Jones & Stokes

Technical Memorandum

Date: November 8, 2006

To: Humboldt Bay Harbor, Recreation and Conservation District

From: Chris Cziesla, Jones & Stokes

cc: Coast Seafoods

Subject: Coast Historic Bottom Culture Operations

I. Introduction

The purpose of this technical memorandum is to address the environmental effects of Coast's proposed operations on eelgrass as compared to the baseline eelgrass conditions at the time Coast first applied for Harbor District approval in 1998. In order to do so, it is necessary to discuss the differences between Coast's operations in the 1998, when Coast applied for its initial Harbor District permit, and its proposed operations under review in its current Harbor District permit application. In addition, this technical memorandum discusses the differences between Coast's baseline bottom culture operations and the bottom culture operations on bed MR 7-1, which were reviewed as part of the Western Regional Aquaculture Center ("WRAC") study in Humboldt Bay.

II. Factual Information

A. Coast Seafoods' Historic Oyster Ground Culture Operations

During the 1990's, Coast Seafoods farmed roughly 500-600 acres annually. Generally Coast farmed the same beds, although Coast occasionally tried new areas or left old areas fallow. General bed sizes varied from crop to crop depending on seed availability and other factors (such as climate and predation). In 1998, Coast had roughly 330 acres of ground culture in production, 95 acres of long-line culture and 11 acres of rack and bag culture.

For ground culture operations, Coast placed approximately 40,000 bags of over winter seed on its nursery from August to March of a given year, and another 20-30,000 bags of spring production seed on the nursery from February to May for hardening (growing to 3mm size prior to planting on beds). Hardened seed was then planted on beds at a density of roughly 700-1000 gallons per acre, with an average density of approximately 750 gal/acre. Each bag of seed totals approximately 2.1 gallons and contains approximately 250 shells with seed attached.

With its ground culture operations, Coast prepared beds by dredging the bed clean of the previous crop with either a drag dredge or a hydraulic dredge (or both), harrowing the bed (dragging a toothed plow) and placing crab pots around the bed at roughly 30-foot intervals. The bed was then allowed to sit for several days to accumulate crabs in the traps and allow the bottom to smooth over from harrowing. Bat ray exclusionary fencing was also constructed around most ground culture beds. Bat ray fencing consisted of 8-foot wooden stakes placed in the mud every 8 inches to form a continuous row or fence. The corners of the bat ray fencing included traps that allowed rays to be caught and removed. Bat ray fences were installed or repaired prior to planting.

During the spring and summer, the seed bags were cut and loaded onto a scow by hand at low tide. This involved bringing a scow onto the nursery, placing the seed bags onto the scow and cutting the bags open. At high tide the scow was towed to the previously prepared beds to be planted by shoveling the seed off by hand in a dispersive manner.

The seed was grown on the beds for approximately 18 months. During this time the beds were frequently crabbed and harrowed as needed to keep oysters on top of the mud. Depending on the location of the bed in the bay, beds were harrowed between 3 and 5 times per year. In addition, if growth was slow or excessive siltation occurred, Coast occasionally transplanted the seed by dredging it and moving it to another bed. If the seed grew too thick it was hand-scattered. Hand-scattering involved a crew of farmers spreading oysters by hand from thick areas to thin areas in order to even out density. Each ground culture crop cycle required 3 years on average.

When ground culture beds were ready to be harvested, Coast used one of three harvest methods: mechanical dredge, hydraulic harvesting and harvesting by hand. Coast initially operated a mechanical dredge that was very similar to scallop, oyster and clam dredges used around the world. The leading edge of the dredge consisted of a steel frame with teeth. A collection bag was attached to the steel frame. The dredge was towed across the surface of the bottom allowing shellfish to be lifted from the substrate by the steel teeth and guided into the bag. The bag was lifted periodically onto the boat deck, emptied and then redeployed.

By the 1990's, most of Coast's bottom culture beds were harvested using a hydraulic harvester. The hydraulic harvester contained a generator, operating controls, and hydraulic apparatus mounted on a floating barge or platform that was towed through the water. The hydraulic apparatus contained a conveyor belt system and arm with "stinger" and rollers extending below the water surface to the sediment. The hydraulic harvester was used to harvest large quantities of oysters with a crew of two people and harvested mostly the larger size oysters. Smaller oysters and oysters less than three years old, as well as residual shells, were screened out mechanically and returned to the bay bottom.

In good weather conditions, the hydraulic harvester could harvest 1/2 acre per day on average.

