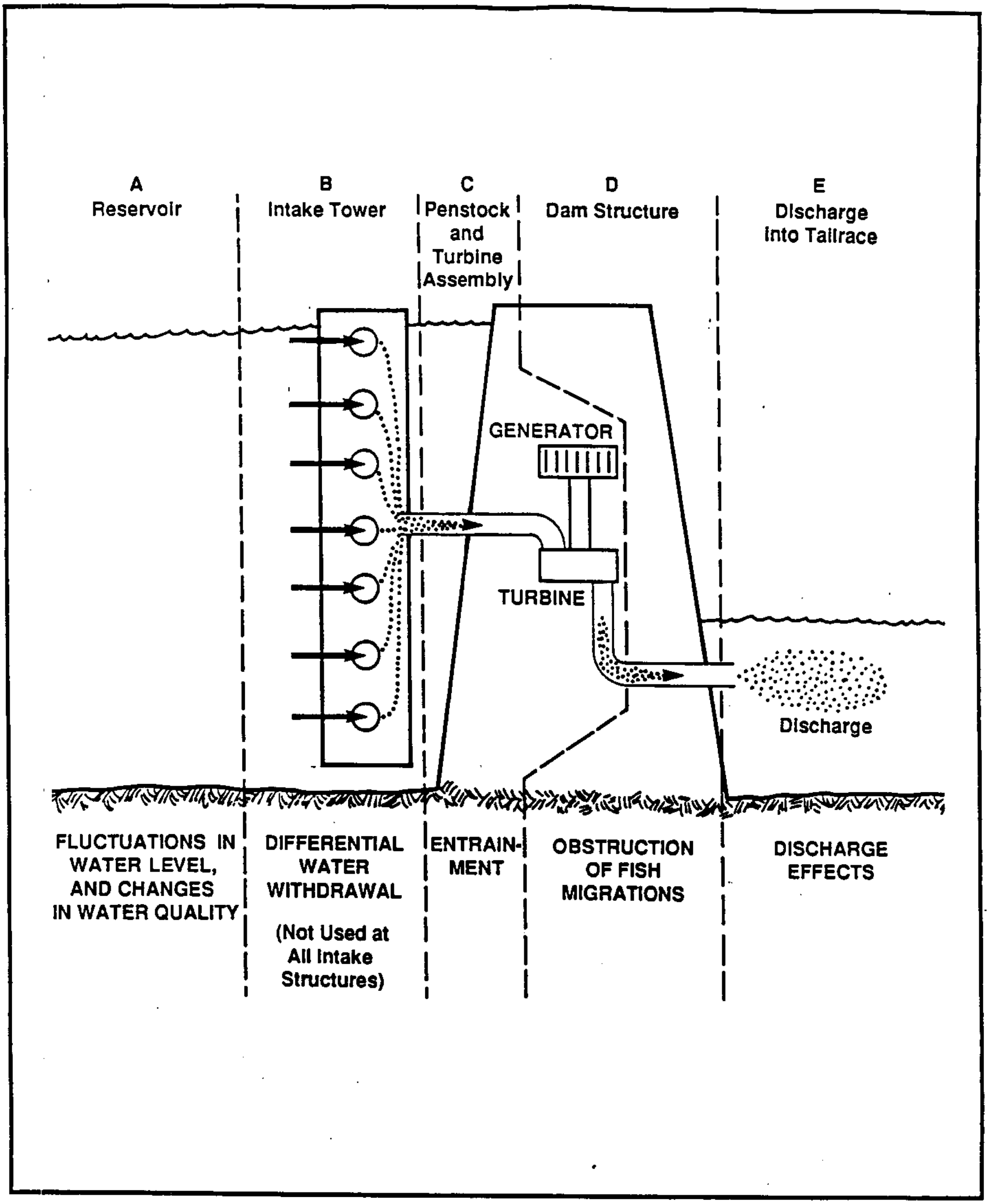

Figure IV-2. Path of water flow through a hydroelectric power plant, and zones of effects on organisms impoundment frequently recurs. Alterations in dissolved oxygen concentration, nutrient concentrations and water temperature are likely to arise in large, stratified impoundments. Stratification occurs during summer when the surface water of impoundments becomes warmer than the bottom water, reducing vertical mixing between layers. Biological activity, mainly microbial decomposition of organic material, depletes the dissolved oxygen from bottom layers more rapidly than it can diffuse from surface layers.

Bottom waters do not become reoxygenated until the fall, when surface layers cool and the impoundment becomes well mixed. Nutrients from the decomposition of organic materials also frequently build up in lower layers of stratified impoundments, especially if anoxic conditions develop. Depending upon the layer of the impoundment from which water entering the turbines is withdrawn, abnormal changes in downstream water temperature, unacceptable concentrations of nutrients and low dissolved oxygen concentration may occur in downstream aquatic habitats.

- Fluctuations in Water Level and Flow Reductions

Unnatural water-level fluctuations occur in impoundments and in aquatic habitats downstream of dams when hydroelectric facilities are operated in a peaking/ storage mode. In addition, a portion of streamflow is sometimes diverted away from the natural streambed for small-scale hydroelectric projects. Fluctuations in water level and flow are not aesthetically pleasing to recreational users of the water body, and may adversely affect aquatic biota. For example, some species of benthic invertebrates have stringent flow requirements and cannot tolerate sporadic fluctuations. Many fish, particularly those in impoundments, spawn near the shoreline, and their eggs cannot tolerate the periodic dewatering (Areas A, B and E, Figure IV-2). Peaking facilities can also cause dewatering downstream, which can cause severe habitat loss and low DO for fish trapped in isolated pools.

- Prevention of Successful Fish Passage

Hydroelectric development can prevent the movement of resident and anadromous fishes past the dam, sometimes leading to out-migration, unless a fish ladder or fish lift is installed. (Areas C and D, Figure IV-2). Mortality associated with entrainment of fish through turbines may also be large, depending on the type of turbine employed, the proportion of the river flow that is diverted through the turbine and the size of fish passing downstream (Turbak *et al.* 1981).

Environmental Concerns

Mortalities due to steam or hydroelectric power operations can cause population declines if they are not offset by compensating mechanisms such as increases in growth, fecundity and/or survival. Losses of phytoplankton and zooplankton are generally recouped quickly because these biota grow and reproduce rapidly (generation times of hours to days). Organisms of higher taxonomic levels have much longer generation times, and power plant-related mortalities to these biota are much more likely to result in population declines. Fish, crabs and many benthic organisms generally spawn once a year; however, some fish may not reproduce until they are several years of age.

The impacts of steam electric generation (i.e., entrainment, entrapment, impingement and discharge effects) are of major concern for spawning and nursery areas of commercially or recreationally important species, particularly fish (Clark and Brownwell 1973; Jensen 1977; Cada *et al.* 1982). Mortality to a large proportion of each year's spawn or nursery stock can adversely impact regional populations and harvests. Similarly, hydroelectric plant impacts on anadromous fish (i.e., blockage of spawning migrations and destruction of a large percentage of juvenile populations due to turbine mortality) can eliminate populations of them in a river system. Localized (i.e. near the plant's discharge) changes in biotic distributions or abundance are less important to ubiquitous species that have relatively broad spawning and nursery areas.

