is approved, it is reviewed by ADF&G commercial and sport fish managers, the State Geneticist and the State Fish Pathologist and approved by the Commissioner.

Despite safeguards to prevent spread of diseases and to protect wild stocks, it is possible that unwanted introductions may occur – as has happened with other agriculture and aquaculture programs. Finfish diseases have been accidentally introduced by aquaculture programs. Whirling disease, for example, was inadvertently imported into the U.S. from Europe and spread to many states (Hoffman 1990). Infectious hematopoietic necrosis virus (IHNV) has been accidentally introduced into other areas by transport of sockeye salmon eggs from Alaska (Wolf 1988). Although IHNV was probably originally confined to anadromous salmon and trout in the Pacific Northwest, it has now spread to all salmonid rearing areas of the country. Héral and Deslous-Paoli (1991) described several devastating outbreaks of disease and parasites among cultured oysters in Europe, some of which were introduced from contaminated stocks.

There is substantial risk of introduction or spread of pathogenic and other exotic organisms with any agricultural program. Conservative measures for prevention are warranted. Gibbons and Blogoslawski (1989) and Kraeuter and Castagna (1989) noted the risk of disease transmission associated with stock transfers and emphasized the need for great caution to be exercised in moving broodstock to new locations. Meyers (1981) pointed out that healthy populations must be protected from possible introductions of exotic diseases by non-certified importation of foreign stocks. He further said that potential pathogens may be endemic to one population and not to another regardless of their geographic separation.

A recent investigation has reported that 24 species of non-indigenous plants and animals have been introduced into Alaskan marine waters; 15 of these species are in Prince William Sound (Hines et al. 2000). Of the 24 species, two, the Pacific oyster (*Crassostrea gigas*) and the softshell clam (*Mya arenaria*) were purposefully introduced. The pacific oyster cannot reproduce in Alaska, but the softshell clam has become established. Some of the four or five other species were probably introduced with imported oyster spat despite the fact that only "clean" seed is allowed or scheduled for import. Hines et al. (2000) identify aquaculture introductions as "a potentially important mechanism of transport for many other associated species".

7. Site selection and loss of productive clam beds

The importance of site selection for successful on-bottom clam mariculture is a primary topic of many reports. Brooks (1997a) evaluated potential littleneck clam culture sites to avoid areas of storm damage, log and sediment transport and freshwater inflow and he assessed water movements, beach slope, substrate grain size and volatile solids. Daisy et al. (1999) demonstrated the importance of site selection, maintenance, access and exposure to weather for the survival of littleneck clams in Kachemak Bay and Prince William Sound. Feder and Paul (1973), Houghton (1977), Kraeuter and Castagna (1989), Paul and Feder (1973) and Paul et al. (1977) discussed how growth, recruitment and survival of different populations of littleneck clams may be affected by environmental conditions at different locations. Rodnick and Li (1983) evaluated habitat requirements and parameters for the littleneck clam from reported studies to develop a habitat suitability index model to estimate the conditions necessary for the maintenance of the species. Thompson (1990) listed several criteria for site selection for habitat improvement by substrate enhancement for production of Manila clams.

IV. Conclusions

Seeding adjacent beds, recruitment mechanisms and stock selection:

Littleneck clam recruitment varies greatly in an area between years and between areas within a year and there was no evidence that larvae from farm sites will help repopulate adjacent areas. Littleneck clams in Kachemak Bay will produce billions of larvae in the 4-months of spawning, but the density and amount of recruitment depends more on habitat conditions and seasonal and annual environmental conditions at the time and place of settlement rather than the number of larvae that are produced. After the eggs are fertilized, littleneck clam larvae remain pelagic for approximately 21 days until they settle to the substrate. The substrate type and current movements at the settling site are two of the most important factors that will determine the survival and growth of the clam. Other factors that also affect survival after settling include: frequency and duration of freshwater inundation, predation, mechanical disturbance from storms and driftwood, freezing weather during low tides and predators.

Genetic integrity:

Few reports of genetic stock separation have been reported for bivalves and none was found for littleneck clams. Although some of the available information seems to be contradictory, there is evidence to suggest that genetic differences among shellfish populations can occur within short distances. The Alaska Department of Fish and Game, Commercial Fisheries Division is expected to complete a Genetic Policy for Shellfish during 2000. This policy will be designed to maintain diversity and minimize genetic risk to wild stocks. There may be some exchange of clam larvae between Kachemak Bay and the Gulf of Alaska, but the complex circulation and tidal mixing of the Bay also operates to retain locally-produced larvae. Ultimately, the definition of what constitutes a shellfish broodstock in southcentral Alaska will not be simple and it should not be taken lightly.

Effects on habitat:
The effects of on-bottom clam mariculture on habitat will depend on the types of activities associated with an operation as well as the size and number of operations in an area and where the sites are located. Trampling and access areas could compact the substrate and crush some organisms. Substrate manipulation and cultivation could alter, and potentially reduce, species diversity because a more uniform habitat typically leads to a less diverse assemblage of organisms. Protective covering changes the local hydrodynamics which can also affect the substrate composition, but it may also improve clam feeding conditions and their abundance. In some cases, associated species may also increase in numbers and variety because predators are excluded. Some harvesting methods such as suction dredging are extremely disruptive because the substrate is completely re-ordered. The actual effects on the habitat and species composition as well as the magnitude of those effects will depend on the original, natural condition of the substrate and the particular operational activities.

Ecological interactions/ biodiversity/ food chain effects:
Bivalves can be considered a keystone species in marine ecosystems because they are food for many consumers and they provide many other functions in the marine ecosystem. The keystone ecological role of bivalves includes trophic, substrate mixing, nutrient recycling, structural integrity; and, they serve as monitors and indicators of changes to their environment. Predators include species such as: sea otter, land otter, white-winged scoter, harlequin duck, spectacled eider, Steller's eider, oldsquaw, oystercatchers, Canada geese, surf scoter, black scoter, shorebirds, gulls, yellowtail flounder, starry flounder, Pacific halibut, Pacific staghorn sculpin, octopus, Dungeness crab, moon snail, starfish and sea stars. The models of energetics, carbon and nitrogen flow and cycles and food webs are extremely complex. The presence of clam farms which remove productive clam beds from the food web will alter the role and function of clams in the ecosystem of Kachemak Bay.

Ultimately, the effects of on-bottom mariculture on the organisms and habitats of the Kachemak Bay ecosystem will depend on the locations, distribution and magnitude where operations may occur and the specific operational plans. A net loss or removal of productive clam beds would be detrimental locally, if not bay-wide.

Predator exclusion nets:
There was no report of animals caught in protective netting nor any report that evaluated this potential hazard. If netting is properly deployed on the substrate and properly maintained, it should present minimal danger to most swimming organisms.

Introduction of diseases, parasites and other organisms:
Introductions or transport of fish and shellfish within Alaska are governed by permitting procedures that have been instituted to protect wild stocks. Never the less, there are frequent warnings included in published reports of unplanned and unwanted introductions of disease and parasites that have occurred in the United States and Europe and these may happen again. There

is substantial risk of introduction or spread of pathogenic and other exotic organisms and conservative measures for prevention are warranted. Some potential pathogens may be endemic to one population and not to another regardless of their geographic separation. Several species of non-indigenous plants and animals have been identified as possibly introduced into Alaskan marine waters with imported oyster spat.

Site selection and loss of productive clam beds:
The importance of site selection for successful on-bottom clam mariculture is an important topic of many reports. Candidate on-bottom clam mariculture sites must be evaluated to avoid areas of storm damage, log and sediment transport and freshwater inflow. Water movements, beach slope, substrate grain size and volatile solids should be within an acceptable range of limits. Sites must be reasonably accessible for operations and maintenance. Potential sites should be located to minimize other potential conflicts with humans and the environment as well.

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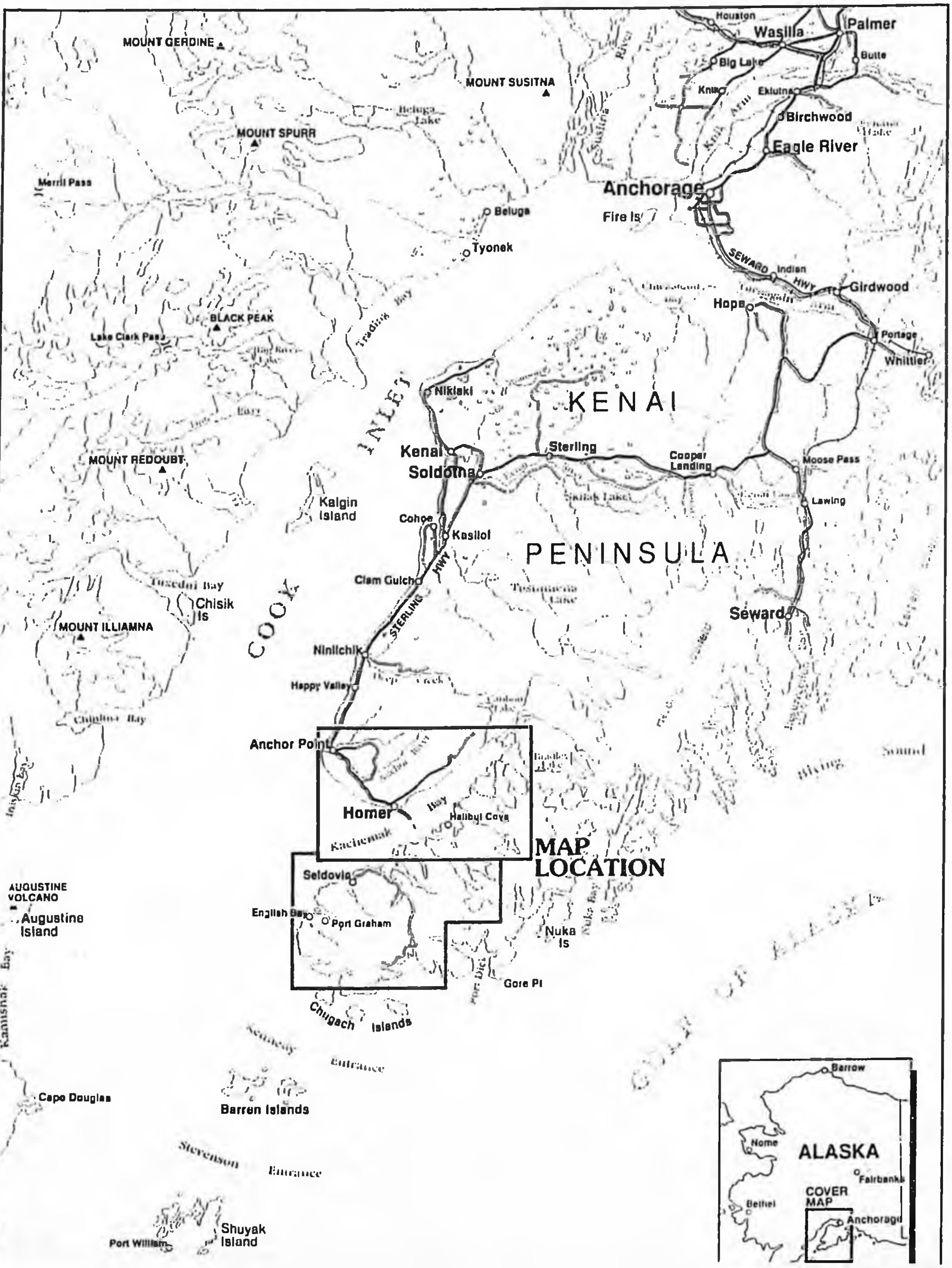
Kachemak Bay