B. Current Operations

Coast's current operations primarily consist of long-line culture. For long-line culture, Coast places about 17,000-19,000 bags of long-line seed on the nursery for hardening. Once hardened, Coast plants the seed by placing the seeded long-line on notched PVC stakes that are arranged in rows on the mudflats. The long-lines are strung through notches on top of the PVC stakes, suspending the oyster seed approximately 1 foot above the bay bottom.

Long-line spacing varies from bed to bed but most beds have five long lines spaced 2.5 feet apart, with a ten-foot space between each group of five lines. Some beds have long lines spaced two and one half feet apart over the entire bed. The proposed action includes the use of long lines at 2.5 foot spacing on all beds with the exception of the multiple spaced beds planted at the request of the MMC or as part of the WRAC study.

A crew of 6 typically plants the long-lines when the tide is low enough to allow the crew to walk on the bed to be planted. On days of sufficiently low tides the planting crew will gather enough bags from the nursery to plant during the low tide. The bags are normally gathered at high tide using a skiff and a hook. The crew will float over the pile of long-line seed and lift the bags into the skiff using the hook. An alternate method of getting the long-line bags is to pull the skiff into the nursery by hand when the tide is coming in but the water is only a foot or two deep and manually throw the bags into the skiff.

Once the seed bags are gathered from the nursery, the crew will take the bags to the bed being planted and place them along the edge of a row of empty long-line pipe. At low tide, the crew will go back out to the bed, cut the long-line out of the bag and pull the line out along side the empty pipe. As crew members walk back to the next bag, they clip the long-line on the notch of each pipe. They continue this until all bags are planted or the tide forces them off the bed. Due to the infrequency of adequately low tides, the planting crew works every low tide that they can.

There is a monthly inspection of each planted bed. Apart from that inspection, virtually no activity takes place on the bed until harvest. A bed inspection involves one or two people walking on the bed at low tide to make sure that the lines are in the notches.

Long-line beds are harvested when they have oysters of a harvestable size and market conditions are right. It usually takes 18 to 36 months for oysters to reach a harvestable size. Market condition is hard to predict, varying with seasons and other factors. Coast currently uses two different methods to harvest long-lines. The first, hand picking, involves placing round 20-bushel tubs on the bed at high tide using an oyster scow. The tubs are then filled at low tide by hand. The picking crew cuts the long-line into manageable single clusters and places them in the picking tub. A floating ball is attached to each tub, and at high tide an oyster scow is used to pull the tub out of the water. The oysters are dumped on the deck of the scow, and the tub is placed back on the bed to be refilled. The oysters are brought to Coast's Eureka plant to be either broken into singles to be sold live in shell, or loaded onto a truck for shipment to Coast's shucking plant in South Bend, Washington.

The second method of harvest, the long-line harvester, involves positioning a scow over the long-line bed at high tide. Individual lines are then pulled onto the floating scow either by hand or by a hydraulically-operated roller. If the lines are pulled by hand then the lines need to be cut into individual clusters, usually at the plant. If the lines are pulled mechanically they run through a breaker that strips the clusters from the line. The long-line harvester does not come in contact with the bottom while harvesting long-lines.

III. Studies Evaluating the Impacts of Bottom Culture and Long-line Culture on Eelgrass

A. Historic Abundance of Eelgrass

Interannual variability exhibited in eelgrass coverage in Humboldt Bay is dramatic. Eelgrass coverage was 840 acres in 1959 (Keller 1963), 1,220 acres in 1961, 1,975 acres in 1962, 900 acres in 1963 (Waddell 1964), 1,075 acres in 1972 (Harding and Butler 1979), 1,000 acres in 1979 (Shapiro and Associates 1980), and 1,011 acres in 1992 (Ecoscan 1992). Surveys completed by CDFG in 1997 and 2000 indicate eelgrass coverage of 1,048 ha (2,589 ac) and 1,105 ha (2,730 ac) respectively. These estimates represent an average eelgrass cover of 1,378 acres with a standard deviation of 776 acres, with no discernible long-term trend. There are no estimates of eelgrass cover in Arcata Bay prior to the start of oyster culture in the 1950's, or prior to the many other potential impacts on eelgrass dating back to the 19th Century, including diking, sedimentation due to upstream timber harvest, and chemical/biological contamination.