Although direct effects (e.g., entrainment and impingement losses to early life stages, changes in water quality downstream of dams) are more likely to be measured, steam and hydroelectric plant operations can also affect populations indirectly. Construction of impoundments for hydroelectric power plants can have profound effects on food web dynamics of rivers and streams by changing the kinds and abundances of biota in the impounded area. Water level and flow fluctuations also affect the composition and abundance of biota in habitats downstream of hydroelectric facilities.

B. Aquatic Habitats

The Chesapeake Bay and the streams and rivers that flow into it are composed of distinct and definable habitat types. Estuarine habitat types are defined by salinity, which is the environmental variable most important in controlling biotic distributions (Lippson *et al.* 1979). Flow characteristics determine freshwater riverine habitat types (Hynes 1970). Each habitat has unique functions in producing or supporting important resource elements, although their biotic components overlap and the areal extent of each habitat varies seasonally (with the exception of nontidal fresh waters). This section addresses the cumulative impact of Maryland power plant operations on the biota over the entire extent of each habitat type within Maryland. Its major emphasis is placed on the maintenance of the long-term integrity and characteristic functions of the defined habitats. Localized plant-related changes to a portion of a habitat are, however, identified and discussed.

Aquatic habitat types can be defined using salinity characteristics (Lippson *et al.* 1979):

Habitat	Salinity Ranges
Marine	30.0 - 35.0 ppt (parts per thousand)
Polyhaline	18.0 - 30.0 ppt
Mesohaline	5.0 - 18.0 ppt
Oligohaline	0.5 - 5.0 ppt
Tidal fresh	0.0 - 0.5 ppt
Nontidal fresh (rivers and lakes)	0.0 ppt

Figures IV-3 and IV-4 illustrate the seasonal locations of these habitats. The major ecological functions of each habitat are described below.

