AFS Policy Statement #17:
TIDAL POWER DEVELOPMENT AND ESTUARINE AND MARINE ENVIRONMENTS
(Full Statement)

A. Issue Definition

Introduction

Production of electricity by harnessing the power of ocean tides is being examined with renewed interest by many industrialized nations. Tidal power has become economically feasible as a result of the dramatic price increases in fossil fuels over the past decade and improved technology for lowhead turbines. Countries possessing few or no conventional energy reserves may turn to power production by tides as an alternative to importing expensive fossil fuels.

World potential for tidal power production is estimated at 1240 billion KWh/yr, with at least 50 coastal areas around the world considered potential sites for tidal power development Nations initiating procedures for implementing tidal power projects include Argentina, Canada, France, People's Republic of China, the Soviet Union, South Korea, and the United States. Countries that have examined tidal power possibilities include Australia, Brazil, the Federal Republic of (West) Germany, Great Britain, India, New Zealand, and Spain.

The Bay of Fundy and Gulf of Maine, located between Canada and the United States, is considered the region most economically feasible for tidal power production in the Western Hemisphere. The Bay of Fundy has the largest tides in the world - up to 16 m. Potential annual energy output for large commercial, tidally-driven generation facilities positioned in the upper Bay of Fundy (Cumberland and Minas Basins) is estimated at 17 billion KWh based on an installed power generating capacity of 6 million KW; most of the energy output is projected for export to the USA. This energy output represents about 22% of New England's energy consumption for 1978 (U.S. Army Corps of Engineers 1980). The Annapolis Tidal Generating Station, located on the Annapolis River estuary in Nova Scotia, is North America's first commercial plant (50,000 KWh) and the prototype for larger projects in the upper Bay of Fundy.

Tidal Power development in the USA is focused on sites in Cook Inlet, Alaska, and the state of Maine. The Passamaquoddy Bay region between Maine and New Brunswick has been considered as a tidal power site since 1920. Separate from the complex, international Quoddy scheme, the USA has investigated smaller tidal projects on its side of the border for Cobscook Bay and Half Moon Cove .

Tidal Power Operations

A tidal power plant is similar in principle to hydropower generation facilities in rivers. A barrage (dam) with a powerhouse and turbines is constructed across an estuary or embayment to form a basin (headpond) of sufficient size to allow production of electricity over a reasonable period. Basic so design configurations are: (1) single basin, single effect; (2) single basin, double effect; (3) linked basin; and (4) paired basin. The single basin, single effect configuration is the oldest form of tidal power generation**,** dating to the tide mills of western Europe in the Middle Ages. Usually the basin is allowed to fill during flood tide through floodgates and powerhouse, with turbines spinning freely. Power is produced on ebb tide. The Annapolis Tidal Generating Station is operated in this manner. The single basin, double effect method of operation is similar to the LaRance power plant in France, which produces power on both flood and ebb tides. A linked basin configuration involves two more or less contiguous basins operated together as a high pool-low pool combination. The high pool is allowed to fill on flood tide. Power is generated by releasing water through turbines from pool one to pool two, and again through turbines from pool two to the ocean. Paired basin designs are two single basin, single effect schemes which are interconnected electrically. This configuration allows more flexibility in operation of the plants in meet market demands . Tidal power generation also can be used in combination with pumped-storage principles or nuclear power plants to provide on-peak power generation .

Statement of the Issue

Environmental concerns are an issue with tidal power, as developments may encompass large embayments and affect wide geographic areas. While specific concerns vary, environmental effects include possible alterations of primary and secondary productivity in coastal waters, fish mortality, sea level fluctuations, local weather patterns, and local and regional socio-economic structure.

For some nations, the benefits of tidal power -nay outweigh environmental concerns. Considering both the demonstrated and potential impacts of conventional electrical generation systems on the atmosphere and aquatic resources, tidal power offers several advantages. The energy source for tidal power is renewable, available locally (thus avoiding the problems and expense of transporting fuel), and not a producer of byproducts such as radioactive waste, thermal effluent, or noxious hydrocarbons. Tidal power proponents list secondary benefits, such as flood control, improved recreational facilities, aquaculture potential, improved infrastructure, and development of secondary industry after construction of the tidal barrage. The LaRance tidal power project in France, for example, resulted in the permanent removal of 1,500,000 ml of water from the Rance River, and the loss of 75 hectares of estuary. No pre- or post -construction studies were conducted to determine effects of construction and plant operation on the estuarine environment.

