RESPONSE TO ENVIRONMENTAL CONCERNS EXPRESSED DURING CONSULTATION PROCESS FOR THE HALF-MOON COVE TIDAL POWER PROJECT

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A Discussion of Some Environmental Concerns Associated with Tidal Power Development in Halfmoon Cove, Cobscook Bay, Maine

By its very nature, tidal power development involves environmental modification. The type and degree of modification is largely dependent on the physiographic conditions at the intended site and the construction and operation methods planned. For these reasons, environmental evaluations of proposed tidal power developments must be largely project specific. About all that can be said at a generic level is that the environmental consequences are associated with altered tidal regimes and modified material exchanges between the tidal impoundment and the sea. The purpose of this document is to discuss some perceived environmental concerns associated with the proposed tidal power facility in Halfmoon Cove, Cobscook Bay, Maine. In particular, comments by involved federal and state agencies are used to organize the discussion in an attempt to identify areas of common environmental concern and to help draw a focus on aspects where further research would be helpful in resolving environmental issues. This exercise is undertaken based firmly on the understanding that the Halfmoon Cove project is proposed largely as a demonstration project, i.e. as an experimental facility for the testing of both environmental and engineering hypotheses related to tidal power development in the unique Northwestern Atlantic region.

The discussions are limited to the Halfmoon Cove project as proposed elsewhere in this document. Certain agencies have suggested a discussion of the environmental consequences of other operating modes and of a major Cobscook Bay tidal power development. This would involve

a worthy, but considerable, undertaking which is beyond the scope of the present exercise.

Tidal Range Changes

The most obvious environmental modification associated with tidal power development is a reduction of the tidal range inside of the tidal barrage. In the case of Halfmoon Cove, the reduction is projected to be about 65%, resulting in the permanent inundation of approximately 380 acres of intertidal area. To say it another way, there will be a shift from an intertidal to a subtidal environment with corresponding shifts in patterns of productivity and energy flow. It is difficult to make a value judgement as to which is more desirable, but the major implications of the change should be appreciated. At present, the productivity of Halfmoon Cove is undoubtedly dominated by benthic diatoms and intertidal macroalgae. With the reduced tidal range, i.e. greater water mass, phytoplankton and, perhaps, subtidal macrophyte productivity will play a larger role. Well-devised studies could give a reliable estimate of the magnitude of this shift.

Several reviewing agencies have commented that a reduction in intertidal area will result in a loss of certain commercially valuable marine resources, especially potentially productive clam and worm beds. Since 82% of Halfmoon Cove is presently open for clamming, it is acknowledged that access to this resource will be lost to the extent that it occurs in areas of the cove to be permanently inundated. Although marine worms support a less important fishery in the region, some small, but undetermined, portion of this resource may become unavailable for harvest. Reasonable estimates of the affected portion

of each of these resources in Halfmoon can be obtained by straightforward survey techniques.

Changes in the numbers and distributions of soft clams and marine worms are indicative of changes in the invertebrate community in general. The many other species residing in Halfmoon Cove are not of direct commercial importance, but are involved in food webs supporting fish and bird populations. Knowledge of changes in their numbers and population structure is therefore also important in understanding the environmental implications of tidal power development. It should be noted that a change from an intertidal to a subtidal habitat will not necessarily lead to a catastrophic change in community structure. Many of the same species will continue to live and flourish regardless, and the species changes that will occur cannot be considered detrimental, only different.

As emphasized by comments from the U.S. Fish and Wildlife Service (FWS), another major component of the coastal ecosystem that will potentially be affected by a shift towards a subtidal environment are shorebirds and waterfowl. Eastern Maine is an important staging area for migrating shorebirds which use the intertidal flats for foraging on invertebrates. The FWS is concerned that the region is at its carrying capacity for these birds and that a reduction in feeding area will cause losses of birds.

The applicant acknowledges the Fish and Wildlife Service ecological characterization study which identified the entire intertidal area of Halfmoon Cove as "tidal flats important to waterfowl" and as "shorebird feeding area." The applicant also recognizes that the project will cause some temporary disturbances to the environment of Halfmoon Cove,

and that approximately 380 acres of intertidal area will be transformed into submerged lands. However, the applicant in response to the FWS comments wishes to present the following information and rationale.