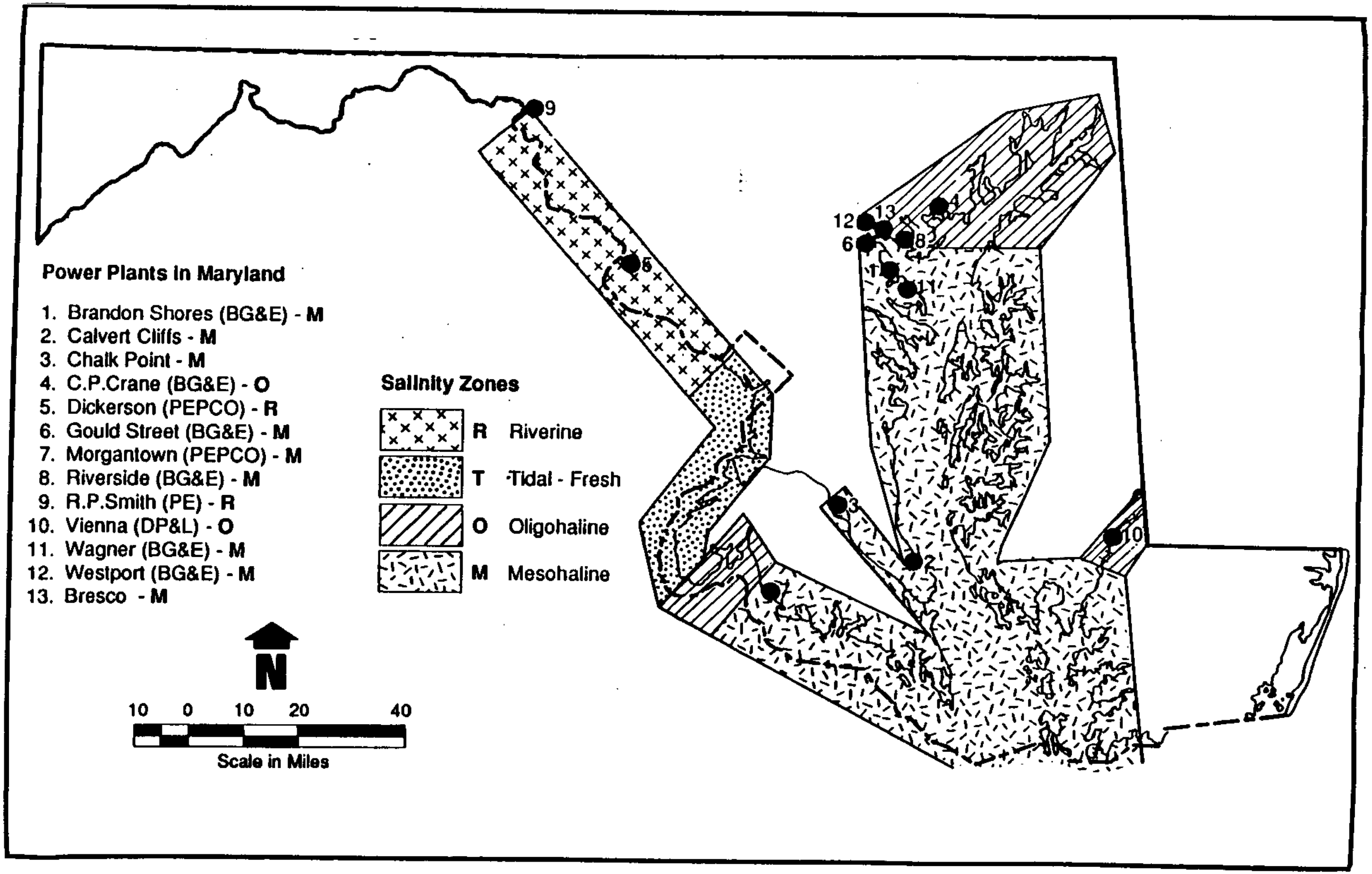

Figure IV-3. Salinity zones of the Chesapeake Bay during the summer/fall seasons

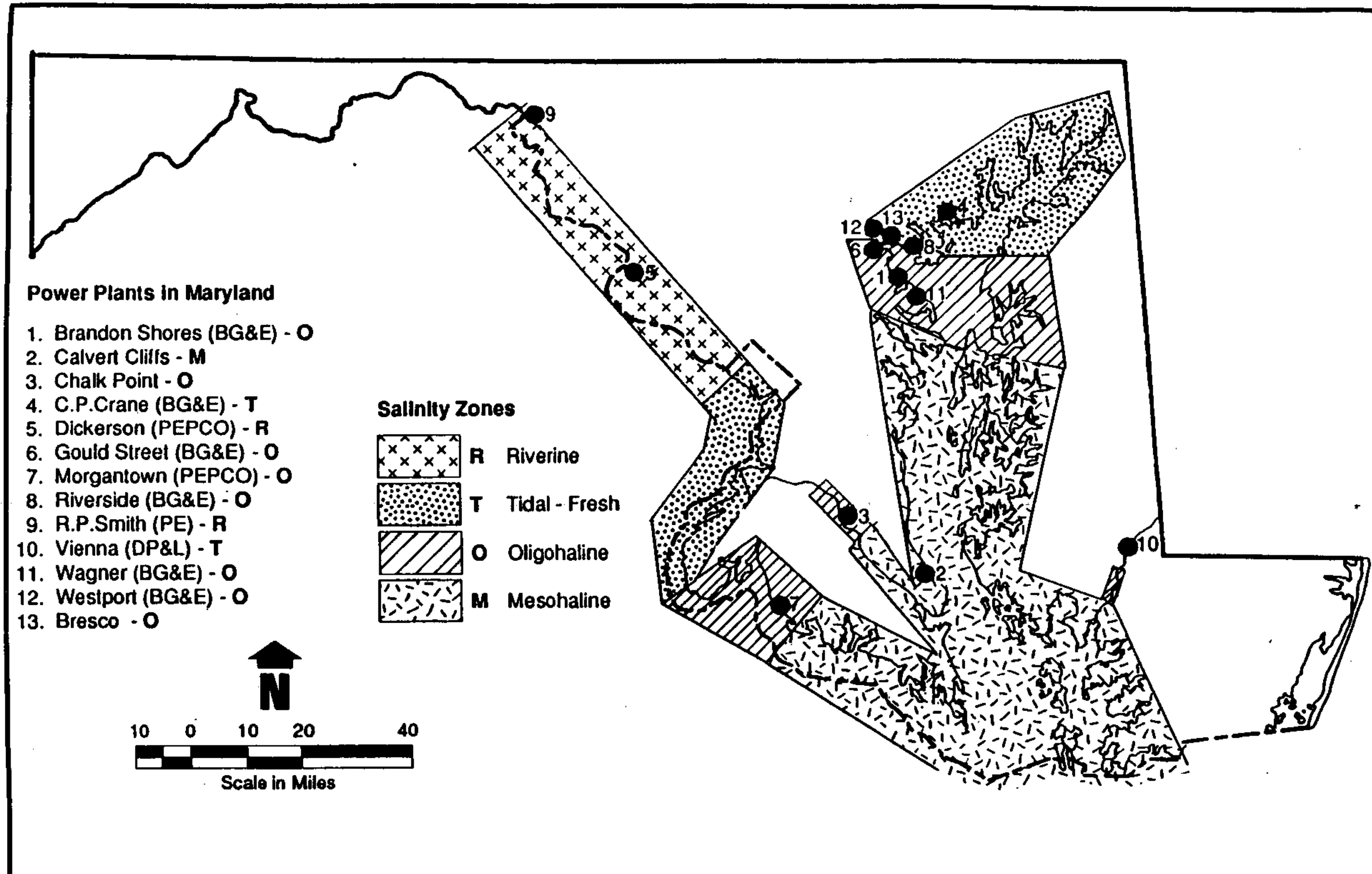

Figure IV-4. Salinity zones of the Chesapeake Bay during the winter/spring seasons

Marine and Polyhaline

These high-salinity waters are primary sites of blue crab spawning and development; they also support hard clam populations. Several fish species (e.g., spot, croaker, weakfish, menhaden) spawn in marine waters; the young of these species seasonally migrate into lower salinity zones and use them as nursery areas. No marine habitats exist in the Maryland portion of the Chesapeake Bay, but polyhaline salinities are consistently found in the lower portions of the Chesapeake Bay up to the mouth of the Potomac River.

Mesohaline

This medium-salinity zone accounts for the greatest percentage of aquatic habitat in Maryland (Lippson 1973). Its habitats are the primary areas of shellfish production (i.e., softshell clams, blue crabs and oysters), and benthic populations are frequently very productive here. Mesohaline habitats also produce most of the estuarine forage fish biomass (e.g., anchovies, menhaden, silversides) and serve as important feeding areas for large, predatory fish (e.g., white perch, bluefish, striped bass). The mesohaline salinity zone is sometimes separated into two habitats: a high mesohaline habitat (salinity of 10-18 ppt) and low mesohaline habitat (salinity of 5-10 ppt). The high mesohaline habitat is important in nursery activities of shellfish, particularly oysters. The low mesohaline habitat is the primary nursery for juvenile blue crabs and many young-of-the-year fish (e.g., spot, bluefish).

Oligohaline

Much of the suspended sediment and detritus that is trapped by the Chesapeake Bay's complex circulation pattern is deposited in this low-salinity zone, providing an important component of the food web. Nutrient concentrations are also high in the oligohaline zone as is primary productivity. These brackish water environments support resident fish populations and serve as spawning and nursery grounds for a few fish, including striped bass and white perch. Some forage fishes (e.g., silversides) use oligohaline areas as spawning and nursery grounds, and a few migratory species (e.g., menhaden) feed on its productive plankton populations.

Tidal Fresh

These segments of estuaries are under tidal influence but see no significant salt intrusion. They provide spawning and nursery habitat for anadromous fishes and also support the larvae and juveniles of these species during early development. Striped bass and white perch are particularly important species that use tidal fresh habitats as spawning and nursery areas. Some resident fish (e.g., white catfish) spend their entire life cycles in this habitat zone. Large quantities of suspended sediment, detritus and nutrients are also trapped in this low-salinity zone by estuarine circulation patterns.

Nontidal Fresh (Rivers and Lakes)

Nontidal riverine habitats in Maryland serve as the major spawning and nursery areas for many anadromous and semianadromous fish (e.g., shad, river herrings, yellow perch). Rivers also support resident fish populations, many of which (e.g., trout, smallmouth bass) are actively pursued by sport fishermen. All large lakes in the state are artificial reservoirs that have been constructed and are managed for specific purposes. Uses of reservoirs in the state include flood control, augmentation of low river flows, municipal water supplies, hydroelectric power and cooling of thermal effluents. Such uses can conflict with the maintenance of aquatic habitat for fish species of recreational importance.

The locations of the estuarine salinity zones change seasonally in response to rainfall and resulting changes in the amount of freshwater inflow. Table IV-2 indicates, by season, the zones in which Maryland steam generating plants are located and the generating capacity of each plant. Two facilities (R.P. Smith and Dickerson) are located on the riverine portion of the Potomac River. Two operational plants (Crane and Vienna) and one plant that is in the planning stages (Perryman) are located in the tidal fresh-oligohaline zone. Eight operational plants (BRESCO, Brandon Shores, Chalk Point, Gould Street, Morgantown, Riverside, Wagner and Westport) are on oligohaline-mesohaline waters. One operational facility (Calvert Cliffs) is located in an area that is

Table IV-2

Steam electric power plant locations in Maryland (by salinity regime and season).

	Net Capacity (MWe)	Winter/Sping				Summer/Fall			
		River-ine	Tidal-fresh	Oligo-haline	Meso-haline	River-ine	Tidal-fresh	Oligo-haline	Meso-haline
Brandon Shores	620 (a)			X					X
BRESCO	50 (b)			X					X
Calvert Cliffs	1,650				X				X
Chalk Point	1,965			X					X
Crane	390		X					X	
Dickerson	556	X				X			
Gould Street	103			X					X
Morgantown	1,412			X					X
Riverside	493			X					X
Smith	114	X				X			
Vienna	150 (c)		X					X	
Wagner	1,002			X					X
Westport	244			X					X
Total Capacity by zone		657	526	5,279	1,650	657	0	526	6,929

(a) One 620 MWe unit is in operation at Brandon Shores, and one 620 MWe unit is under construction.
(b) BRESCO (Baltimore Southwest Resource Recovery Facility) began operations in 1985.
(c) The Nanticoke 1 unit at Vienna, originally planned as a 500 MWe cooling tower unit, was scheduled to be operational in 1995; at present its on line date is postponed and its design is under modification.

mesohaline in all seasons. There are no operational or planned steam generating plants in polyhaline habitats or in marine habitats along the Atlantic shoreline of Maryland.