Recent research indicates that environmental changes could affect natural resources over a wide geographic area. Altered habitats should benefit some aspects of the aquatic community while causing problems for others.

B. Environmental Effects

Seaward of the Barrage

As a result of removing energy from the tide and reducing the volume of seawater exchange across the barrage site, water circulation patterns and the tidal regime will be altered both behind and seaward of the barrage. The resultant physical changes to an estuary could influence a large geographic area. For example, computer modeling of potential tidal change in the Bay of Fundy indicates that tidal amplitude just seaward of a barrage could be reduced up to 30 cm (depending on the barrage site) and be increased 10-15 cm at sites up to 500 km distant from the barrage**.** Damming the headwaters of the Bay of Fundy will reduce the free period of tidal oscillation of the Bay of Fundy-Gulf of Maine system from 13 hours closer to 12.4 hours, the natural oscillation period, and cause the waters in the system to oscillate near the natural resonance period, thereby increasing tidal amplitude. The corresponding higher high tides would submerge a narrow but substantial (1,680 ha) portion of the Maine coast. Long-term storm damage is anticipated to be correspondingly greater in this region.

Behind the Barrage

The tidal range in the headpond will be reduced but mean water level will be increased. Under these conditions, the water column in the tidal basin will undergo increased stratification, producing greater extremes in surface temperatures and more ice cover in temperate climates. In turbid coastal environmentals, turbidity should decrease and sedimentation, at least in certain locations, should increase. Reduced storm surges and extreme tides could diminish flooding and erosion. Changes in tidal amplitude may alter groundwater drainage and cause changes in local climatic conditions. Higher mean water levels could interfere with drainage of diked land and cause changes in the elevation and distance from the coast of the saltwater/freshwater boundary. Because of the importance of air-sea interaction, local climate regimes such as number of fog days, amount of precipitation, and length of growing season, may be affected. Basins suitable for tidal power development usually are in regions receiving municipal, agricultural, and industrial wastes. Since flushing time would be decreased in the headpond, effluent disposal and assimilation problems could develop.

Changes in turbidity and sedimentation patterns could have major impacts on biotic communities in the headpond by increasing phytoplankton production, reducing saltmarsh inundation, and shifting species compositions. Sedimentation could decrease the intertidal area, impacting local intertidal shellfish fisheries. Sedimentation will kill clams and potentially damage existing fisheries, yet increased water temperatures should increase production of surviving shellfish . The ultimate effect of these two counteracting forces will be decided largely by the physical attributes of each site. Except for the immediate and possible permanent shifts in distribution and abundance of certain species, many believe overall production of benthos and zooplankton in the headpond will not be appreciably altered by construction of tidal barrages.

Fish Stocks

Studies on fisheries impacts caused by tidal power development are few and opinions concerning effects are varied, although some authors seem to anticipate little impact. There seems to have been no appreciable change in the fish community or fisheries of the LaRance region. However, the area had an extremely small fishery and no professional fishermen after 1960. Tidal power impact on fisheries will be greatest in regions where fish are abundant and fish passage is repeated by the same population many times over the year. Small tidal dams may be relatively benign, particularly if fish passage is a cause for concern only during a few short intervals each year.

Introducing hydraulic turbines into an estuarine environment will create the problems inherent to fish passage associated with riverine power installations, with several important exceptions: the estuarine environment contains larger fish populations, larger fish species, and marine mammals. Potential impact of organisms passing through the draft tube of the turbine will depend on the engineering design of the turbine such as rotation speed, blade and hub diameter, and presence or absence of wicket gates. The actual striking of a fish by a blade is a probability, based on water length and fish length. Under present design specifications the incidence of turbine blades striking fish varies from 1 to 50% for fish of 10 to 200 cm in length. Incidence of gas bubble disease and the effect of sudden pressure change on sensitive stages of larval fishes must also be considered. Knowledge of these factors is woefully inadequate, and it seems unlikely that engineering methodology developed for fish by-pass in rivers can deal with the tremendous volume of water moving through a tidal barrage. Migrating and transient fish populations will move with each tidal exchange, causing fish to pass through the turbines a number of times.