There have been several studies that have included some level of interpretation or investigation regarding the relationship between oyster culture and eelgrass. Historically, virtually all oyster culture operations consisted of bottom culture techniques with either hand or mechanical harvesting. In Humboldt Bay, Waddell (1964) documented the impacts of harvesting oysters from eelgrass beds by hydraulic dredges and a modified dragline-type dredge. Under conditions of no dredging, eelgrass biomass declined 38 percent (this may have been due to a combination of impacts to Humboldt Bay from logging sediment, agricultural impacts on water quality, residential construction and storm water runoff, heavy rainstorm sediment input, and others) while biomass declined 96 percent after three dredging episodes. In some cases, the eelgrass failed to recover following dredging activities. This data indicates a significant decline in eelgrass from oyster harvesting using an oyster dredge as well as potential longer lasting effects on eelgrass recovery.

Other studies also suggested impacts to eelgrass from oyster culture farming practices (Carlton et al. 1991, Pregnall 1993, Everett et al. 1995, Rumrill and Christy 1996); however, because these studies evaluated culture methods not historically (or currently) employed by Coast Seafoods (such as stake and rack culture) they are not discussed further.

B. Western Regional Aquaculture Center Study

More recently the Western Regional Aquaculture Center (WRAC 2005) completed several studies evaluating the relationships between oyster culture and eelgrass. One of the express project objectives was to assess the immediate and longer-term response of eelgrass to aquaculture practices, including bottom culture (planting, harvest dredging, hand harvesting) and long-line operations (planting and harvesting). The experiments were conducted in both Willapa Bay, Washington and Humboldt Bay, California. The WRAC examination of the effect of oyster aquaculture on eelgrass included two components 1) A survey of existing oyster aquaculture areas in Willapa Bay, Washington where grow-out and harvesting practices are fairly diverse and 2) an experimental approach in both Willapa Bay and Humboldt Bay to examine individual practices and their effect on eelgrass growth and survival over time.

The WRAC study reported the following from surveys of the distribution and growth of eelgrass within and adjacent to oyster culture:

> Eelgrass density showed variability between sites and culture type, but all cultured areas had lower density and cover than uncultured meadow areas (Figure 1).

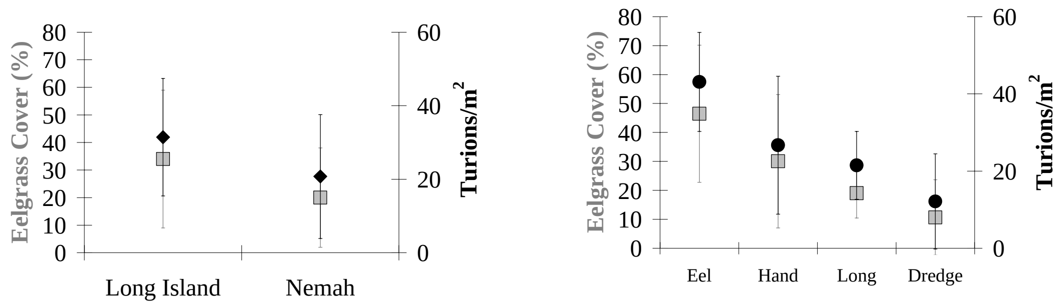

Figure 1. Eelgrass density in May 2004 varied among sites (a) and oyster culture types (b). All cultured areas (Hand-picked, Long lines, Dredged) had lower eelgrass density than uncultured areas (Eel).

> Harvest dredged sites had the lowest eelgrass density with approximately one third of the eelgrass cover seen in uncultured areas. Individual plant growth rates (g/plant/day) and size corrected growth rates were lower in all cultured areas than in eelgrass meadows (Figure 2). Eelgrass in long line beds showed the slowest growth, but when density and growth rates are combined to give a measurement of aerial productivity, harvest dredged beds had the lowest overall eelgrass production.

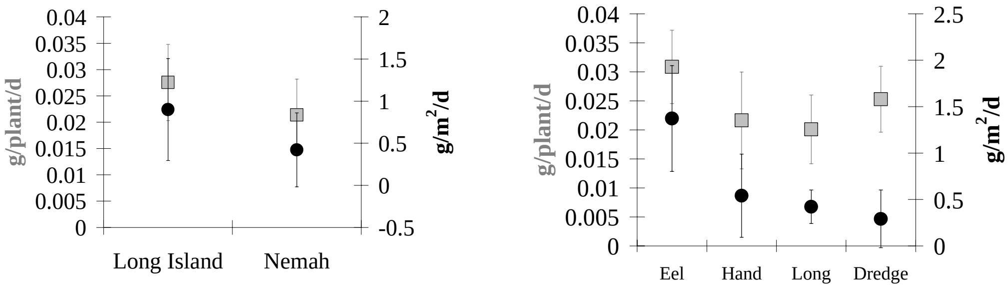

Figure 2. Eelgrass growth varied among sites (a) and oyster culture types (b). Individual plant growth rates (g/plant/d) were lowest in long line culture, while aerial productivity (a combination of density and growth measures, $g/m^2/d$) was lowest in dredged culture.