Cobscook Bay and Passamaquoddy Bay have a total water surface area of nearly 150 square miles at mean high tide. Assuming that this area is comprised of 20% intertidal area, the intertidal zone transformed in Halfmoon Cove by the plant's construction and operation represents less than two percent of the region's intertidal area. This potential feeding area is within a twenty mile radius of Halfmoon Cove. All this area has not been identified as shorebird feeding habitat, but it is important to point out the availability of other sites within the area which could potentially support the shorebirds and waterfowl that populate the area. Studies to document the feeding habitat requirements of shorebirds are needed to evaluate the underutilized flats. Limited studies of this sort are presently underway in the Lubec area and are being conducted by the University of Maine and the FWS.

Data are not available to indicate that the region's carrying capacity for shorebirds and waterfowl has been exceeded or is approaching that limit. However, intuitively, it seems that the occurrence of a two percent displacement in feeding habitat would not adversely affect the existing shorebird and waterfowl population. The statistical determination of bird population would not seem to be an accurate technique of detecting a 2% change in population. Additional studies are needed, but it is unlikely that these studies would be accurate enough to observe the maximum changes estimated for Halfmoon Cove.

The developer holds the position that development impact on shorebirds may be less severe in Halfmoon Cove than it would be in similar nearby coves. This is based on the belief that the birds preferentially feed at the higher intertidal levels which will be unaffected by development. Where a bird will feed is largely controlled by the availability of invertebrate prey which in turn depends on the zonation of the prey and the porosity of the sediments. A preferred prey in eastern Maine is the amphipod Corophium volutator. This species occurs in the high intertidal and is available to the birds as long as the sediments stay moist. If the sediment dries, Corophium withdraws beyond reach in its burrow, and the birds must move to more moist, lower portions of the flats to find prey.

Observations by project staff taken at Halfmoon Cove have confirmed the fact that sandpipers feed mostly along the mid and upper levels of the tidal spectrum, whereas, in Carringplace Cove the birds follows the tides all the way down to low tide level. Evidence for this feeding variability exists in the literature (Goss-Custard, J.D., 1977. Predator responses and prey mortality in redshank, Tringa totanus (L.), and preferred prey, Corophium volutator (Pallas). J. Anim. Ecol. 46: 21-35). Likewise, similar observations have been made in the Bay of Fundy by Canadian researchers (D.C. Gordon, personal communication).

Independent observations by McCollough and May (Habitat Utilization by Southward Migrating Shorebirds in Cobscook Bay, Maine during 1979; unpublished contract report) confirm that upper Halfmoon Cove, that area which will be largely unaffected by tidal regime changes, is a more popular feeding area for shorebirds than is lower Halfmoon Cove. For comparative purposes, this same report indicates that the adjacent

Carryingplace Cove is utilized for feeding by over 15 times as many shorebirds as Halfmoon Cove.

The above discussion of the potential effects of tidal power development on marine bird life has emphasized feeding because this is the activity with the greatest potential to be impacted. Roosting and breeding take place at or above the high tide line, and hence will not be influenced by the environmental modifications associated with the Halfmoon Cove project as presently planned.

Mitigation measures for losses to commercial resources of Halfmoon Cove have been addressed elsewhere as part of the terms for the submerged lands lease with the State of Maine. The development of an allied aquaculture industry within the modified confines of Halfmoon Cove is another way that "environmental losses" can be countered with a productive utilization of the created environment. The Passamaquoddy Tribe has conducted a number of experimental aquaculture programs in Halfmoon Cove which have not proven successful due to harsh conditions that presently exist. However, the prospects for an economically feasible aquaculture venture will be greatly enhanced by the changes predicted for Halfmoon Cove resulting from the project's construction, i.e., warmer summer temperatures, reduced currents, increased water depths.

In certain unique situations it is possible for construction of a tidal power barrage to alter the tidal regime outside as well as inside the impoundment. Such is the case with the proposed projects in the upper Bay of Fundy. Because of its small size and location with the tidal system, the Halfmoon Cove project will have no effect on tides outside of the dam.

Reduced Exchange Between Halfmoon Cove and the Sea

The other major environmental modification of tidal power development in Halfmoon Cove is a reduction in material movement and energy flow between the Cove and the sea. This is a simple consequence of less water being moved across a reduced cross-sectional area. This has implications for water quality, fish passage, endangered species and erosion/deposition patterns.

Reduced tidal exchange between an embayment and the sea can often lead to modifications in water quality, including reduced salinity, increased stratification, higher summer water temperatures, lower dissolved oxygen, ice accumulations, and eutrophication. Some of these areas of concern have been noted in agency comments. None appear to be highly significant in the Halfmoon Cove situation.