Table IV-3 summarizes the characteristics and locations of hydroelectric power plants in nontidal fresh waters. Water-use rates at peak power output, average river flows and impoundment volumes permit comparisons of relative size. The Conowingo plant on the Susquehanna River is the only large scale hydroelectric facility in Maryland. Ten small-scale hydroelectric facilities (i.e., less than 30-MW capacity) are operational, and two more are presently under construction. Several more facilities have preliminary permits or have applied for permits.

C. Regulatory Considerations

Steam Generating Power Plants

The intake, use and discharge of water by Maryland steam power plants is regulated through State Surface Water Appropriation and Use Permits and National Pollutant Discharge Elimination Systems (NPDES) permits. These permits reflect federal and state constraints on the amount of water and the type of intake used, as well as the chemical and physical characteristics of effluents.

Because it is not possible or cost-effective to assess power plant effects on all of the species inhabiting aquatic environments, state regulations governing thermal discharges provide for the evaluation of plant impacts on Representative Important Species (RIS). These species, because of their abundance, distribution, ecological roles (e.g., food web linkage) or economic importance (e.g., commercially exploited species), are essential to or representative of the maintenance of balanced indigenous populations of shellfish, fish and wildlife. Changes in their abundance or distribution may be signs of system-wide alterations, which enables them to be used as indicators.

The impact of once-through cooling systems on aquatic habitats is evaluated in conjunction with the NPDES permit process and the Code of Maryland Regulations (COMAR) 10.50.01.13. Under these regulations, an initial evaluation of impact is based on the amount of water use and the size of the thermal plume

Table IV-3

Licensed and/or operational hydroelectric facilities in nontidal fresh waters in Maryland

Facility	Date Operational	River	Peak Capacity (kw)	Annual Generation (MWh)	Turbine Capacity At Peak Output (cfs)	Normal Impoundment Capacity (Acre-Feet)
Deep Creek	1925	Deep Creek	20,000	29,000	N/A	93,000
Brighton	1985	Patuxent River	480	2,685	130	19,000
Duckett	Under Construction	Patuxent River	125	1,090	16	17,000
Bloomington	Under Construction	North Branch Potomac River	13,846	55,000	900	94,700
Potomac River #4	Early 1900's	Potomac River	1,000	4,338	940	7,300
Parker Pond	1950's	Beaverdam Creek	40	N/A	N/A	130
Conowingo	1926	Susquehanna River	512,000	1,738,000	85,000	310,000
Gilpin Falls	1984	Northeast Creek	396	2,700	56	8
Potomac River #3	1912	Potomac River	600	1,588	334	1,075
Potomac River #5	1919	Potomac River	1,120	6,851	940	4,900
Gore's Mill	1950's	Little Falls	10	N/A	N/A	4
Wilson Mill	1983	Deer Creek	23	N/A	N/A	5

with respect to physical characteristics of the receiving water body (mixing zone criteria) and the importance of the area as a spawning and nursery site. Mixing zone criteria are indicators of the receiving water body's ability to dilute effluents, and failure to pass them indicates that the potential for discharge effects is large. The importance of the area as a spawning and nursery habitat is an indicator of the potential biological and geographical extent of entrainment and impingement impacts. If the plant fails to pass these screening criteria, a more detailed evaluation of biological impacts is required. Table IV-4 outlines the types of screening criteria and summarizes the status of those Maryland power plants that are subject to thermal discharge criteria. Alternate effluent limitations (i.e., a water use rate or a mixing zone that exceeds those defined by mixing zone specifications in COMAR 10.50.01.13) may be requested by the utility based upon the findings of the detailed biological studies.

Because impinged organisms generally represent losses to life stages that are the major reproductive units of populations, Maryland thermal regulations require that impingement losses be estimated and that actions to minimize impingement impacts (e.g., modifications to intake structures or operating practices) be evaluated. Estimates of the monetary value of impingement losses are used to evaluate the cost-effectiveness of actions required to reduce impingement. Actions required to mitigate entrainment losses are not subject to financial limitations, but are required to be commensurate with the consequences of entrainment losses to regional RIS populations, ecosystem functioning and economically important fishery resources. Management actions required to mitigate discharge impacts are similarly unrestricted, including any that may be required to preserve balanced indigenous populations in the receiving water body.

Hydroelectric Power Plants

Because small-scale hydroelectric facilities fall under federal regulatory jurisdiction, the State of Maryland does not license them. However, under provisions of the Fish and Wildlife Coordination Act, the concerns of state and local resource agencies must be incorporated into the federal licensing process. PPRP has been designated the lead agency within the Department of Natural Resources (DNR) for coordinating the review of small-scale hydroelectric facility applications. The federal licensing agency, the Federal Energy Regulatory

Table IV-4

Status of power plants under Maryland thermal discharge criteria

Plant	Mixing Zone Criteria	Spawning and Nursery Area of Consequence	Alternate Effluent Limitations	Regulatory Status
BRESCO	Fails	PPRP recommended passage	PPRP recommended passage	Hydrothermal and impingement studies conducted; resolution pending
Calvert Cliffs	Passes	PPRP recommended passage	N/A	Approved 12/81
Chalk Point	Fails	Fails	Presently being evaluated	NPDES permit reissued 9/87 with 18-mo. deadline to complete mitigation studies
Crane	Fails	PPRP recommended passage	PPRP recommended passage	Approved 9/84
Dickerson	Fails (under some flow conditions)	PPRP recommended passage	PPRP recommended passage	Approved 2/82
Gould Street	Passes	Passes	N/A	Approved 7/82
Morgantown	Passes	PPRP recommended passage	PPRP recommended passage	Approved 8/81
Riverside	Passes	Passes	N/A	Approved 7/82
R.P. Smith	Fails (under some flow conditions)	PPRP recommended passage	PPRP recommended passage	Approved 5/82
Wagner	Fails	Presently being evaluated	Presently being evaluated	Detailed biological studies presently being conducted
Westport	Passes	Passes	N/A	Approved 7/82

Commission (FERC), has adopted procedures for exempting certain projects (primarily small projects for which the applicant possesses property rights) from federal jurisdiction. In such cases, requirements to address environmental concerns of state and federal agencies are included in the exemptions, and monitoring for compliance with these conditions is the responsibility of those agencies.

Although there are presently no state licenses or permits specifically required for the operation of a hydroelectric power facility, Chapter 448 of COMAR requires that owners and operators of dams on state waters must cooperate with DNR to ensure sufficient water is released to maintain downstream water quality and aquatic habitat. Several state permits, such as the Water Appropriation and Use Permit and Waterway Construction Permit (both granted by the Water Resources Administration), are generally required. COMAR also calls for dam owners and operators to consult with other resource agencies, such as the Scenic River Review Board, the Maryland Geological Survey and the Maryland Historical Trust. More details on the permits and consultations required for licensing and permitting of small-scale hydroelectric facilities are provided in the Inventory of Maryland Dams and Assessment of Hydropower Resources (Weisberg *et al.* 1985).