Looking beyond problems inherent with turbines, changes in the hydrography of a tidal basin by construction of a tidal barrage have potential nearfield and farfield effects, none of which are wholly predictable. Certainly among these changes could be altered migration routes and changes in availability of food organisms for fish. Development of tidal power at certain sites may benefit certain species, or be a disaster to some fisheries. It also is possible that less desirable species may benefit, or that impacts on highly-migratory stocks will be felt over the entire range of the species. Each potential tidal power site must be examined carefully by fisheries scientists so that knowledgeable decisions on tidal power development can be made.

C. Needed Actions

The American Fisheries Society (AFS) is concerned with the potential impacts of dams and power structures on aquatic resources. Like other energy development projects, tidal power has certain environmental costs or impacts associated with the benefits. Evidence suggests these impacts could be far-reaching and alter physical and biological systems. AFS recommends the following actions be taken to increase awareness of potential environmental consequences of largescale tidal power development in order to minimize damage to fisheries and aquatic resources:

1. Available information regarding pre- and post-construction at existing tidal power sites should be compiled and synthesized so it can be used to estimate, at least on a gross scale, potential effects of proposed projects. As an example of information compilation, see the Bay of Fundy Environmental and Tidal Power Bibliography, which provides a comprehensive list of references on environmental characteristics of the Bay region, environmental impact studies, and engineering and economic aspects of tidal power. As an example of information synthesis, see the National Oceanic and Atmospheric Administration (NOAA) report assessing ocean thermal energy conversion technology on oceanic fishery resources.

2. Potential impacts cover a wide array of organisms and ecological interactions (benthic, aquatic, and terrestrial); thus, AFS encourages all relevant federal and state agencies to become involved and consider preparing policy statements on tidal power, regardless of their regulatory jurisdiction over the project. Transboundary effects of projects may require agency participation from more than one country. Appropriate coordinating bodies could be the National Advisory Committee on Oceans and Atmosphere, Office of Technology Assessment of the Congress of the United States, National Research Council of Canada, or the International Joint Commission. Because consideration of tidal power development is global in nature, AFS also should encourage adoption of policy guidance in the international environmental arena, perhaps with one of the specialized organizations of the United Nations serving as the coordinating body.

3. AFS members should encourage management-oriented decisions based on scientific evidence and be cautious of alarmist reactions or emotional response to proposed projects. In this regard, AFS should support programs designed to produce information needed to develop scientifically rigorous management recommendations.

4. AFS should encourage long-term funding to determine ecosystem effects of tidal power (i.e., before and after construction). Funds from all sources (federal, state/provincial, private) should be solicited for these studies. Effect could be far-reaching and, thus, analyses should be regional in scope. Design and implementation of such studies should follow the conceptual approach outlined by the Ocean Sciences Board of the National Academy of Sciences.

5. Response to proposed tidal power projects should be similar to that for other large-scale construction projects: developers should be responsible and financially capable of preparing detailed Environmental Impact Statements and conducting pre- and post-operational studies on a long-term basis. In conjunction with these efforts, resource researchers and managers should be involved with all stages of tidal power development: feasibility studies, examination of alternatives, pre-operation baseline studies, mitigation projects during and after construction. and post -operational monitoring.

6. Fishery workers need greater understanding of the effects of turbines on fish. AFS should encourage better cross discipline discussion on the effects of tidal power projects among engineers and fishery biologists.

7. A special symposium on tidal power and its potential impact on aquatic resources should be held in conjunction with the AFS annual meeting or other suitable international meeting with a natural resources theme. A possible outcome of such a symposium would be consensus on research priorities for assessing tidal power impacts, and minimum information needs for adequate long-term monitoring.