Detailed Map Showing:

- Campgrounds
- Roads & Trails
- Facilities
- Fishing Information
- Trail Descriptions
- Topo



Dear Alaskan:

The Department of Fish and Game proposes to adopt regulation changes in Title 5 of the Alaska Administrative Code, dealing with on-bottom aquatic farming in the Kachemak Bay and Fox River Flats Critical Habitat Areas including the following:

(1) Existing regulations would be clarified by adding a new section or sections to 5 AAC 95 that would specifically prohibit on-bottom aquatic farming in the Kachemak Bay and Fox River Flats Critical Habitat Areas. A definition of "on-bottom aquatic farming" would also be provided.

You may comment on the proposed regulation changes, including the potential costs to private persons of complying with the proposed changes, by submitting written comments to:

Claudia Slater, Claudia_Slater@fishgame.state.ak.us
ADF&G, Habitat and Restoration Division
333 Raspberry Road
Anchorage, Alaska 99518-1599, Phone: (907) 267-2336

The comments must be received no later than 5:00 p.m. on December 13, 2000.

If you are a person with a disability who needs a special accommodation in order to participate in this process, please contact Claudia Slater at (907) 267-2336 no later than November 27, 2000 to ensure that any necessary accommodations can be provided.

For a copy of the proposed regulation changes, contact Claudia Slater at the address or phone number listed above, or go to www.state.ak.us/adfg/habitat/geninfo/kbaf.pdf.

After the public comment period ends, the Department of Fish and Game will either adopt these or other provisions dealing with the same subject, without further notice, or decide to take no action on them. The language of the final regulations may be different from that of the proposed regulations. YOU SHOULD COMMENT DURING THE TIME ALLOWED IF YOUR INTERESTS COULD BE AFFECTED.

Statutory Authority: AS 16.05.020; AS 16. 05.050.
Statutes Being Implemented, Interpreted, or Made Specific: AS 16.20.500 – 530; AS 16.20.580 and 590.
Fiscal Information: The proposed regulation changes are not expected to require an increased appropriation.

DATE: November 6, 2000

/s/ Ken Taylor, Director
Division of Habitat and Restoration
Alaska Department of Fish and Game

ADDITIONAL REGULATIONS NOTICE INFORMATION
(AS 44.62.190(d))

1. Adopting agency: Department of Fish and Game

2. General subject of regulation: The draft regulation proposes to prohibit on-bottom aquatic farming within the legislatively designated Kachemak Bay and Fox River Flats Critical Habitat Areas and provides a definition of on-bottom aquatic farming.

3. Citation of regulation: Title 5 AAC 95

4. Reason for the proposed action: The proposed regulation would clarify existing Department of Fish and Game regulations by specifying that on-bottom aquatic farming is prohibited in the Kachemak Bay and Fox River Flats Critical Habitat Areas.

5. Program category and BRU affected: Habitat and Restoration, BRU; Habitat Permitting/Title 16.

6. Cost of implementation to the state agency and available funding: There will be no cost associated with this regulatory clarification.

7. The name of the contact person for the regulation:

Claudia Slater, Habitat Biologist
Habitat and Restoration Division
333 Raspberry Road
Anchorage, Alaska 99518-1599
(907) 267-2336, Claudia_Slater@fishgame.state.ak.us

8. The origin of the proposed action: Habitat and Restoration Division.

9. Date: November 6, 2000 Prepared by: /s/ Claudia Slater
Habitat Biologist
(907) 267-2336

5 AAC 95 is amended by adding a new article to read:

ARTICLE 3.

PROHIBITED ACTIVITIES

5 AAC 95.300. ON-BOTTOM AQUATIC FARMING. (a) A person may not conduct "on-bottom aquatic farming" within the legislatively designated Special Areas listed below:

(1) Kachemak Bay Critical Habitat Area;
(2) Fox River Flats Critical Habitat Area.

(b) In this section, "on-bottom aquatic farming" means a facility that grows, farms, or cultivates aquatic farm products in captivity or under positive control on or in the substrate. (Eff. / / , Register)

Authority: AS 16.05.020 AS 16.20.520
AS 16.05.050 AS 16.20.530
AS 16.05.251 AS 16.20.580
AS 16.05.255 AS 16.20.590
AS 16.20.500

STATE OF ALASKA

TONY KNOWLES, GOVERNOR

DEPARTMENT OF FISH AND GAME

Habitat and Restoration Division

333 Raspberry Road
Anchorage, AK 99518-1599
PHONE: (907) 267-2285
FAX: (907) 267-2464

December 12, 2000

Mr. Rodger Painter
Alaskan Shellfish Growers Assn.
P. O. Box 20704
Juneau, AK 99802

Dear Mr. Painter

Re: Proposed Kachemak Bay/Fox River Flats On-Bottom Mariculture Regulations

I received your request on behalf of the Alaskan Shellfish Growers Association requesting an extension to the public comment period regarding the proposed regulations to prohibit on-bottom aquatic farming in the Kachemak Bay and Fox River Flats Critical Habitat Areas. While we appreciate your interest in the proposed regulations, the Alaska Department of Fish and Game (ADF&G) has far exceeded the requirements for proposing a regulatory change, and we do not believe it is necessary or appropriate to delay the process.

ADF&G initiated this regulatory planning effort in September 1999 when we established an inter-agency planning team to participate in the process and help guide the department. Nine other agencies were invited to join the team, of which five actively participated. These agencies included: the Alaska Department of Natural Resources, Alaska Department of Environmental Conservation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and City of Seldovia.

The department also solicited public comments regarding on-bottom mariculture within these legislatively designated critical habitat areas from November 18, 1999 through January 7, 2000. Advertisements were placed in local newspapers and letters were sent directly to potentially interested parties, including the Alaskan Shellfish Growers Association. Written comments were accepted throughout this period, and three public meetings were held on December 15, 16 and 17, 1999.

In addition, ADF&G reviewed and summarized much of the available scientific literature regarding on-bottom clam farming. We focused on littleneck clams because, to date, this has been the culture species of interest in Kachemak Bay. In an effort to ensure that our literature

F&G Response on Extension Request

review included as much relevant information as possible, we contacted Mr. Raymond RaLonde with the University of Alaska, Fairbanks, Marine Advisory Program. We asked Mr. RaLonde to send us a list of literature that he felt we should review, which he did. We reviewed and considered all of the literature suggested by Mr. RaLonde.

The department proposed the regulatory change to prohibit on-bottom aquatic farming in the Kachemak Bay and Fox River Flats Critical Habitat Areas after completion of this year-long planning process. We carefully considered the statutory mandate for managing the critical habitat areas, the goals and policies contained in Kachemak Bay and Fox River Flats Management Plan, the available scientific literature, recommendations of the inter-agency planning team, and public comments from the 1999/2000 public outreach effort. We also coordinated extensively with the Department of Law. The planning process we conducted far exceeds the legal requirements for proposing a regulatory change and, consequently, we do not believe it is necessary to extend the current public comment period.

Thank you for your interest in the proposed regulatory change.

Sincerely,

Claudia Slater
Habitat Biologist

cc: Frank Rue
Ken Taylor
Lance Trasky
Representative-elect Drew Scalzi
Senator John Torgerson
Lt. Governor Fran Ulmer
Raymond RaLonde

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MEMORANDUM

To: Frank Rue
Commissioner
Department of Fish & Game

Through: Ken Taylor
Director
Habitat & Restoration Division

From: Lance L. Trasky
Habitat & Restoration Division
Region II

Date: February 6, 2001

Subject: Recommendation to Adopt Kachemak Bay and Fox River Flats On-Bottom Mariculture Regulation

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Habitat and Restoration (H&R) Division has completed its evaluation of whether the department should adopt the regulation specifically prohibiting commercial on-bottom aquatic farming in the Kachemak Bay and Fox River Flats Critical Habitat Areas (CHAs). We recommend that the department proceed with adopting the regulation for the reasons described below.

Background Information

Kachemak Bay is one of the most productive marine ecosystems in Cook Inlet. The bay's high level of biological productivity is partially the result of a large gyre-like circulation pattern, which serves to hold shellfish larvae in the bay. Productivity is further enhanced by a two-layered "nutrient trap" estuarine system in which organic nutrients are moved out of the bay by surface waters and settle to the bottom only to be moved back into the bay by deeper on-shore currents (ADF&G 1991). Conditions favorable for the growth of macrophytes (e.g., kelp, rockweed), which serve as the base of many of the food webs in Kachemak Bay, also contribute to the area's biological productivity (Sanger and Jones 1984).