Freshwater input into the Cove is limited to two minor streams. Sufficient tidal exchange will exist after barrage construction so that a depression of salinity will not occur. The volume of freshwater entering the Cove is not sufficient to cause stratification in the present tidal regime, and adequate tidal mixing will be maintained after construction to prevent significant stratification from solar warming.

The same tidal mixing which produces cool summer surface water temperatures in Cobscook Bay also acts to keep winter surface temperatures fairly mild. This, combined with strong tidal currents, result in a low degree of ice cover relative to other places on the Maine coast. Although tidal currents will be reduced in the Cove after barrage construction and wave action should be decreased, it is believed that the combined effect should not be enough to lead to long standing

ice cover. Low ice cover will maintain the potential of Halfmoon Cove as an eagle feeding area.

Concern has been expressed by the Maine Department of Environmental Protection (DEP) that the projected increase in water temperature in Halfmoon Cove will adversely affect dissolved oxygen (DO) levels. Adequate levels of DO are necessary to maintain a healthy aquatic environment. Environmental degradation quickly ensues when biological oxygen demands become excessive and overwhelm the productive components of the system. For this reason, environmental scientists and managers are very concerned with DO levels and use them as an indicator of environmental quality. The EPA suggests that DO levels in coastal waters should be maintained at 6.0 ppm or more, although it is understood that natural phenomena can cause levels to fall below this point. DO levels are influenced by a number of factors including temperature, the metabolic activities of resident biota and the introduction of oxygen demanding pollutants. In Halfmoon Cove, temperature is the dominant factor.

Engineering projections indicate that summer water temperatures may increase by up to $1.5^{o}C$ ($2.7^{o}F$). DEP presently allows only a $1.5^{o}F$ ($0.83^{o}C$) temperature increase below a maximum of $85^{o}F$ ($29.4^{o}C$). This is consistent with EPA standards for artificially induced increases in temperature. These are guidelines generally applied to all U.S. coastal waters. The question we must address is: What are the implications of a $1.5^{o}C$ temperature increase for the DO levels in Halfmoon Cove?

DO and water temperature have a non-linear, inverse relationship; high DO values are associated with low temperatures and low DO with high temperatures. A given temperature change has a larger effect on DO at

high temperatures than at low temperatures. Most DO problems, therefore, occur in the summer. Cobscook Bay, of which Halfmoon Cove is an arm, manifests the lowest summer water temperature on the east coast of the U.S., hence DO levels are presumed to be high. Observed summer values in Halfmoon Cove range from 8.9 to 10.5 ppm (Merrill and Oullette, 1979) well above the suggested lower limit of 6.0 ppm. How would these values be affected by a 1.5°C temperature increase? Assuming a mean high temperature in Halfmoon Cove of 15°C and a salinity of 30 °/oo, the corresponding DO level, from standard tables, would be 8.5 ppm, less than the observed values. With the addition of 1.5°C to the summer maximum temperature, the DO would drop to 8.25 ppm. In other words, because of the low, ambient summer water temperatures in Halfmoon Cove, a 1.5°C increase in temperature would only decrease DO by 3% and maintain it well above the suggested lower limit of 6.0 ppm.

The observed DO values quoted above appear to be above the predicted values indicating the waters of Halfmoon Cove may be supersaturated with oxygen. This is a common phenomenon in coast embayments and is caused by the photosynthetic activity of micro- and macroalgae. This condition should not be significantly changed by the advent of tidal power development.

Another possible consequence of reduced tidal exchange between the impoundment and the sea is a buildup of plant nutrient material leading to eutrophication. This is of some concern in Halfmoon Cove because of sewage inputs to the Cove from Quoddy Village. This input is significant enough to close 18% of the intertidal area to clamming. Discussions are underway concerning the building of a treatment plant, but in the meantime the issue of the anthropogenic nutrient input needs to be

addressed. In consultation with Dr. Christopher Garside, a chemical oceanographer at the Bigelow Laboratory, it was determined that the limiting nutrient in the area was nitrogen. Calculations were done to estimate the amount of naturally occurring nitrogen in the waters of Halfmoon Cove and the amount that would be added by the people living and working in Quoddy Village. The conclusion was reached that the input from anthropogenic sources was so small relative to natural inputs that it would be undetectable by standard techniques. In other words, Quoddy Village sewage has a insignificant impact on the Halfmoon Cove nitrogen budget.

Like water quality consequences, the impacts of tidal power development on fisheries appear to be minimal. Quoting from a June 22, 1981 letter to the Maine Department of Marine Resources to Dr. Normand Leberge:

"The cove does not have freshwater streams that support anadromous fish runs sufficient to warrant construction of a fish ladder in the proposed structure."