One of the first steps in PPRP's licensing review for proposed small hydroelectric projects is preparation of a site description based on information submitted by the applicant. Site descriptions provide information on the water quality, biological resources and recreational activities near proposed projects, as well as engineering information on the type, size and mode of operation of the proposed facility. These site descriptions are used to identify potential environmental impacts while proposed projects are in the planning stage. The developer then has the opportunity to modify the proposed project to minimize expected impacts or to conduct additional studies to precisely define potential impacts. The environmental review procedure has been applied to 11 projects over the last six years: Bloomington, Savage River, Duckett, Brighton, Daniels, Union, Atkisson, Gilpin Falls, Dam No. 4, Little Falls and Pine Grove.

D. Aquatic Impact Assessment for Steam Generating Power Plants

Since the publication of CEIR-5 (MD-PPRP 1986), the utilities have conducted impingement monitoring at several plants (Chalk Point, Calvert Cliffs and BRESCO) and special studies have been completed relating to biofouling, entrainment estimates, chlorination regimes and the use of auxiliary dilution pumps. All data available through the end of 1986 have been incorporated into the following assessment of the impacts of steam generating power plants on aquatic habitats in Maryland.

Mesohaline Power Plants

The three largest plants in Maryland -- Calvert Cliffs, Chalk Point and Morgantown -- are located in this zone. Each uses once-through cooling. The Calvert Cliffs monitoring studies have provided baseline information and operating information that has been used to assess impacts for the first 10 years of operations (1975-1984). Detailed results for the Calvert Cliffs assessment studies are reported in ANSP (1970a, 1970b, 1972a, 1972b), BG&E and ANSP (1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982), MMEC (1980) and Holland *et al.* (1985a), and were summarized in previous CEIR's (MD-PPRP 1975, 1978, 1982, 1984, 1986). The Morgantown findings are summarized in Bongers *et al.* (1975) and ANSP (1977). They were also discussed in earlier CEIR's (MD-PPRP 1975, 1978, 1982, 1984, 1986). The results of Chalk Point studies conducted in the 1960's are summarized in Mihursky (1969). Results of recent studies for Chalk Point are summarized in MMES (1985a), Otto (1983) and ANSP (1983a). Only the major findings of studies conducted at Calvert Cliffs, Morgantown and Chalk Point are summarized in this chapter.

Six plants (Gould Street, Riverside, Wagner, Westport, Brandon Shores and BRESCO) are located in Baltimore Harbor, where salinities are generally in the low mesohaline range for most of the year and the oligohaline range in the spring. Gould Street, Riverside and Westport are each more than 20 years old and are used for peaking and cycling service. BRESCO, a resource recovery facility that burns municipal solid waste to produce commercial electricity and steam, was completed in 1984. BRESCO's Maryland State Discharge Permit (83-DP-2119) required that the thermal plume at peak load conditions and impingement rates be investigated. The results of these studies are summarized in this chapter.

- Entrainment

Phytoplankton and zooplankton entrainment effects at Calvert Cliffs and Morgantown were summarized in previous CEIR's (MD-PPRP 1975, 1978, 1982, 1984, 1986). Losses were generally variable, and were greatest in the summer, especially at Morgantown where chlorine is used as a biocide (Bongers *et al.* 1975; ANSP 1977). Entrainment losses did not result in nearfield depletions at either facility (ANSP 1977; MMEC 1980). This was probably because plankton populations recovered rapidly from power plant-related stresses, and only a small proportion of the water available was withdrawn into the Morgantown and Calvert Cliffs facilities.

Entrainment losses of phytoplankton and zooplankton have not been directly measured at Baltimore Harbor facilities; however, no nearfield depletions of plankton populations have been found that can be attributed to power plant operations (NA 1981). In addition, entrainment losses to phytoplankton and zooplankton from BRESCO and Brandon Shores are projected to have no adverse impact upon Harbor populations (APL 1972; EA 1983), because both of these facilities withdraw relatively small volumes of water.

Chalk Point is the mesohaline power plant with the greatest potential for entrainment impacts to phytoplankton and zooplankton. During partial power operations there, phytoplankton biomass declined by an average of approximately 20% between plant intake and discharge on most dates (ANSP 1983a; MMES 1985a). There was no apparent relationship between cross-condenser declines in phytoplankton biomass, DT or chlorination status. Therefore, a large part of the decline appears to be due to mechanical damage. In summer and early fall, entrainment at Chalk Point depressed phytoplankton productivity when chlorine was applied (Morgan 1968; Morgan *et al.* 1969; Morgan and Stross 1969; Hamilton *et al.* 1970; Flemer and Sherk 1977; ANSP 1983a). In cooler seasons, when chlorine was not used, entrainment frequently (but not always) enhanced phytoplankton productivity. This may have been due to the increased water temperature or to the greater availability of nutrients as organic detritus was broken down in passage through the plant (Morgan 1968; Hamilton *et al.* 1970; ANSP 1983a). Phytoplankton entrainment effects at Chalk Point thus include thermal effects (positive and negative), chemical effects (negative) and mechanical damage (negative). Phytoplankton entrainment losses and gains, however, did not have consistent nearfield effects on algal productivity or biomass (Flemer and Sherk 1977; ANSP 1983a). Nor did plant operations change phytoplankton species composition in the nearfield (MMES 1985a). Patuxent phytoplankton populations recover rapidly (in hours) from entrainment stresses, usually by the time they reach the end of the discharge canal.

Zooplankton entrainment losses at Chalk Point have not been measured for full power operations; however, during partial power operation, zooplankton losses were generally largest during periods of chlorination, when reductions in density between the intake and the end of the discharge canal frequently were 30-80% (Heinle 1976; ANSP 1983a). Without chlorination, through-plant losses of zooplankton averaged 20-30%. Highest zooplankton entrainment losses were measured during periods of highest ambient densities (ANSP 1983a). The discharge canal thus had the net effect of increasing exposure time, thereby increasing zooplankton mortalities due to stresses from high temperature and chlorine. Full-power generation is expected to increase zooplankton entrainment mortality rates to 90-100% during summer, when temperatures in the discharge canal are projected to exceed the upper thermal tolerance of dominant summer zooplankton (ANSP 1983a; MMES 1985a). Full-power operation is not expected to increase mortality during winter, spring and fall when discharge temperatures will not be in a lethal range for zooplankton (ANSP 1983a). Nearfield zooplankton depletions have not been observed consistently at Chalk Point, probably because nearfield temperature and chlorine concentration do not approach lethal levels, and the effects of through-plant entrainment are rapidly diluted (ANSP 1983a; MMES 1985a). Entrainment losses of zooplankton do not have regional consequences because zooplankton populations recover rapidly.

Planktonic life stages of benthic organisms, including oysters and softshell clams, are entrained at Calvert Cliffs (MMEC 1980). However, entrainment losses to these biota do not result in local population depletions (Holland *et al.* 1985a, 1979). Near-plant abundances of oysters and softshell clams, as well as most other benthic species with developmental stages in the water column, are generally similar to those found at nearby reference areas (MMEC 1980; Holland *et al.* 1985a).