F&G Memo on Recommendation for closure

The south side of Kachemak Bay is lined with rocky shores and kelp beds interspersed with pocket beaches of sand, gravel and mud. These substrates support a variety of clams, such as littleneck, butter and soft-shelled clams, as well as mussels (ADF&G 1993). The north side of the bay, including the Homer Spit, is composed primarily of gravel and sand. Razor, cockle, red-necked, and some littleneck clams occur in this portion of the bay. These rich invertebrate communities provide an important food source for sea ducks, diving ducks, shorebirds, marine fish, and small mammals (ADF&G 1991).

Two hundred and thirty-one species of birds have been identified on and around Kachemak Bay (Erickson and West 1992). Large flocks of ducks, geese, and shorebirds move through the bay during the spring and fall migration. The greatest concentrations of migrants occur at the head of the bay on the Fox River Flats, in several of the small bays and coves along the south side of Kachemak Bay, and in Mud Bay at the base of the Homer Spit (ADF&G 2000). Outer Kachemak Bay and nearby waters also support high seabird densities during the spring and summer (ADF&G 1991). In addition, 90 percent of the seabirds and waterfowl that overwinter in lower Cook Inlet are found in Kachemak Bay (Erikson, 1977).

At least ten species of marine mammals are also found in the bay, with the greatest diversity occurring in outer Kachemak Bay (ADF&G 1993). Some species, such as sea otters, harbor seals, sea lions and beluga whales, are year-round residents, while other species like gray and minke whales are present seasonally.

In addition, Kachemak Bay supports a wide variety of fish including five species of Pacific salmon, Pacific halibut, walleye pollock, flounders, Pacific cod, and rockfish (ADF&G 1993). In past years, Pacific herring and several species of crab and shrimp were also abundant. All of these resources, combined with the accessibility of Kachemak Bay to a large portion of the state's human population, make this area important to residents and visitors alike.

In recognition of these outstanding values, the Alaska Legislature established the Fox River Flats and Kachemak Bay CHAs in 1972 and 1974, respectively. The purpose of the CHAs is to preserve habitat crucial to the perpetuation of fish and wildlife, and to restrict all uses not compatible with that primary purpose. In 1993, the Alaska Department of Fish and Game (ADF&G) adopted (through regulation) a combined management plan for the CHAs. This plan was prepared after an extensive public process. The management plan presents goals and policies to be used in determining whether proposed activities are compatible with protection of fish and wildlife, their habitats and public use of the areas.

<u>On-Bottom Mariculture Regulatory Planning Process</u>

ADF&G initiated this planning effort in September 1999 by establishing an inter-agency planning team to participate in the process and help guide the department. Nine other agencies were invited to join the team, of which five actively participated. These agencies included: the Alaska Department of Natural Resources (ADNR), the Alaska Department of Environmental Conservation, the U.S. Fish and Wildlife Service, National Marine Fisheries Service (NMFS) and the City of Seldovia.

The department also solicited informal public comments regarding on-bottom mariculture within Kachemak Bay and Fox River Flats CHAs from November 1, 1999 through January 7, 2000. Advertisements were placed in local newspapers, and letters were sent directly to potentially interested parties. Written comments were accepted throughout this period and public meetings were held on December 15, 16 and 17, 1999.

In addition, ADF&G reviewed and summarized much of the available scientific literature regarding on-bottom aquaculture of littleneck clams. Although the proposed regulation is not restricted to littleneck clams, the literature review focused on this species because all of the on-bottom farming applications to date for Kachemak Bay have been for littleneck clams, and to accommodate ADF&G funding and staff constraints.

The department then carefully considered the statutory mandate for managing the critical habitat areas, the goals and policies contained in the Kachemak Bay and Fox River Flats management plan, the available scientific literature, recommendations of the inter-agency planning team, and public comments from the 1999/2000 public outreach effort. Based on the results of this evaluation, and in close coordination with the Department of Law, ADF&G determined it was appropriate to propose a regulatory change prohibiting on-bottom aquatic farming in the Kachemak Bay and Fox River Flats CHAs. A formal public notice of the proposed regulation was published in local newspapers and letters were sent directly to potentially interested parties. Written comments were accepted from November 10 through December 13, 2000.

Public Comments on the Proposed Regulation

ADF&G received comments from 27 individuals and organizations regarding the proposed regulation: 14 opposed prohibiting on-bottom mariculture in the critical habitat areas, and 13 supported prohibiting on-bottom aquaculture. A list of all the individuals and organizations that submitted comments is presented in Attachment 1. A summary of the key points raised in the public comments, and how they were considered, is contained in Attachment 2. The main reasons given by individuals, for either opposing or supporting the regulation, did not differ significantly from the informal comments ADF&G received during the 1999/2000 public outreach effort.

Some individuals that opposed the regulation questioned whether ADF&G has a sound scientific basis to justify prohibiting on-bottom mariculture. They stated that aquaculture is an environmentally sensitive industry, and can be accomplished in a manner consistent with applicable statutes and regulations. Additionally, a few people commented that clam farming would provide employment opportunities to offset recent declines in commercial fishing. Several people noted that on-bottom farming would be very limited because most of the southern shoreline of Kachemak Bay is within the state park where commercial shellfish farming is prohibited. Consequently, a few relatively small clam farms in other areas of the bay would not significantly interfere with existing commercial, sport and personal clam digging. Instead, clams from farmed sites would contribute to repopulating adjacent depleted beaches, thereby benefiting the resource and other user groups. A number of individuals stated that prohibiting on-bottom mariculture in Kachemak Bay would have a significant, adverse affect on the aquaculture industry, and the financial viability of the Qutekcak shellfish hatchery.

Conversely, several people that support the regulation commented that on-bottom mariculture violates provisions of the State Constitution and the statutes and regulations governing management of the Kachemak Bay and Fox River Flats CHAs. A few individuals expressed concern that on-bottom clam farming could compromise the genetic integrity of wild clam stocks, or result in the introduction of diseases or exotic species. Several people commented that use of predator-exclusion netting, as proposed in the 1999 on-bottom mariculture applications, would deny wildlife access to feeding habitat, and potentially entangle wildlife. Others noted that littleneck clams in Kachemak Bay are fully utilized and voiced concerns that on-bottom clam farming would require reducing the harvest level(s) of one or more of the existing user groups.

Applicable Statutes and Regulations

AS 16.20.500 mandates that the Kachemak Bay and Fox River Flats CHAs be managed "to protect and preserve habitat areas especially crucial to the perpetuation of fish and wildlife, and to restrict all other uses not compatible with that primary purpose." Several goals contained in the management plan for these critical habitat areas, which have the force of regulation, provide further direction to assure conformance with this statutory mandate. Under the management plan category "Fish and Wildlife Populations and Their Habitat" ADF&G must make decisions in accordance with the following goals:

- Protect important wildlife habitat including water quality.
- Minimize harmful disturbance to wildlife, especially to marine mammals and nesting, rearing, staging and wintering waterfowl, shorebirds, and seabirds.
- Maintain, protect and, if appropriate, enhance the quality and quantity of nesting, rearing, feeding, staging and wintering habitat for resident and migrant waterfowl, shorebirds, and seabirds.
- Protect natural substrate, aquatic vegetation, water quality and circulation patterns to maintain aquatic habitats.

Under the category "Public Uses" the following additional goals apply, provided they can be attained in a manner consistent with the other goals of the management plan:

- Maintain or improve public access to and within the critical habitat areas.
- Maintain or improve opportunities for hunting and fishing within the critical habitat areas.
- Maintain or improve opportunities to recreate in the critical habitat areas.
- Maintain or improve opportunities for viewing, photography, education, and study of fish and wildlife.

The "Access" policy included in the management plan requires that the department "Maintain existing public access into Kachemak Bay and Fox River Flats critical habitat areas" and "Improve public access within Kachemak Bay Critical Habitat Area." The department interprets this policy to include maintenance of public access to common property public trust resources.

In addition, AS 16.40.105(2), which addresses issuance of aquatic farm and hatchery permits, states "the proposed farm or hatchery may not require significant alterations in traditional fisheries or other existing uses of fish and wildlife resources."

Discussion and Recommendation

To date, the species of interest for commercial on-bottom mariculture in Kachemak Bay has been the littleneck clam. Consequently, ADF&G searched the scientific literature for relevant information on the ecological considerations related to on-bottom farming of littleneck clams (approximately 120 publications were reviewed and considered). If commercial on-bottom mariculture were allowed in the critical habitat areas, habitat that is presently available to a diversity of organisms would be managed exclusively for littleneck clam production. The literature clearly indicates that on-bottom aquaculture can alter natural habitat as well as the diversity and abundance of intertidal organisms. Use of predator-exclusion netting, which was proposed in the 1999 Kachemak Bay on-bottom mariculture applications, can deny wildlife access to feeding habitat. In addition, loose or derelict netting could potentially entangle a range of fish and wildlife species. Animals that feed on littleneck clams include oldsquaws, eiders, scoters, sea otters, halibut, several species of crab, and numerous other marine organisms. These are the fish and wildlife resources that the critical habitat areas were specifically established to protect.

Opportunities for common property commercial, recreational, and personal uses of littleneck clams would also be reduced because farm sites would no longer be accessible to the public for shellfish harvest. The littleneck clam resource in Kachemak Bay is fully utilized by existing fisheries and all available habitat is necessary to maintain these fisheries. Allowing on-bottom culture of littleneck clams would conflict with AS 16.40.105(2), as well as the public use and access goals and policies in the critical habitat areas management plan. While some individuals have theorized that on-bottom clam farming would help increase clam densities on adjacent beaches, thereby benefiting this resource and the general public, the scientific literature does not support this hypothesis. Environmental conditions at the time and place of settlement, rather than the number of larvae produced, are likely the key factors affecting clam recruitment.

Considering the potential effects of on-bottom mariculture on fish and wildlife, habitat, and public uses of these resources, allowing this activity would be fundamentally inconsistent with the statutory and regulatory mandates for managing the critical habitat areas. These legal conflicts cannot be eliminated on a case-by case basis through permit stipulations. ADF&G must prohibit on-bottom aquatic farming in the Kachemak Bay and Fox River Flats CHAs to ensure conformance with the legal mandates governing management of these areas.