"The area does not support a commercial fishery for scallops, herring or other demersal or pelagic species."

"Fish passage to and from the cove will be reduced and made more difficult for bottom dwelling species. Access is possible through the filling gates and turbines. The net effect does not appear to be significant."

The same letter states "Project impacts on indigenous populations of winter flounder are unknown." While this is certainly true, it should be considered that a 380 acre increase in permanently submerged land may be beneficial to these populations.

In its comments, the National Marine Fisheries Service (NMFS) asks for an estimate of the number of fish affected by a 2-5% turbine-related fish mortality. The 2-5% estimate is based on the experience of French investigators at the large LaRance project. Canadian scientist believe a 5% mortality of moderate sized fish is realistic on each pass through the turbine (Dadswell, personal communication). Although there is good agreement on the percentage of fish impacted by passage through a large, slow moving turbine, good figures do not exist for absolute numbers of fish impacted. Surveys of present fish movement through the dam site would be of limited value because the patterns of movement will change after barrage construction. Some insight may be gained from the French experience. During his visit to the LaRance facility, Dr. Peter Larsen interviewed fishery biologists evaluating the effects of the project. Although they willingly conceded that fish mortality did occur due to the action of the turbines, they were unable to demonstrate any changes in fish populations in the impoundment. For this reason, it would not seem reasonable to require the building of any structure to deny fish access to the turbines.

The only indigenous endangered species with the potential for utilizing Halfmoon Cove is the American eagle. A large population exists in the Cobscook Bay region but no nests are located in the vicinity of Halfmoon Cove. The possibility exists that Halfmoon Cove could be used for feeding by eagles, but this activity should not be detrimentally affected by operation of the tidal plant. Indeed, feeding conditions could actually be improved if the turbines in fact kill or disorient 5% of the fish passing through them. This would supply

additional food for eagles and for other waterfowl upon which eagles might prey.

Endangered marine mammals have been recorded in Cobscook Bay proper, but none are known to have entered Halfmoon Cove. The harbor seal is the only marine mammal observed in the Cove. It would seem desirable to prevent marine mammals from entering a shallow, confined embayment such as Halfmoon Cove where they may get confused and grounded. In this regard, the proposed dam may be viewed as beneficial to marine mammals.

The NMFS has raised complex questions regarding alteration of erosional deposition patterns during construction and operation. The problems are different and therefore will be considered separately.

The construction of the tidal plant will erode overburden around the dam site. The construction of the cofferdam on the Perry side of the project will enable the removal of any troublesome deposits of overburden without much problem within a strip approximately 400 ft. wide. The Eastport side of the project will have to be handled differently since cofferdam will not be constructed. Present plans include provisions to build up a rockfill dam on the Eastport side in such a manner to minimize excessive erosion. Final plans for the proposed excavation and dredging activities will be finalized with the submittal of a Section 404 permit from the Corps of Engineers. The applicant proposes to defer the review of this particular phase of project development to the time when the Corps' permit is filed and that the FERC license includes conditions to enable an appropriate review of the dredging and excavation plan. This will allow on-site detailed investigation of the material in question. The present current regime,

reaching 2.1 m/sec, is sufficient to erode all but very coarse material. The result is that any material picked up by the increased current velocity (due to inlet restriction) will be of a size such that it will be redeposited in the immediate vicinity, i.e., as soon as the current diminishes to about 2.0 m/sec. This should occur quickly due to the widening channel. In addition, the material does not appear to be fine-grained enough to smother benthic fauna.

During the power production phase the currents exiting the turbines may obtain a velocity of 5.5 m/sec. Water moving at this speed has a large competence for moving sediment particles. However, only about one half of the original volume of water will be moving across the barrage. This means that a lowered capacity for moving particles will at least partially offset the increased competence. Furthermore, the bore of the water flow will increase rapidly causing a dramatic reduction in current speed just a short distance downstream from the barrage. In other words, it is unlikely that the increased current velocity at the dam site will be felt on nearby fine-grained sedimentary flats.

Study Plans

The NMFS and FWS have both suggested that meaningful environmental studies should be strongly coupled to the development of the Halfmoon Cove project. This has been the intention of the developer since the inception of planning activity. The objectives behind the concept of a demonstration project will be aggressively pursued as part of the applicant's development plans. The inclusion of an environmental studies program as part of the conditions for the issuance of a license is agreeable to the applicant. The proposed plan of study coordinated

with appropriate Federal and State agencies due within one year of license issuance is also agreeable to the applicant.