Salinities in the vicinity of Morgantown, Chalk Point and Baltimore Harbor plants are marginal for the development and growth of planktonic life stages of oysters and softshell clams (EA 1983; Holland *et al.* 1985a; MMES 1985a). Because these species seldom complete their life cycle near these power plants, entrainment losses to their planktonic life stages are not considered an important impact. Abundances of other benthic organisms with entrainable life stages have not declined in the discharge regions of Morgantown, Chalk Point or Baltimore Harbor facilities (Holland and Hiegel 1981; Heck *et al.* 1981; Holland *et al.* 1985a). However, the number of benthic species and the abundance of benthic biota colonizing bottom sediments in the discharge canal at Chalk Point was less than that found at nearby reference areas (Holland and Hiegel 1981).

Potential losses to regional fish populations from ichthyoplankton entrainment were estimated at Calvert Cliffs, Morgantown, Chalk Point, and Wagner to assess potential impacts of plant operations on spawning and nursery areas of RIS (MD-PPRP 1986; Rose 1987). These estimates were based on information about hydrodynamics, life history and stock size, and assumed entrainment mortality of 100%. These projections suggested that Atlantic croaker, bay anchovy, and possibly naked goby and winter flounder may be marginally affected at Calvert Cliffs (MMEC 1980). Naked goby populations were potentially affected at Morgantown (Polgar *et al.* 1979). Bay anchovy and silversides were affected at Wagner. Calculated entrainment losses caused little change in net system productivity at Calvert Cliffs and Morgantown, but projected losses in net system productivity were higher (8%) at Chalk Point (MD-PPRP 1986). Regional ichthyoplankton populations of several RIS may be adversely affected at Chalk Point (Edinger and Buchak 1983; Summers 1987). Forage species (e.g., naked goby, silversides, bay anchovy) were determined to be particularly vulnerable.

Field survey data support the findings of entrainment modeling. Ichthyoplankton entrainment losses at Calvert Cliffs and Morgantown did not result in nearfield depletions in ichthyoplankton populations (ANSP 1977; MMEC 1980). However, forage species were consistently less abundant in the discharge region of the Chalk Point SES than in the intake region (ANSP 1983a). Entrainment losses to forage populations at Chalk Point also have a potential adverse impact on spawning and nursery areas and successful completion of the life cycles of other species as well (MMES 1985a). Forage species, particularly bay anchovy, silversides and menhaden, provide the primary source of nutrition for many RIS fish and birds in the Patuxent Estuary (Summers 1987). Studies are currently being performed and evaluated to accurately estimate entrainment of forage species at Chalk Point and to assess the impact of entrainment on regional populations of RIS.

The Baltimore Harbor power plants are not located in a spawning area for harvested fish species. The major fish species spawning there are forage organisms, including bay anchovy, Atlantic silversides, tidewater silversides, rough silversides, naked goby and hogchoker (Dovel 1970; APL 1972; Koo 1975; EA 1979c, 1980a, 1983; LMS 1980). Ichthyoplankton entrainment losses at the Gould Street plant were low; at the Riverside and Wagner plants losses were greater (EA 1979c; LMS 1980). Entrainment losses at Brandon Shores and the BRESCO facility are projected to be low (APL 1972; EA 1983). Estimates of the potential regional impacts of entrainment losses at Baltimore Harbor facilities have not been made because of insufficient baseline information on RIS ichthyoplankton that use the Harbor area as spawning and nursery grounds. Baltimore Gas and Electric Company (BG&E) is currently collecting the baseline data required to assess the potential impacts of ichthyoplankton entrainment on spawning and nursery areas of RIS in Baltimore Harbor.

Augmentation pumps used to temper thermal and chemical power plant effects in the discharge canal and nearfield area were an additional source of entrainment at Chalk Point until 1986. These pumps drew water from the intake canal and put it directly into the discharge canal without passing it through the plant (see Figure IV-1). In 1985, their use was discontinued in response to a PPRP recommendation. Recent studies have shown that unscreened tempering pumps at Chalk Point did not substantially reduce adverse impacts in the discharge and nearfield area, but did substantially increase mortality of juvenile and adult fish and crabs due to entrainment (PEPCO 1983; Cadman and Holland 1986). In addition, discontinuing the use of the pumps helped to reduce the utility's financial liability for losses due to impingement (Loos 1987).

- Impingement

Impingement at mesohaline facilities was discussed in previous CEIR's (MD-PPRP 1975, 1978, 1982, 1984, 1986). This information, along with 1984-1985 data for Chalk Point and Calvert Cliffs and 1985-1986 data for BRESCO, is summarized below.

At Calvert Cliffs, bay anchovy, spot, menhaden, hogchoker and blue crabs have generally dominated impingement counts, which have been relatively constant (MD-PPRP 1984). However, species composition and total numbers impinged fluctuated widely from 1982 to 1985 (Table IV-5). Bay anchovy was the most abundantly impinged fish in every year from 1975 to 1981, except for 1976, when spot was most abundantly impinged (MD-PPRP 1984). However, from 1982 to 1985, a different species of fish dominated impingement samples each year (Table IV-5). The species constituting the largest portion of impingement were hogchokers in 1982 (over three quarters of the estimated impingement), Atlantic croaker in 1984 (although large numbers of hogchoker and bay anchovy were impinged as well), spot in 1984 and bay anchovy in 1985. Also, Atlantic croaker was impinged in much greater numbers in 1983 than in other years, as was weakfish in 1985.

Impingement at Chalk Point has declined substantially since PEPCO installed a dual barrier net system (Burton 1986b; Loos 1987). In 1981, a barrier net of 32-mm mesh was first deployed at the mouth of the intake canal in order to reduce impingement of fish and crabs. In 1984 a second net of 19-mm mesh was deployed inside the first net after it was discovered that many small fish and crabs were passing through the larger mesh. In 1985, additional improvements in the design and deployment of the barrier net system were made.

The current system consists of two barrier nets, each held in place by an arc of 40-50 pilings about 12-13 ft apart. The inner net is made of eight 46-m-long panels of 19-mm mesh. A skirt is attached to the pilings to prevent gaps between the inner barrier net and the river bottom, particularly during deployment. The outside net, constructed of 32-mm mesh, is changed once or twice a week during the spring and summer to control fouling and clogging. Changing procedures for the net have also been improved. Scuba inspections and impingement results suggest

Table IV-5

Estimated annual impingement at Calvert Cliffs for both units combined

	1982 (a)		1983 (b)		1984(c)		1985 (d)	
Species	Number	Percent of Total Fish	Number	Percent of Total Fish	Number	Percent of Total Fish	Number	Percent of Total Fish
Bay anchovy	54,689	6.5	430,817	23.3	1,929,765	20.0	228,067	41.9
Spot	15,677	1.9	33,423	1.8	5,581,361	57.7	35,527	6.5
Atlantic menhaden	45,163	5.4	48,957	2.7	1,195,964	12.4	13,133	2.4
Weakfish	- (e)	-	-	-	-	-	67,825	12.4
Hogchoker	657,758	78.6	540,294	29.3	687,412	7.1	42,886	7.9
Blueback herring	20,515	2.5	-	-	16,791	0.2	41,280	7.6
Atlantic silverside	20,405	2.4	-	-	37,748	0.4	38,170	7.0
Atlantic croaker	-	-	670,633	36.3	55,066	0.6	33,201	6.1
Other fish species	22,219	2.7	122,015	6.6	167,155	1.7	44,800	8.2
Total fish	836,426		1,846,139		9,671,262		544,897	
Blue crabs	488,900		912,623		1,883,619		807,024	

(a)Data taken from Hixson, Hirshfield, and Hepner 1983.
(b)Data taken from Hixson, Morin, and Gallagher 1985.
(c)Data taken from Breitburg, Hixson, and Gallagher 1986.
(d)Data taken from Breitburg and Hixson 1986.
(e)'-' indicates that fish were collected but annual estimates were not presented.
Annual estimates for these species are included in the category of "other fish species."

that the barrier nets are effective. The barrier nets are deployed from April through November.