C. Humboldt Bay Long-Line Experiments

As part of the WRAC study to understand the potential ecological effects of off-bottom (long line) culture, experimental long line plots were established at line spacing distances of 1.5 ft., 2.5 ft., 5 ft., and 10 ft. Additionally, an adjacent control plot (no long lines), an oyster ground culture plot, and six eelgrass reference plots (no recent history of oyster culture) were included. Prior to establishment of the experimental long line plots, the spatial cover of eelgrass ranged from 14 to 51 percent and eelgrass density ranged from 15 turions/m^2 to 46 turions/m^2. Initial spatial cover and density was 91 percent and 76 turions /m^2 within the eelgrass reference sites and 45 percent and 38 turions/m^2 with the ground culture plot.

Over the course of the 2 year study, eelgrass spatial cover and density exhibited a seasonal pattern and response that was directly related to the density of oysters in the experimental long line study plots with a trend of decreased spatial cover and density with decreased distance between suspended oyster long lines (Figure 3). Eelgrass metrics within the oyster ground culture plot (MR 7-1)[1] were intermediate and similar to the 5 ft spaced long line culture plot.

[1] Additional information on the ground culture plot used in the WRAC study (bed MR 7-1) is included in the section entitle Ground Culture Plot MR 7-1 below.

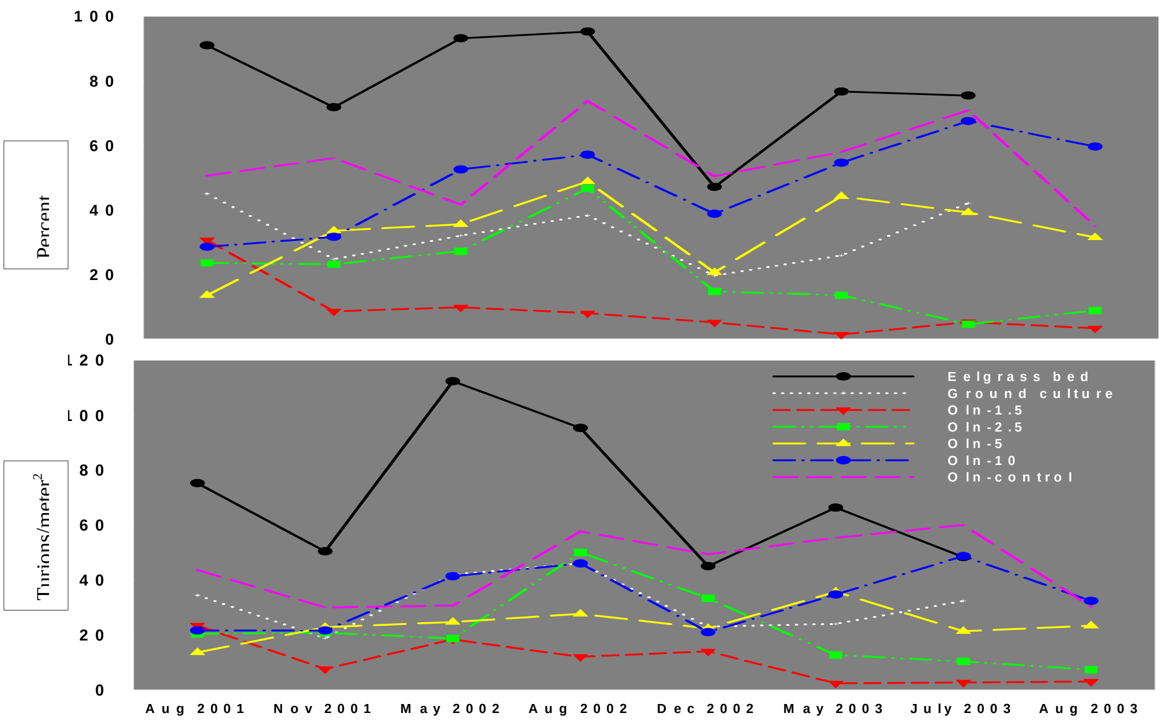

Figure 3. Humboldt Bay WRAC Study Results (Rumrill 2004).