Although some people commented that adopting the regulation would have an adverse economic impact on the aquaculture industry and Qutekcak shellfish hatchery, we did not receive any specific information on what the economic effect might be. The regulation would prohibit only one specific type of culturing in one specific area of the state. The vast majority of Alaska's 39,000 miles of coastline and millions of acres of tide and submerged lands would not be affected by the regulation. With respect to the Qutekcak hatchery, and its reliance on selling species commonly cultured using on-bottom techniques, it is important to note that ADF&G

raised questions about the viability of the hatchery business plan when it was being prepared. According to the then ADF&G mariculture coordinator, Qutekcak was unresponsive to the department's concerns. Another comment made by several members of the public was that on-bottom mariculture would provide a new economic opportunity that could help offset the recent decline in some traditional fisheries. While ADF&G shares public concerns about declining fisheries, the department cannot authorize activities that conflict with statutory and regulatory mandates to provide an opportunity for a new enterprise to help compensate for these losses.

For these reasons, ADF&G should adopt the regulation prohibiting commercial on-bottom aquatic farming in the Kachemak Bay and Fox River Flats CHAs. The necessary paperwork to proceed with adopting the regulation is enclosed.

Attachments (for internal use) [2]
Enclosure (paperwork to be submitted to Department of Law)

cc: Claudia Slater

LITERATURE CITED

1. Alaska Department of Fish and Game (ADF&G), 1991. Kachemak Bay Critical Habitat Area. ADF&G/HQ, Juneau, Alaska. 2 page leaflet.

2. Alaska Department of Fish and Game, 1993. Kachemak Bay and Fox River Flats Critical Habitat Areas Management Plan. 126 pp. plus maps.

3. Alaska Department of Fish and Game, 2000. Most Environmentally Sensitive Areas Along the Coast of Alaska. ADF&G/Region II. Anchorage. Series of oversized maps.

4. Erickson, D. 1977. Distribution, abundance, migration and breeding locations of marine birds: lower Cook Inlet. Alaska, 1976. Vol. VIII. Environmental studies of Kachemak Bay and lower Cook Inlet. Marine/Coastal Habitat Management, Alaska Department of Fish and Game, Anchorage. 182pp.

5. Sanger, G. A. and R. D. Jones Jr., 1984. Winter feeding ecology and trophic relationships of oldsquaws and white-winged scoters on Kachemak Bay, Alaska. Pp. 20-28 in D. N. Nettleship, G. A. Sanger, and P. F. Springer, eds. Marine birds: their feeding ecology, and commercial fisheries relationships. Can. Wildl. Serv. Spec. Publ.

Attachment 1

Summary of Public Comments on On-Bottom Aquatic Farming in the Kachemak Bay & Fox River Flats Critical Habitat Areas

Comment period from November 10, 2000 through December 13, 2000

Last Name	First Name	Company	Address	City	State	State & Zip	E-Mail date	Letter or card date	Addl Info/ Comments	Allow On-Bottom Farming	Ban On-Bottom Farming
1. Agosti	Jon	Qutekcak Shellfish Hatchery	Box 369	Seward	AK	99664		12-11		1	
2. Cheney	Daniel P	Pacific Shellfish Institute	120 State Avenue NE #142	Olympia	WA	98501		12-13	Organization	1	
3. Downey	Robin	Pacific Coast Shellfish Growers Association	120 State Avenue NE PMB #142	Olympia	WA	98501		12-13	Organization	1	
4. Faulkner	Donna Rae		PO Box 3004	Homer	AK	99603	12-4				1
5. Griswold	Mary		PO Box 1417	Homer	AK	99603	11-22				1
6. Hartley	Robert		Box 2284	Homer	AK	99603		12-7		1	
7. Hebert	Steve		628 23rd	Des Moines	IO	50312		11-16			1
8. Hensel	Richard J.		11405 Hawkins	Anchorage	AK	99516		11-15			1
9. Highland	Roberta	Kachemak Bay Conservation Society	PO Box 846	Homer	AK	99603		11-14	Organization		1
10. Hillstrand	Nancy	Pioneer Alaskan Fisheries, Inc.	PO Box 170	Homer	AK	99603	12-10	12-10			1
11. Hilsinger	John		3601 Raspberry Rd #1A	Anchorage	AK	99502		12-8			1
12. Huycke	Peter		2815 Glacier St	Anchorage	AK		11-28			1	
13. Jackson	Jimmy		15301 Elmore Rd	Anchorage	AK	99516	11-16				1
14. Lentfer	Jack		PO Box 2617	Homer	AK	99603		12-6			1
15. Long	Ron	Qutekcak Native Tribe	PO Box 1467	Seward	AK	99664	12-10	12-10	Organization	1	
16. Mezirow	Andy		PO Box 2794	Seward	AK	99664		12-1		1	
17. Minsch	Sharon		PO Box 670689	Chugiak	AK	99567	11-13				1

Last Name	First Name	Company	Address	City	State	State & Zip	E-Mail date	Letter or card date	Addl Info/ Comments	Allow On-Bottom Farming	Ban On-Bottom Farming
18. Painter	Rodger	Alaska Shellfish Growers Assn					12-1	(121-30)	Organization	1	
19. Phillips	Representative Gail	Alaska State Legislature	345 W. Sterling Hwy, #102B	Homer	AK	99603		12-5	State Representative	1	
20. RaLonde	Raymond	UAA Marine Advisory Program	2221 E. Northern Lights Blvd	Anchorage	AK	99508		12/13		1	
21. Reeves and Patty Johnson	James	Dorsey & Whitney LLP	1031 W. Fourth Ave, Suite 600	Anchorage	AK	99501-5907		12-13	Attorney repr several clients. Count is just for Reeves & Johnson	2	
22. Scalzi	Representative-Elect Drew	Alaska State Legislature	345 W. Sterling Hwy, #102B	Homer	AK	99603		12-11	State-Representative Elect	1	
23. Scheer	David	Natural Mystic Sea Farms	PO Box 870978	Wasilla	AK	99687	11-18			1	
24. Sowls	Art		PO Box 1693	Homer	AK	99603		11-13			1
25. Stockwell	Bill	Cooper Landing Fish & Game Advisory Committee	PO Box 721	Cooper Landing	AK	99572		12-12	Organization		1
26. Wheeler	Gary	USF&W	605 W. 4th Ave, Rm G62	Anchorage	AK	99501		12/13	Organization		1
Totals									7 organizations	14	13

Attachment 2

KACHEMAK BAY AND FOX RIVER FLATS CRITICAL HABITAT AREAS PROPOSED ON-BOTTOM MARICULTURE REGULATION SUMMARY OF PUBLIC COMMENTS

The department received comments from 27 individuals and organizations on the proposed regulation to prohibit on-bottom mariculture in the Kachemak Bay and Fox River Flats Critical Habitat Areas. Fourteen of the commenters opposed adopting the regulation and 13 supported a prohibition. A list of the individuals and organizations that provided comments is presented in Attachment 1. A summary of the key points raised, and how they were considered, is provided below.

Key Comments Opposing the Regulation/Prohibition

1. Comment: Several individuals said it was difficult for the public to provide meaningful comments on the proposed regulation because the public notice did not provide any rationale for prohibiting on-bottom aquaculture in the critical habitat areas.

   Response: The public notice issued by ADF&G adhered to the informational and format requirements outlined in the September 2000 Drafting Manual for Administrative Regulations. This manual was prepared by the Alaska Department of Law to ensure compliance with AS 44.62, and ADF&G is obligated to conform to these requirements. Although the specific regulatory language proposed in the public notice had not been previously released, the department conducted an extensive and deliberative year-long planning process in reaching its decision to propose the regulation. This process included creation of an inter-agency planning team, an informal solicitation of public comments, a review of considerable scientific information (see response to comment #2), careful consideration of the statutes and regulations governing management of the critical habitat areas, and close coordination with the Alaska Department of Law. Most of the individuals that raised questions about the department's rationale for proposing the regulatory amendment participated in this planning process. The department believes the proposed regulation is necessary to ensure compliance with the statutory purpose for which the critical habitat areas were established (AS 16.20.500) and consistency with other regulations contained in the Kachemak Bay and Fox River Flats Critical Habitat Areas Management Plan (see response to comment #8).

2. Comment: Several individuals commented that ADF&G should not prohibit on-bottom mariculture in the critical habitat areas without a sound scientific basis to justify such a decision. Some of these individuals requested that the public comment period be extended to allow for a peer review of the scientific information used or prepared by the department in deciding to propose the regulatory amendment.

Response: Prior to proposing the regulation. ADF&G conducted an extensive literature review and summarized much of the relevant scientific information on this topic. Approximately 120 publications were reviewed and carefully considered. The literature summary prepared as part of this effort was never intended to be a peer reviewed technical report or manuscript. Rather, its intent was to provide the necessary scientific information for ADF&G's decision-making process. The staff member that summarized the literature is a Ph.D. fishery biologist with over 20 years of experience with the department. Three other senior staff biologists, with over 70 years of combined professional experience, reviewed and commented on the document before it was completed. These staff members are highly qualified to evaluate the potential effects of land and resource use activities on fish, wildlife, habitat and human harvest activities. Considering this, and the extensive public process conducted prior to proposing the regulatory amendment, ADF&G determined that extending the formal public comment period was not warranted.

3. Comment: Several people said that there is no evidence of predator exclusion nets entangling wildlife, and concerns about this potential impact are unfounded. One individual commented that he had worked for 11 years at a Puget Sound shellfish farm where predator netting covered clam plots on three acres of beach. He stated that abundant sea ducks and shorebirds continued to feed in the area and never got entangled in the netting. He also referenced previously submitted correspondence from a different, large clam farming company in Puget Sound that had not reported bird entanglements either.