Total impingement in 1984-1985 was one-tenth that of 1976-1977 (Loos 1987) (see Table IV-6). Impingement of both fish and crabs was reduced by about 90%. Atlantic menhaden remained the dominant fish in impingement samples.

Mortality rates of impinged fish varied from species to species and from facility to facility. Impinged organisms at Chalk Point are returned to the receiving body via the discharge canal, and summer discharge canal temperatures frequently exceed the upper thermal tolerance of finfish and crabs (ANSP 1983a). The canal also contains toxic chlorine residuals. Post-impingement mortality rates at the Chalk Point plant were estimated to be unacceptably high during summer (Hamilton *et al.* 1970). During other seasons and at other Maryland power plants, about 90% of the hardy species (e.g., spot, hogchoker) survive impingement, whereas only about 25% of the sensitive species (e.g., menhaden, other clupeids) survive (BG&E and ANSP 1977; ANSP 1977, 1983a). Blue crabs had essentially no postimpingement mortality at facilities other than Chalk Point (MMEC 1980; PEPCO 1982; ANSP 1983a).

In 1985, PEPCO initiated a cooperative program with DNR to restore striped bass in the Patuxent River. PEPCO's Chalk Point Aquaculture Center currently consists of fourteen ponds, six 20-ft. diameter tanks and smaller culture tanks. The facility released 300,000 striped bass fingerlings into the Patuxent in 1987.

High impingement episodes account for a large proportion of annual impingement estimates at mesohaline facilities (MMEC 1980). At Chalk Point, high impingement episodes were related to seasonal migration (ANSP 1983a). At Calvert Cliffs and Morgantown, high impingement episodes were related to the occurrence of low dissolved oxygen concentrations in the intake embayment (MMEC 1980; SWEC 1981). Removal of panels from curtain walls (see Figure IV-1) at Calvert Cliffs reduced the frequency of high impingement episodes, presumably by providing entrapped fish with an escape route. Recent increases in the volume of Bay water with low dissolved oxygen levels, which can cause organisms to become less active and unable to avoid intake currents, suggest that

Table IV-6

Estimated annual impingement (number of individuals) at the Chalk Point power plant, comparing impingement before and after installation of barrier net and dual barrier net

Species	1976-1977 Before Barrier Net		1982-1983 With Barrier Net		1984-1985 With Dual Barrier Net	
	Number	Percent	Number	Percent	Number	Percent
Atlantic menhaden	1,347,490	31	233,656	25	194,558	34
Spot	647,016	15	33,796	4	9,170	2
Hogchoker	191,926	5	94,764	10	19,019	4
White perch	41,910	1	344,676	37	10,459	3
Other fish species	139,982	2	25,358	3	82,016	19
Total fish	2,368,324	55	944,132	71	265,222	62
Blue crabs	1,948,132	45	380,760	29	164,738	38
TOTAL IMPINGED ORGANISMS	4,316,456	100	1,324,892	100	429,960	100

Sources: ANSP 1983a; PEPCO 1983; Loos 1987.

the frequency and severity of high impingement episodes may increase in the future at Calvert Cliffs and Morgantown (Holland *et al.* 1985a).

Estimates of impingement were made of the BRESCO facility for July 1985 through June 1986 as required by the Maryland State Discharge Permit (EA 1987). Blue crabs (66% of total) and grass shrimp (8%) were the most abundant invertebrates impinged. Of the fish impinged, 40% were Atlantic menhaden, 26% were mummichogs, 13% were Atlantic silversides and 8% were bay anchovy. Estimated total annual impingement was 80,178 fish and shellfish for July 1985 to June 1986 at BRESCO. Based on COMAR valuations and an assumption of 100% mortality, the value of the total estimated annual impingement is $14,702.

Impingement losses to dominant species at all mesohaline plants are small compared to commercial landings and are only a small percentage of the forage required for major predatory fish populations (ANSP 1977, 1983a; MMEC 1980). Thus, impingement losses are not expected to affect commercial or recreational landings of fish and crabs from mesohaline habitats.

- Discharge Effects and Habitat Modification

Thermal plume dimensions for power plants in the mesohaline zone were discussed in previous CEIR's (MD-PPRP 1975, 1978, 1982, 1984, 1986). In all cases, the distribution and size of the plumes vary with season, tidal stage, wind velocity and direction, and plant operating level.

Of the mesohaline power plants, Chalk Point has the greatest potential for causing discharge effects: the receiving water body there is shallow, and plant water use exceeds the amount of flow available for dilution. Thus a relatively large region of the Patuxent River is affected by the plant's thermal discharge. In addition, the plant discharge is located approximately 4 km upstream of the intake, resulting in changes to natural salinity patterns. Chalk Point failed to comply with any of the mixing zone specifications in state thermal regulations, and mitigation studies designed to reassess and limit the impact of the cooling water intake systems are currently being performed.

Nearfield changes in biotic distributions resulting from Chalk Point's thermal effluents were localized, however, and included increases in the abundance of heat-tolerant benthic species, mainly small segmented worms called oligochaetes, and mortalities to heat-sensitive benthic species and zooplankton (Holland and Hiegel 1981; ANSP 1983a). Fish and crabs were attracted to or excluded from the Chalk Point discharge region depending upon season (Holland and Johnson 1982; PEPCO 1985). Some sport fish were attracted to the Chalk Point discharge canal during winter (Moore and Frisbie 1972; Moore *et al.* 1973). Fish migration routes were not blocked (Holland and Johnson 1982; MMES 1985a), and thermal effluents did not adversely affect the growth and reproduction of fish or other biota (Abbe and Hart 1974; Homer *et al.* 1979a, 1979b, 1980a, 1980b; Souza *et al.* 1980; ANSP 1983a).

In the past, copper released from the copper-nickel condenser tubes (recently replaced with nontoxic titanium tubes) at Chalk Point was of concern. The copper bioconcentrated by oysters in the discharge region (Roosenburg 1969; Eaton and Chamberlin 1982; ANSP 1983a, 1983b). Bioconcentration of copper, however, did not adversely affect oyster growth or survival (ANSP 1983b). The affected region is not prime oyster habitat, and oysters are not commercially harvested there (MMES 1985a). High tissue burdens of copper have rarely been reported in oysters from commercial oyster beds located downstream (ANSP 1983a; MMES 1985a). Also, a monitoring program conducted by the utility (PEPCO 1985) found no abnormal tissue burdens of copper in oysters near the Chalk Point discharge. The complete elimination of the use of copper in the plant discharge should eliminate any such conerns in the future.