D. WRAC Study Conclusions

WRAC study results indicated complicated interactions between different shellfish farming techniques and the response of other commercially and ecologically important species. Specifically in their final report the researchers concluded "that there is substantial spatial and temporal variability in oyster growing practices and eelgrass density, growth, and survival. This variability must be taken into account when evaluating and comparing the effects of shellfish aquaculture. Nonetheless, we were able to show a consistent trend in the effects of harvest practices with reduced eelgrass density in all areas where oysters were cultivated and approximately two thirds lower density observed in areas where a harvest dredge implement had been used versus that found in nearby eelgrass meadows. Beds where oysters were picked by hand and where long-line culture was used had intermediate densities and cover."

IV. Ground Culture Plot MR 7-1

The Humboldt Bay WRAC study included a ground culture plot (MR 7-1) to provide some information regarding the effects of ground culture on eelgrass. (The vast majority of the WRAC study analysis of bottom culture effects was based on beds in Willapa Bay.) The study indicated that eelgrass metrics within the ground culture plot were similar to those observed in the 5 foot spaced oyster long lines. The discussion below compares and contrasts the oyster ground culture practices on MR 7-1 during the WRAC study to the historic ground culture practices used by Coast Seafoods in 1998 (baseline).

By the onset of the WRAC study, Coast had virtually ceased all of its ground culture operations. Bed MR 7-1 was one of the last ground culture plots remaining, and it had recently been hand-harvested. Upon its inclusion into the WRAC study, bed MR 7-1 was planted with the remaining seed from the nursery. This was approximately 5,475 gallons of seed distributed over the 10.46-acre bed, resulting in a density of approximately 523 gallons per acre. That density is slightly more than half of the typical density of ground culture planting historically used by Coast Seafoods.

As also noted above, prior to its planting for the WRAC study, MR 7-1 was most recently harvested by hand instead of by hydraulic harvester. Bed MR 7-1 was not dredged or harrowed prior to the WRAC study planting, as was done with Coast's commercial ground culture beds. Nor were any crab pots or significant bat ray exclusion[2] placed around the study bed. Observations by Coast personnel indicated that during the first year of the study, oyster predation on MR 7-1 was significant, resulting in a loss of 80-90% of the planted oysters. The analysis of bed MR 7-1 does not show any of the effects of harvesting ground culture beds because the oysters were not harvested prior to completion of the WRAC study.

Based on the substantial operational differences in how the MR 7-1 ground culture study plot was cultivated during the WRAC study, eelgrass growth on that plot is not representative of ground culture as it historically occurred on Coast Seafoods ground culture beds. As indicated by previous studies (Waddell 1964, Griffin 1999) and the WRAC experiments in Willapa Bay (WRAC 2005), higher oyster density in, and mechanical harvesting of, ground culture beds can result in significant reductions in eelgrass. The eelgrass disruption over the dredged harvested beds in Willapa was greater than on beds with commercially spaced long-lines. The results from the WRAC Humboldt Bay ground culture plot (MR 7-1), which was planted, maintained and harvested in a manner that was not representative of Coast's baseline operations or commercial bottom culture operations in general, are not particularly useful to determining the environmental effects of Coast's proposal.

To summarize: eelgrass density at MR 7-1 was greater at planting than eelgrass density at planting under baseline conditions. Conversely, oyster density at MR 7-1 was significantly lower than on bottom culture beds that constitute baseline conditions. Furthermore, unlike baseline bottom culture conditions, no predator control activities took place on MR 7-1. Additionally, MR 7-1 was not harvested during the study, so the study did not evaluate the effects of dredging on this bed. For these reasons, operations at MR 7-1 are not representative of baseline operations. Similarly, eelgrass abundance

[2] A limited amount of bat ray stakes were relocated to bed MR 7-1 from other beds; however, these stakes were at the end of their useful life and no additional stakes were added, rendering the bat ray fencing ineffective.

and density at MR 7-1 are not representative of eelgrass abundance and density under baseline conditions.

V. Conclusions

Operational practices employed by Coast Seafoods have substantially changed from the historic operations at the time of the permit applications in 1996 (baseline). These changes have included:

- a reduction in operational footprint from over 500 acres to 300 acres;
- the conversion from bottom culture to off-bottom culture (long lines);
- the cessation of harrowing and dredging;
- the cessation of bat ray and crab depredation;
- the cessation of discharging shell into intertidal areas to harden the substrate; and
- the transition to beds that are at or near the upper elevation of eelgrass to avoid negative interactions.

All of these changes have reduced the environmental impacts of Coast's operations to Humboldt Bay in general, and eelgrass in particular. The factual information and studies cited herein support a conclusion that Coast Seafoods proposed operations represent a reduction in impacts compared to baseline environmental conditions.

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