   Response: Despite an extensive search of the literature, ADF&G was unable to find any reports indicating that this aspect of mariculture operations has ever been studied. There is a large body of scientific literature on the effects of derelict and loose netting, or netting like material, on fish and wildlife. Properly deployed and maintained netting (i.e., secured tightly to the substrate) should present minimal danger to most swimming organisms. However, concerns about possible entanglement of birds and sea otters remain, particularly at remote sites where it would be difficult to maintain predator netting during inclement weather. Otters and birds that attempt to dig through the netting to reach prey items might dislodge netting and become entangled. Predator netting that becomes disrupted, or loosened and derelict, could present a potential hazard to a range of species including birds, mammals, and fish.

4. Comment: Several individuals commented that clam farming does not create a monoculture or decrease the abundance and diversity of intertidal organisms. One person said that clam farming helps create a healthier habitat by providing protection for a more diverse and abundant benthic community.

   Response: The scientific literature indicates that on-bottom aquaculture can have varying effects on the intertidal benthic communities depending on the type of substrate,

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associated biota, the types and intensity of mariculture practices, and other factors. Some studies have documented a decrease in species abundance and diversity, others an increase, and still others found little change from natural benthic communities. However, the potential for altering natural species abundance and diversity is clearly present. Moreover, in at least some cases, the observed increase in species abundance and diversity was attributed to the use of predator netting. While protective netting may enhance the diversity and numbers of organisms living in the substrate, this is accomplished by excluding predators such as starfish, crabs, and numerous species of birds. In the case of Kachemak Bay and Fox River Flats, excluding natural predators is inconsistent with the areas' statutory purpose to "protect and preserve habitat areas especially crucial to the perpetuation of fish and wildlife."

5. Comment: Several individuals noted that wild clam populations in Kachemak Bay are very low. They indicated that clam farms would serve as spawner refuges and contribute to repopulating adjacent depleted beaches, thereby benefiting the resource and other users.

   Response: ADF&G surveys show that clam populations in Kachemak Bay are within natural population fluctuations. Sufficient numbers of wild clams are present in the bay to seed beaches. ADF&G did not find any evidence in the literature supporting the hypothesis that larvae from farm sites would help repopulate adjacent beaches. Rather, the density and amount of clam recruitment appears to depend more on the environmental and habitat conditions (e.g., current movements and substrate) at the time and place of settlement.

6. Comment: Several people commented that it is not necessary to completely prohibit on-bottom aquatic farming to avoid conflicts with existing recreational, subsistence, and commercial users. They noted that 80 to 90 percent of the southern shore of Kachemak Bay is located within the state park and closed to shellfish farming. One individual stated that carefully siting a farm where there is little or no public clamming (e.g., the north shore or Fox River Flats) would be a reasonable and desirable community use according to the policies contained in the critical habitat areas management plan. This would also fulfill the goal of enhancement of shellfish populations for human use by expanding the bay's littleneck clam population into new areas.

   Response: The amount of littleneck clam habitat in Kachemak Bay has not been measured; however, the estimated theoretical amount of littleneck habitat is about 750 acres. This represents approximately 0.4 percent of the bay, which includes roughly 200,000 acres. Consequently, as little as 10 acres would correspond to about one percent of the total available littleneck clam habitat. All of the applications that ADF&G has received for on-bottom aquaculture in Kachemak Bay have been to cultivate littleneck clams in areas where wild clams occur. Information that the department has received from applicants and industry advocates is that farms need to be located in areas that naturally support clams. Wild littleneck clams within the critical habitat areas are fully utilized by existing fisheries and managed under a plan adopted by the Board of Fisheries. According to public testimony received by ADF&G, all of the application sites to date are locations used by the public for sport, personal use and/or commercial clam digging. Allowing on-bottom mariculture at these locations would conflict with AS 16.40.105(2), which states that a proposed farm or hatchery may not require significant alterations in existing fisheries or other existing uses of fish and wildlife resources. It would also conflict with the access policy included in the critical habitat areas management plan. This policy requires that ADF&G maintain existing public access into Kachemak Bay and Fox River Flats Critical Habitat Areas, and improve public access within Kachemak Bay Critical Habitat Area consistent with the goals of the management plan. The department interprets this policy to include maintenance of public access to common property public trust resources, such as clams.

7. Comment: One individual commented that the proposed regulation would also prohibit subtidal seafloor farming of other species like geoducks, which would not conflict with any existing shellfish resource use. Farming of geoducks could increase the abundance of this species, another example of enhancement of public access to shellfish resources in the critical habitat areas.

   Response: Geoducks are not known to occur in the Cook Inlet region and it is unlikely that ADF&G would allow importation of this non-indigenous species into Kachemak Bay. Although culturing geoducks may not conflict with existing shellfish uses, the department's general practice is to prohibit the introduction of species into regions of the state where they do not naturally occur. This approach is taken to prevent the potential adverse effects that exotic introductions often have on native species.

8. Comment: Several people commented that clam farming is a clean and efficient enterprise that would help maintain water quality in Kachemak Bay. These individuals noted that specific concerns can be adequately addressed through the existing permitting process, and an out-right ban is not warranted.

   Response: The available scientific literature clearly indicates that on-bottom mariculture can adversely affect fish, wildlife, and habitat (see responses to comments # 3 and 4). All of the on-bottom aquatic farm applications that ADF&G has received to date have been for intertidal areas that support wild littleneck clams, which are fully utilized and managed under a plan approved by the Board of Fisheries (see response to comment # 6). Littleneck clam habitat within Kachemak Bay is limited and, in addition to supporting commercial, recreational and personal use fisheries, provides an important food source for a wide range of fish and wildlife species. Prohibiting on-bottom mariculture in Kachemak Bay and Fox River Flats Critical Habitat Areas is, in the department's judgement, necessary to ensure compliance with the state statutes and regulations governing management of these special areas. AS 16.20.500 mandates that these areas be managed "to protect and preserve habitat areas especially crucial to the perpetuation of fish and wildlife, and to restrict all other uses not compatible with that primary purpose." Regulations contained in the critical habitat areas management plan also necessitate prohibiting this activity. For example, ADF&G is directed to make management decisions that protect natural substrate and important wildlife habitat, minimize harmful disturbance to wildlife, and maintain or improve public access to and within the critical habitat areas. The department interprets this latter requirement to include public access to common property public trust resources. Consequently, on-bottom aquatic farming is, in the department's view, fundamentally inconsistent with the legal mandates for managing the critical habitat areas. A case-by-case consideration of applications will not eliminate these legal concerns.

9. Comment: Several individuals stated that commercial clam harvesting has depleted wild clam stocks in Kachemak Bay and that it makes no sense to prohibit on-bottom aquaculture, but allow commercial harvesting with no restoration of wild stocks.

   Response: As previously noted, wild clam populations fluctuate. Although clam densities vary over time, ADF&G does not have any scientific evidence that wild stocks in Kachemak Bay are depleted and in need of restoration. The State Constitution requires that common property shellfish resources be managed on the sustained yield principle. ADF&G monitors commercial clam harvests and implements harvest restrictions, when necessary, in accordance with sound management practices.

10. Comment: Several people commented that it is not prudent to ban a small environmentally-friendly industry that has a proven track record in other states, given the decline in shrimp and crabs in Kachemak Bay and shrinking salmon fisheries.

    Response: ADF&G is not banning the aquatic farming industry from Kachemak Bay. Mariculture using suspended culture techniques is allowed in many areas, and there are currently 24 permitted operations for this type of culturing in Kachemak Bay. This represents more mariculture authorizations than anywhere else in the state. Rather, ADF&G has found that one specific type of aquatic farming (i.e., on-bottom) is inconsistent with the statutes and regulations governing management of the critical habitat areas. The department shares public concerns about recent declines in other species, such as shrimp and crab. However, ADF&G will not authorize activities that are inconsistent with statutory mandates and regulations, or displace existing sport, subsistence, and commercial harvesters to provide an opportunity for a new enterprise to help compensate for these losses.

11. Comment: One person commented that allowing on-bottom aquaculture would be consistent with the management plan goals and policies to maintain and enhance fish and wildlife populations and their habitats.

    Response: Although on-bottom mariculture could potentially increase the abundance of cultured species at a farm site, it could also adversely affect habitat, other fish and wildlife species, and existing user groups (see responses to comments # 3, 4, 6 and 8).

Consequently, this activity is inconsistent with the statutes and regulations governing management of the critical habitat areas.

12. Comment: One individual commented that prohibiting on-bottom aquaculture would reduce public access to fresh clams because not everyone can dig their own clams.

    Response: ADF&G must manage the critical habitat areas in a way that protects habitat for fish and wildlife and maintains public access to Kachemak Bay and Fox River Flats. On-bottom aquatic farming cannot be allowed because it conflicts with these statutory and regulatory requirements. However, clams from commercial harvests in Kachemak Bay, other areas of Alaska, and the Pacific Northwest would not be affected by the regulation. People that do not dig their own clams can obtain commercial product from supermarkets and seafood stores.

13. Comment: Several individuals commented that, although it's difficult to quantify the potential economic impact of the proposed regulation, its adoption would seriously hurt the mariculture industry. Two people said that closing Kachemak Bay to on-bottom aquatic farming would jeopardize the financial viability of the Qutekcak shellfish hatchery. One of these individuals further stated that the hatchery business plan was approved by ADF&G, and that the sale of littleneck clams and other species commonly cultured using on-bottom techniques is an integral part of the plan.

    Response: It is important to note that the prohibition would apply only to the Kachemak Bay and Fox River Flats Critical Habitat Areas, a relatively small portion of coastal Alaska. The vast majority of Alaska's 39,000 miles of coastline and millions of acres of tide and submerged lands would not be affected by the regulation. With respect to the hatchery, the department's aquatic farming policies actually enhance, rather than detract from, the hatchery's ability to sell its products. This is because ADF&G has always supported farmers who engage in actual aquatic farming – growing fishery resources from planted seed stock. What the department has questioned, in areas where on-bottom mariculture does not conflict with specific statutes and regulations, are "farmers" who intend to harvest existing wild stocks under the pretext of mariculture. For example, ADF&G recently issued six geoduck permits, but the applicants rejected them because conditions in the permits would have prevented the farmers from selling wild geoducks from their farm sites. It should be apparent to all concerned that farmers who merely intend to harvest wild stocks won't have much need for seed from a hatchery. With respect to the Qutekcak hatchery business plan, it should be noted that ADF&G never approved the plan. In fact, the department made it clear to Qutekcak that it had doubts about the viability of the plan. According to the then ADF&G mariculture coordinator, Qutekcak was unresponsive to the department's concerns.

14. Comment: Several people commented that, because aquaculture requires high quality water, shellfish farming helps maintain a clean marine environment and can serve as a barometer of water quality in the critical habitat areas.

Response: ADF&G appreciates that shellfish farming requires clean water, and Kachemak Bay currently receives the highest level of protection possible. Under state water quality standards, Kachemak Bay is classified for a) water supply, b) aquaculture, c) growth and propagation of fish, shellfish, other aquatic life and wildlife, and d) harvesting for consumption of raw mollusks and other raw aquatic life. The department will certainly do its best to maintain clean water for these purposes, and the twenty-four mariculture operations presently authorized in the bay can help serve as a barometer of water quality.

15. Comment: One individual commented that AS 16.05.050(17) directs ADF&G to "permit and regulate aquatic farming in the state in a manner that assures the protection of the state's fish and game resources and improves the economy, health, and well being of the citizens of the state." Additionally, the critical habitat areas management plan recognizes aquatic farming (on-bottom and suspended culture) as compatible with the goals of the habitat areas. Sufficient regulatory oversight presently exists to protect the resources of these areas without a blanket exclusion of on-bottom culture.

    Response: The department recognizes its responsibility to permit and regulate aquatic farming in a manner that assures protection of the state's fish and game resources and improves the economy, health, and well being of the citizens of the state. In the Kachemak Bay and Fox River Flats Critical Habitat Areas, ADF&G is also responsible for protecting and preserving habitat areas especially crucial to the perpetuation of fish and wildlife, and to restrict all other uses not compatible with that primary purpose (AS 16.20.500). Aquatic farms in Kachemak Bay must conform to both of these laws, other statutes, and the goals and policies contained in the critical habitat areas management plan, which were adopted in regulation. On-bottom mariculture in Kachemak Bay is not consistent with all of these legal requirements (see response to comment # 8). It should also be noted that the management plan does not recognize aquatic farming (on-bottom and suspended culture) as compatible with the goals of the habitat areas. The plan actually states that aquatic farming may be permitted in a manner consistent with the protection of fish and wildlife populations and their habitats, continued use of fish and wildlife, and public use and enjoyment of the critical habitat areas if compatible with other existing uses. At the time the plan was written and adopted, only suspended aquaculture techniques were considered. On-bottom mariculture was not anticipated, evaluated, or specifically addressed.

16. Comment: One person stated that prohibiting on-bottom mariculture in Kachemak Bay is inconsistent with AS 16.05.020(1[2]), which directs ADF&G to "manage, protect, maintain, improve, and extend the fish, game, and aquatic plant resources of the state in the interest of the economy and general well being of the state." ADF&G has not shown that on-bottom culture will have deleterious effects to the resources, economy, or general well-being of the state. Sport and commercial clam harvesting comprise nearly 100 percent

of the intertidal disruption that occurs. If habitat protection is truly the goal, all intrusive activities should be restricted (but not necessarily prohibited).

Response: See responses to Comments # 8 and 15. Also, there is an important difference between on-bottom mariculture and commercial and sport clam digging. Commercial and sport users do not attempt to prevent fish and wildlife from preying upon clams or exclude other people from using the resource. ADF&G and the Board of Fisheries also regulate sport and commercial clam harvests to ensure that the constitutional mandate for sustained yield is met.

17. Comment: One individual commented that concerns about privatization or exclusive use of a public resource are inappropriate because 5 AAC 95.440(2) specifically allows a permit holder to restrict public access or public use of a special area. More general examples include limited entry permits, oil and gas leases, timber harvest contracts, mineral claims, and private docks on leases issued by the Department of Natural Resources within the critical habitat areas.

    Response: 5 AAC 95.440(2) is not intended to specifically allow permit holders to restrict public access or public use of a special area. To the contrary, the purpose of this regulatory provision is to stipulate that such restrictions will not be allowed unless specifically authorized. Moreover, regulations adopted particularly for the Kachemak Bay and Fox River Flats Critical Habitat Areas (5 AAC 95.610) require that ADF&G maintain or improve public access to and within these critical habitat areas. It should also be noted that concerns regarding the privatization or exclusive use of public resources are based on provisions in Article VIII of the State Constitution dealing with common property, exclusive fisheries and sustained yield; not the critical habitat area statutes and regulations.

Additional Comments on ADF&G's Literature Review

Two people commented specifically on the department's literature review entitled "Ecological Considerations for On-Bottom Aquaculture of Littleneck Clams (*Protothaca staminea*) in Kachemak Bay, Alaska.[1] Responses to some of their comments, which were also raised by others, are provided above. Responses to additional remarks made by either one or both of these individuals are noted below.

18. Comment: The conclusions drawn from the literature review are erroneous and overstate the potential impacts of on-bottom mariculture. In some cases, relevant information was not considered; in other cases, inapplicable information about other species, locations and farming activities was used. A shellfish biologist familiar with shellfish biology should

[1] Although the proposed regulation is not restricted to littleneck clams, the literature review focused on this species because all of the on-bottom farming applications submitted to date for Kachemak Bay have been for littleneck clams, and to accommodate ADF&G funding and staff constraints.

have been assigned to write the review, or the literature review should have been peer reviewed by shellfish biologists outside ADF&G to assure accuracy.

Response: The comments provided on ADF&G's literature review included numerous citations that the department had not examined. Many of the citations were for unpublished reports that are not readily available. More importantly, few were about littleneck clams or pertinent to clam mariculture. Consequently, the department was unable to glean any specific information from the remarks provided that ADF&G's literature review failed to consider important, relevant information. While the department's report focused on littleneck clams in Kachemak Bay, it was necessary and appropriate to draw upon information about other species and from areas outside of Alaska. As acknowledged by one of the commenters, there are only three on-bottom clam farms in the state; all are located in southeast Alaska, and farming techniques are being developed. To ADF&G's knowledge, no reports about these farming operations have ever been produced or made available. Thus, the limited amount of site and species-specific information necessitated broadening the department's literature review. This was done cautiously and with an understanding of the scientific limitations inherent in using the information. Similar caution was used in considering information about culture techniques. The literature review specifically acknowledges that the effects of on-bottom mariculture will depend, in part, on what farming practices are employed. It is the department's practice to rely on best available data when making decisions and, in the absence of better information, we see no reason to alter the conclusions of the literature review. Department staff that worked on the report are well qualified and there was no need to seek an independent peer review of the document (see response to comment # 2).

19. Comment: ADF&G's literature review discounts potential long drift patterns of bivalve larvae as a means of recruitment to more distant beaches.

Response: The department's literature review did not dismiss the hypothesis of long larval drift; rather, it acknowledged that there are opposing hypotheses regarding the mechanisms or dispersal and recruitment (downstream larval drift versus local dispersion). In addition, local geography, tidal current patterns, seasonal and annual weather patterns, and inflowing currents from the Gulf of Alaska create strong circulation gyres in both inner and outer Kachemak Bay that could retain planktonic organisms leading to complex dispersal and recruitment mechanisms. Although these phenomenon are poorly understood, they could significantly affect littleneck clam recruitment in Kachemak Bay and must be considered.

20. Comment: Any biologist could raise the genetic integrity issue for any fishery management and aquaculture venture and devastate the Alaska fishery and prevent any aquaculture development. Shellfish transport permits probably receive more scrutiny in Alaska than in any other coastal state. In developing a new genetics policy, compliance with the current regional transport regulations is reasonable in the short term pending research that would support its modification.

Response: The literature review primarily acknowledges that ADF&G is working on a genetics policy for shellfish, which will be similar to the department's finfish policy in that it will be designed to maintain diversity and minimize genetic risk to wild stocks. A short section summarizing some of the relevant literature was also included, but the report does not contain any conclusions regarding genetic questions that have been raised concerning on-bottom clam farming in Kachemak Bay. It should be noted, however, that ADF&G's shellfish transport regulations were established for shellfish health and disease control, not to maintain genetic integrity.

Key Comments Supporting the Regulation

21. Comment: Several people commented that prohibiting on-bottom mariculture is necessary to comply with existing regulations governing management of the critical habitat areas. Some of the regulatory provisions mentioned by these individuals included management plan goals and policies that require: maintaining and enhancing fish and wildlife populations and habitats, minimizing loss of habitat values due to habitat fragmentation, and maintaining and improving opportunities for hunting and fishing.

    Response: ADF&G agrees (see responses to comments # 6, 8 and 15).

22. Comment: Several individuals commented that on-bottom aquatic farming could compromise the genetic integrity of wild clam stocks, or result in the introduction of diseases or exotic species. One person stated that ADF&G should not allow any more aquatic farms in the critical habitat areas until the department develops a genetic policy and other appropriate safeguards to protect wild shellfish populations.

    Response: ADF&G agrees that it is essential to protect the genetic integrity and health of wild shellfish stocks. The department has shellfish transport regulations in place that were established to prevent the introduction of exotic species and disease. Nevertheless, several species of non-indigenous plants and animals have been identified as possibly introduced into Alaskan marine waters with imported oyster spat. A recent report by scientists from the Smithsonian Institute who conducted a survey of south-central Alaskan waters reported that non-indigenous species were found at sites associated with aquaculture in Prince William Sound (e.g., Tatitlek). Consequently, the department must continue to take a cautious and conservative approach to protecting the health of wild shellfish. With respect to genetic issues, ADF&G is developing a shellfish genetics policy that will be designed to maintain diversity and minimize genetic risk to wild populations (see response to comment # 20).

23. Comment: Several people stated that littleneck clams in Kachemak Bay are already fully utilized and expressed concern that on-bottom mariculture would require reducing the harvest level(s) of one or more of the existing user groups. One individual noted that such a reduction would conflict with AS 16.40.105(2), which states that a proposed farm or

hatchery may not require significant alterations in traditional fisheries or other existing uses of fish and wildlife resources. This individual commented that it would also conflict with AS 16.40.120(d), which states that a permit for aquatic farming will be denied or restricted if the proposed harvest will disrupt established uses of the resources by commercial, sport, personal use, or subsistence users. Another person commented that giving on-bottom farmers exclusive rights to harvest wild clams would circumvent the Board of Fisheries allocation process.

Response: The department considered these issues in reaching its conclusion that on-bottom mariculture is inconsistent with statutes and regulations governing management of the Kachemak Bay and Fox River Flats Critical Habitat Areas (see responses to comments # 6, 8 and 15).

24. Comment: In addition to adversely affecting existing clam fishers, one individual commented that on-bottom mariculture could create conflicts with adjacent landowners for access, mooring buoys, and running lines. This person stated that existing landowners should receive preference by prohibiting on-bottom aquatic farming.

Response: ADF&G does not have the authority to give adjacent landowners preferential use of the critical habitat areas. However, there are aquatic farming statutes and critical habitat area regulations designed to protect existing public uses of fish and wildlife resources and public access to the critical habitat areas (see responses to comments # 6, 8 and 15). The department also has a public trust responsibility to assure reasonable access to private waterfront property.

25. Comment: Two people expressed concern that if a few on-bottom aquatic farms were allowed in the critical habitat areas, it would set a precedent. Additional applications would likely follow, further impacting existing user groups. Another person noted that allowing on-bottom mariculture could lead to enforcement problems if farmers did not have to adhere to the same seasons and size limits as commercial diggers. Such enforcement problems almost always lead to resource conservation problems.

Response: ADF&G agrees that it would be difficult to limit the number of on-bottom aquatic farms once a few were authorized. The department also concurs that enforcement problems could arise in areas where both commercial clam digging and on-bottom mariculture occur. However, in the case of Kachemak Bay and Fox River Flats Critical Habitat Areas, ADF&G has determined that this type of mariculture is inconsistent with statutory and regulatory requirements, irrespective of the number of farms (see responses to comments # 6, 8 and 15).

26. Comment: Several individuals commented that use of predator exclusion netting, as proposed in the 1999 Kachemak Bay on-bottom mariculture applications, would deny wildlife (e.g., sea otters and birds) access to feeding habitat, and could potentially entangle wildlife.

Response: ADF&G agrees that predator exclusion netting could deny wildlife access to feeding habitat. A research project in south-central Alaska that compared clam survival at sites with and without predator netting reported that clam survival was higher at experimental plots covered with nets. This demonstrates that predator netting can preclude or reduce at least some species' ability to feed where netting is deployed. The department also concurs that predator netting poses a potential entanglement threat to wildlife (see response to comment # 3). Consequently, authorizing mariculture activities that include use of predator netting would be inconsistent with critical habitat area statutes and regulations (see responses to comments # 6, 8 and 15).

27. Comment: One person noted that available evidence does not support the hypothesis that on-bottom mariculture would benefit the public by seeding and helping rebuild clam populations on adjacent beaches. This person indicated that other factors, such as temperature, storms and suitable substrate, may play a more significant role in clam spawning success.

    Response: ADF&G agrees (see response to comment # 5).

28. Comment: Two people said they were opposed to giving exclusive use of common property resources (i.e., shellfish) to private individuals. One person noted that it would be inconsistent with the State Constitution, Article VIII, Section 3, which reserves naturally occurring fish, wildlife, and waters for common use by the public. This person noted that on-bottom mariculture might also conflict with Article VIII, Sections 4 and 15, which deal with sustained yield and exclusive fisheries.

    Response: ADF&G agrees that on-bottom mariculture raises significant constitutional questions, which have statewide implications. However, resolving these questions is not necessary to reach a decision about on-bottom aquatic farming in the Kachemak Bay and Fox River Flats Critical Habitat Areas. The specific statutes and regulations governing management of the critical habitat areas support a prohibition of this type of activity (see responses to comments #6, 8 and 15).

Miscellaneous Comments

Other less material comments, both for and against the proposed regulation, were also provided in the correspondence received. While ADF&G reviewed and considered all of these remarks, they have not been highlighted in this summary.

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December 13, 2000

Claudia Slater
Alaska Department of Fish and Game
Habitat Restoration Division
333 Raspberry Road
Anchorage, AK 99518-1599

Re: Ecological Considerations for On-Bottom Aquaculture of Littleneck Clams (*Protothaca staminea*) in Kachemak Bay, Alaska

Dear Ms. Slater:

This is a comment letter written to respond to the recent ADF&G sponsored literature review, referenced above. The Pacific Shellfish Institute (PSI) is a private, non-profit research and technical assistance organization specializing in bivalve shellfish and environmental research and education. Our staff and associates have experience in marine invertebrate aquaculture, diseases of shellfish, and aquatic toxicology. Established in 1995 primarily to assist in export markering for U.S. west coast growers of molluscan shellfish, PSI now has a portfolio of shellfish research projects. Most of these are undertaken at the request of the North American West Coast Shellfish Industry and address specific research topics encompassed in the Pacific Coast Shellfish Growers Association/National Shellfisheries Association-Pacific Coast Section 2010 Goals: Research and Initiative Priorities. PSI research and administrative offices are located in Olympia and Sequim, Washington.

We understand ADF&G is proposing to close Kachemak Bay to intertidal shellfish farming, and that this closure decision is based largely on the literature review referenced above. The author, William J Hauser, states in the introduction to the review that the "search for publication and information was not exhaustive or all inclusive ... Rather, this review is intended to provide an objective evaluation of readily-available literature..." Unfortunately, while the author provides reasonable descriptions of littleneck clam biology, clam farming methods, and clam resources in Kachemak Bay, the review contains errors in both facts and interpretation which paint a negative picture of clam farming and require clarification. Attached are detailed comments addressing specific sections in Hauser's literature review.

Thank you for your consideration of our comments.

Sincerely,

Dr. Daniel P. Cheney
Executive Director
Pacific Shellfish Institute

Comment letter on Hauser report

Section Comments to "Ecological Considerations for On-Bottom Aquaculture of Littleneck Clams (*Protothaca staminea*) in Kachemak Bay, Alaska"

Comments related to the overview of the littleneck clam stocks in Kachemak Bay, shellfish biology and culture practices.

- Resource availability and abundance in Kachemak Bay – There is little reference to the decline in abundance of littleneck clams other than increased regulatory restriction on harvest. Information from Bechtol and Gustafson (1998), which is cited in the report, suggests there are wide annual variations in survey efficiencies, abundances/biomass, or both in a littleneck clam population sampled at Chugachik Island in northeastern Kachemak Bay from 1992 to 1996. Does ADF&G have sufficient understanding of the population dynamics of littleneck clams to ensure long-term sustained yield?

- Distinction between differing species and culture practices – Because the literature related to the culture of native littleneck clams is limited, the author utilized reports on other species, including Manila clams, eastern hardshell clams, Dungeness crabs and salmonids. Manila clams, which appear outwardly similar to littlenecks, have many differing characteristics. They tend to be at higher bottom elevations, prefer finer-grained substrates, and tolerate a wider range of temperatures, salinity and dissolved oxygen (Cheney and Mumford, 1986; Elston, MacDonald and Cheney, 2001; LSSG, 1990). Beach graveling is practiced only where sediments consist of fine silts or sands and is not a common farming practice. Many farms rely in part or solely on natural recruitment, augmented with hatchery reared seed, including those in intensively harvested embayments of south Puget Sound. Annual harvest rates in these embayments range from 22,000 to 45,000 kg/ha (20,000 to 40,000 lb/ac) (LSSG, 1990).

Comments to specific sections of the literature review.

- Seeding adjacent beds and recruitment mechanisms – We didn't fully understand the intent of this section; however, we agree with the observations cited that farmed clam stocks do contribute larvae and seed to adjacent areas. Observations from Little Skookum Inlet in South Puget Sound taken during five years of quarterly surveys indicated relatively little variation in total clam densities despite continued harvest. High densities of juvenile and subharvestable stocks occurring at this site were a reflection of substantial natural recruitment from the farmed grounds. This site has a high rate of tidal exchange, strong currents, and variable seasonal temperatures and salinities. It should be made clear that under the appropriate environmental conditions, littleneck clams grown in Kachemak will spawn and will contribute seed to farmed grounds and adjacent beaches in the bay.

- Genetic integrity – We were again unclear as to the rationale for this section. It is my understanding that littleneck clams farmed in Kachemak Bay will be grown from naturally recruited stocks or from hatchery reared seed utilizing broodstock from the farmed area. This practice is similar to that used by many growers in Washington State. On-going research on Manila clams and Pacific oysters in Puget Sound and California is demonstrating site-specific tolerances for temperature and salinity which have genetic and environmental conditioning components (Cheney, et al. 2000; Griffen, et al. 2000; Elston, MacDonald and Cheney, 2001; and Langdon, 2000). We also understand that the State of Alaska has a regional transport policy to control the movement of genetic material within the state. The state of Washington has a similar policy in place for the movement of geoduck clam broodstock. Therefore, assuming animals will be taken from local sources, there will be no risk to the genetic integrity of littleneck clams in Kachemak Bay or adjacent waters due to the proposed farming activities.

- Effects on habitat – Much of the reviewer's discussion applies to beach graveling and mechanical harvest. Neither method will be employed in Kachemak Bay. Disturbance of the harvest area during planting and harvest will be necessary aspect of the culture practice; however, as was noted in the review, the effects of hand rake harvest are minimal To be fair, some comparative reference should be made to the harvest impacts of commercial and recreational clam fisheries in the Bay. Our impression of recreational clam digging is that it can have a significant impact on beach habitat. The diggers often use shovels instead of rakes, may crater the landscape, and have no economic incentive for environmental stewardship and restocking harvested beaches.

  This section also reviews the effects of netting on the benthic habitat. Netting is often used to prevent scouring and improve the survival of newly planted seed which can be dislodged by high currents and waves. Predator exclusion is also an important application, particularly to prevent loss of juvenile clams. Sedimentation deposition is not normally an issue in netted areas of Washington State, except in areas where storms waves may transport sediment over the nets. In general, as the reviewer noted, protective netting generally enhances and increase benthic diversity.

- Ecological interactions – The reviewer correctly notes the importance of marine bivalves to a wide variety of marine invertebrate, fish and wildlife species. Clams and other bivalves also perform a vital role in enhance the productivity of the benthic ecosystem. This enhancement role should be considered an ecological benefit of the proposed clam farming practice in Kachemak Bay. As discussed by Dame (1996) and others, clams and other bivalves filter feed and remove phytoplankton and detritus particulates from the water column. They remain more or less permanently in the ecosystem, their feeding filtration rates increase with increasing food supply, and their biomass turns over at a relatively low rate. The suspended organic material (phytoplankton and detritus) removed and consumed by these animals is then remineralized into forms that are readily utilized by phytoplankton. In dense cultures, feces and pseudofeces enrich sediments surrounding the bivalves, and microorganisms in the sediments further enhance remineralization rates. These processes move nutrients – carbon, nitrogen and phosphorus – through and within the system at a faster rate than would occur without the bivalves. As a consequence, both the productivity and stability of the ecosystem are increased. The nutrient cycling aspects of shellfish populations is of great significance to submerged aquatic vegetation (SAV). Farmers describe dense stands of eelgrass and algae growing on and among oysters and in netted clam tracts (Luckenback, 2000). An eelgrass transplant study in the Baltic Sea reported higher eelgrass densities when mussels were placed on the bottom than on bare sediment (Worm and Reusch, 2000). Therefore, in addition to the phytoplankton interactions, there may also be subtle beneficial inter-relationships between the bivalve shellfish and the larger plant forms.

- Predator exclusion nets – All netting used by Washington State clam farmers is placed on the bottom. There is secure anchoring around the perimeter of the net and along adjacent seams. Because of the potential for clam losses, there is great economic incentive to maintain the netting. We know of no reports of waterfowl, shorebird or marine mammal entanglement in clam netting.

- Introduction of diseases, parasites – This section overstates a problem that does not exist. Particularly annoying and out-of-context were the references to diseases in fish and the concerns regarding importation of non-indigenous species. No diseases of significance have been reported for native littleneck clams on the U.S. west coast. Parasites and potential disease organisms have been reported, but these are rare events. Elston (1990) described three diseases -- hemic neoplasia, vibriosis, and hinge ligament disease. No littleneck clam stocks were noted as being affected. The importation and transported of non-indigenous species is now highly regulated and controlled both in Alaska and Washington. It is our understanding that the proposed farming activity applies only to native littleneck clams and that the seed for these clams must come from local sources using Kachemak Bay broodstock. Therefore, it appears there should be no risk of importing an exotic species or disease to the area.

- Site selection and loss of productive clam beds -- This section correctly points to need for careful site selection. It is unclear how productive clam beds would be lost considering the general decline in clam abundance in Kachemak Bay. We assume the proposed farms could be sited in areas with a history of clam production, although the abundance may be depressed due to excessive commercial/recreational harvest and poor recruitment.

- Conclusions -- The proposed rule change by ADF&G to ban intertidal littleneck clam culture in Kachemak Bay is in marked contrast to the efforts by other state and local agencies in the U.S. to promote private and public shellfish culture as a means of enhancing benthic diversity, improving water quality, and providing economic and cultural benefits to the private sector and general public. Dr. Hauser's literature review provides no justifiable conclusions or recommendations that clam farming should be a prohibited activity.

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Chapter 16.05. FISH AND GAME CODE

Sec. 16.05.020. Functions of commissioner.

The commissioner shall

(1) supervise and control the department, and may appoint and employ division heads, enforcement agents, and the technical, clerical, and other assistants necessary for the general administration of the department;

(2) manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state;

(3) have necessary power to accomplish the foregoing including, but not limited to, the power to delegate authority to subordinate officers and employees of the department.

Sec. 16.05.050. Powers and duties of commissioner.

(a) The commissioner has, but not by way of limitation, the following powers and duties:

(1) to assist the United States Fish and Wildlife Service in the enforcement of federal laws and regulations pertaining to fish and game;

(2) through the appropriate state agency and under the provisions of AS 36.30 (State Procurement Code), to acquire by gift, purchase, or lease, or other lawful means, land, buildings, water, rights-of-way, or other necessary or proper real or personal property when the acquisition is in the interest of furthering an objective or purpose of the department and the state;

(3) under the provisions of AS 36.30, to design and construct hatcheries, pipelines, rearing ponds, fishways, and other projects beneficial for the fish and game resources of the state;

(4) to accept money from any person under conditions requiring the use of the money for specific purposes in the furtherance of the protection, rehabilitation, propagation, preservation, or investigation of the fish and game resources of the state or in settlement of claims for damages to fish or game resources;

(5) to collect, classify, and disseminate statistics, data and information that, in the commissioner's discretion, will tend to promote the purposes of this title except AS 16.51 and AS 16.52;

(6) to take, capture, propagate, transport, buy, sell, or exchange fish or game or eggs for propagating, scientific, public safety, or stocking purposes;

(7) under the provisions of AS 36.30, to provide public facilities where necessary or proper to facilitate the taking of fish or game, and to enter into cooperative agreements with any person to effect them;

(8) to exercise administrative, budgeting, and fiscal powers;

(9) under the provisions of AS 36.30, to construct, operate, supervise, and maintain vessels used by the department;

(10) to authorize the holder of an interim-use permit under AS 16.43 to engage on an experimental basis in commercial taking of a fishery resource with vessel, gear, and techniques not presently qualifying for licensing under this chapter in conformity with standards established by the Alaska Commercial Fisheries Entry Commission;

(11) not later than January 31 of each year, to provide to the commissioner of revenue the names of those fish and shellfish species that the commissioner of fish and game designates as developing commercial fish species for that calendar year; a fish or shellfish species is a developing commercial fish species if, within a specified geographical region,

(A) the optimum yield from the harvest of the species has not been reached;

(B) a substantial portion of the allowable harvest of the species has been allocated to fishing vessels of a foreign nation; or

(C) a commercial harvest of the fish species has recently developed;

(12) to initiate or conduct research necessary or advisable to carry out the purposes of this title except AS 16.51 and AS 16.52;

(13) to enter into cooperative agreements with agencies of the federal government, educational institutions, or other agencies or organizations, when in the public interest, to carry out the purposes of this title except AS 16.51 and AS 16.52;

(14) to implement an on-board observer program authorized by the Board of Fisheries under AS 16.05.251
(a)(13); implementation

(A) must be as unintrusive to vessel operations as practicable; and

(B) must make scheduling and scope of observers' activities as predictable as practicable;

(15) to sell fish caught during commercial fisheries test fishing operations;

(16) to establish and charge fees equal to the cost of services provided by the department, including provision of public shooting ranges, broodstock and eggs for private nonprofit hatcheries, department publications, and other direct services, and reasonable fees for the use of state facilities managed by the department; fees established under this paragraph for tours of hatchery facilities, commercial use of sport fishing access sites, and for operation of state hatchery facilities by private aquaculture associations are not subject to the cost limit under AS 37.10.050 (a);

(17) to permit and regulate aquatic farming in the state in a manner that ensures the protection of the state's fish and game resources and improves the economy, health, and well-being of the citizens of the state; ←

(18) to operate state housing and facilities for employees, contractors, and others in support of the department's responsibilities and to charge rent that is consistent with applicable collective bargaining agreements, or, if no collective bargaining agreement is applicable, competitive with market conditions; rent received from tenants shall be deposited in the general fund;

(19) to petition the Alaska Commercial Fisheries Entry Commission, unless the Board of Fisheries disapproves the petition under AS 16.05.251(g), to establish a moratorium on new entrants into commercial fisheries

(A) that have experienced recent increases in fishing effort that are beyond a low, sporadic level of effort;

(B) that have achieved a level of harvest that may be approaching or exceeding the maximum sustainable level for the fishery; and

(C) for which there is insufficient biological and resource management information necessary to promote the conservation and sustained yield management of the fishery.

(b) The commissioner shall annually submit a report to the Board of Game regarding the department's implementation during the preceding three years of intensive management programs that have been established by the board under AS 16.05.255 for identified big game prey populations.

Sec. 16.05.251. Regulations of the Board of Fisheries.

(a) The Board of Fisheries may adopt regulations it considers advisable in accordance with AS 44.62 (Administrative Procedure Act) for

(1) setting apart fish reserve areas, refuges, and sanctuaries in the waters of the state over which it has jurisdiction, subject to the approval of the legislature;

(2) establishing open and closed seasons and areas for the taking of fish; if consistent with resource conservation and development goals, the board may adopt regulations establishing restricted seasons and areas necessary for persons 60 years of age and older to participate in sport, personal use, or subsistence fishing;

(3) setting quotas, bag limits, harvest levels, and sex and size limitations on the taking of fish;

(4) establishing the means and methods employed in the pursuit, capture, and transport of fish;

(5) establishing marking and identification requirements for means used in pursuit, capture, and transport of fish;

(6) classifying as commercial fish, sport fish, guided sport fish, personal use fish, subsistence fish, or predators or other categories essential for regulatory purposes;

(7) watershed and habitat improvement, and management, conservation, protection, use, disposal, propagation, and stocking of fish;

(8) investigating and determining the extent and effect of disease, predation, and competition among fish in the state, exercising control measures considered necessary to the resources of the state;

(9) prohibiting and regulating the live capture, possession, transport, or release of native or exotic fish or their eggs;

(10) establishing seasons, areas, quotas, and methods of harvest for aquatic plants;

(11) establishing the times and dates during which the issuance of fishing licenses, permits, and registrations and the transfer of permits and registrations between registration areas is allowed; however, this paragraph does not apply to permits issued or transferred under AS 16.43;

(12) regulating commercial, sport, guided sport, subsistence, and personal use fishing as needed for the conservation, development, and utilization of fisheries;

(13) requiring, in a fishery, observers on board fishing vessels, as defined in AS 16.05.475 (d), that are registered under the laws of the state, as defined in AS 16.05.475 (c), after making a written determination that an on-board observer program

(A) is the only practical data-gathering or enforcement mechanism for that fishery;

(B) will not unduly disrupt the fishery;