No consistent discharge effects on phytoplankton, zooplankton or fish were measured at Morgantown or Calvert Cliffs. However, high-velocity discharge systems modified habitat characteristics at both sites, scouring away natural sands and muds in the immediate vicinity of discharges. These habitat modifications affected the abundance and makeup of benthic biota in a localized portion of the nearfield area. Plant-related increases and decreases in benthic abundance, growth and productivity away from the scoured areas were also measured. Increases far outweighed decreases, and appeared to be related to organic additions to bottom habitats resulting from entrainment mortality of plankton (MMEC 1980; Holland *et al.* 1985a). Many of the species that increased in abundance were heat-tolerant organisms. Oysters in the vicinity of Calvert Cliffs and Morgantown bioaccumulated copper; however, oyster densities in the affected areas were too low to support a fishery (Phelps 1979; MMEC 1980). No copper uptake by other benthic biota in the nearfield areas of these plants was observed (ANSP 1977; MMEC 1980; Holland *et al.* 1985a).

From the available data, it is not possible to separate the effects of the Wagner plant on benthic populations from those of a variety of other industries located in the Harbor. Spot and white perch were attracted to the Wagner thermal plume, but not consistently (Heck *et al.* 1981). No zooplankton depletions were observed in the discharge region of Wagner (NA 1981). The Brandon Shores and BRESCO facilities in the Harbor area probably cause no additional adverse environmental impact on mesohaline habitats (APL 1972; EA 1983). Empirical data on the extent of the thermal plume at BRESCO collected in 1985 (EA 1987) indicate that the facility complies with applicable thermal discharge compliance criteria, except that the discharge flow exceeds 20% of the annual average net flow past the point of discharge. The utility must now demonstrate that the facility will not adversely impact indigenous populations.

- Conclusions for Mesohaline Power Plants

When the results of studies at all mesohaline plants are considered collectively, a picture emerges that indicates a low probability of cumulative impact on mesohaline habitats. Although large phytoplankton and zooplankton entrainment losses have been frequently measured, no consistent nearfield depletions have been found. This is probably due to the rapid recovery of most plankton from entrainment stress. Since no important commercial or recreational species spawn in the mesohaline zone, there are no entrainment losses of these species and thus no economic losses. Forage fish species spawn in this zone, and large numbers of their ichthyoplankton are entrained. The only mesohaline facility that may impact riverwide spawning and nursery areas of forage species is Chalk Point. In general, research has shown that large numbers of juvenile fish and crabs are impinged at mesohaline power plants; however, impingement losses do not result in measurable nearfield population depletions. Discharge effects in mesohaline habitats are generally localized. Fish and crabs are variously attracted to and repelled from plant discharges, but fish migration, spawning activity or growth are not adversely affected. Benthic abundance and productivity are generally higher in thermally affected areas; however, increases in secondary productivity do not impact local or regional food web dynamics.

Tidal Fresh - Oligohaline Power Plants

Of the eight plants located in waters that are oligohaline in the spring (Table IV-2), Chalk Point, Morgantown, and the Baltimore Harbor area plants are on waters that are mesohaline during the summer and fall. The impacts associated with these plants were discussed in the preceding section.

The remaining tidal fresh-oligohaline plants -- Possum Point, Vienna and Crane -- are in waters that are tidal fresh in the winter and spring, and oligohaline in the summer and fall. Possum Point in Virginia, on the Potomac River, and Vienna, on the Nanticoke River, are both in major striped bass spawning areas. Crane, though located on tidal fresh/oligohaline waters, does not impact a striped bass spawning area. The Perryman site, the likely location for BG&E's next generating station, is also located on waters that are tidal fresh in the spring and oligohaline in the summer and fall.

- Entrainment

At Crane, entrainment enhanced phytoplankton productivity at low temperatures and inhibited it at high temperatures. Zooplankton entrainment generally did not result in nearfield depletions except during summer. Although ichthyoplankton entrainment losses were large in the receiving water body adjacent to Crane, the potential for regional impact from these losses was small (Grant and Berkowitz 1979a, 1979b; Sellner *et al.* 1980; EA 1981c; MMEC 1983).

Entrainment of phytoplankton and zooplankton at Vienna was estimated to be low (Otto *et al.* 1980). Although the Vienna facility is located in a striped bass spawning area, ichthyoplankton entrainment of RIS is also probably low (DP&L 1982). Only Unit 8, which has a cooling tower with intake flows of 0.12 m^3/sec for makeup water, is operational (DP&L 1982).

Entrainment studies have not been conducted at Possum Point. However, no nearfield depletions of phytoplankton or zooplankton were found during nearfield surveys, suggesting that entrainment losses, if they occurred, did not have nearfield consequences (EA 1979a). Possum Point saw high entrainment losses to spawning populations of striped bass (6.3%), white perch (5.1%) and river herrings (6.0%) are relative to other Maryland power plants (Polgar *et al.* 1979). This corresponds to a monetary value of about 3.3% of the annual value of the Potomac fishery, and to a loss in ecosystem productivity of 0.44% (Polgar *et al.* 1979).

- Impingement

Impingement of juvenile and adult fish at Vienna is negligible (Portner and Kohlenstein 1979; DP&L 1982). Impingement at Possum Point is also suspected to be small since water use is not high. At Crane, a significant number of menhaden, white perch and blue crabs are impinged (EA 1979b, 1981a), but at lower rates than for mesohaline facilities.

Increasing the intake screen wash cycle from once every 8 hours to once an hour increased the impingement rate at Crane (EA 1979b). Therefore, 8-hr screen wash cycles may be optimal to minimize impingement losses. Factors contributing to the loss of fish from intake screens using an 8-hr wash cycle are discussed in Section H (Best Available Technology and Operating Practices). Although impingement rates at Crane were irregular and fluctuated considerably from one sampling date to another, the general trend was for impingement to be highest in summer and fall and lowest in late winter (EA 1979b).

Post-impingement mortalities at Crane varied from species to species. Mortality rates were high for menhaden and gizzard shad (70-100%). Spot, hogchoker, white perch and yellow perch had post-impingement mortality rates of 10 to 50%. Post-impingement mortality rates were size-dependent, with largest mortalities generally associated with smaller individuals. Essentially all blue crabs that were impinged survived (EA 1981a).

- Discharge Effects and Habitat Modification

The thermal plume at Vienna is small, and discharge effects are negligible (Carter and Regier 1975). No discharge effects from Possum Point were found in the Potomac River, probably because the point of discharge release is located on Quantico Creek (EA 1979a). In Quantico Creek, only small changes in biotic distributions were attributed to effluents from Possum Point (EA 1979a). Fish avoided the thermal effluents during summer and were attracted to them during winter, but fish migration and spawning and nursery activities of RIS were not adversely affected.

The thermal plume at Crane affected about 40% of the volume of the receiving creek system (Aquatec, Inc. 1978). Crane effluents also resulted in a slight increase in nearfield salinity, but did not affect nearfield dissolved oxygen (Zubkoff 1980; EA 1980b, 1981b). No above-ambient levels of copper were found in sediments or biota near Crane or any other tidal fresh-oligohaline zone power plant (EA 1979a; Harris *et al.* 1980; DP&L 1982). Thermal effluents from Crane inhibited nearfield phytoplankton productivity during summer, but not during other seasons (EA 1980b, 1981c; Sellner *et al.* 1980). Submerged aquatic vegetation (SAV) grew marginally better at reference areas near Crane than in the thermally affected area (Nichols *et al.* 1979; Nichols and Anderson 1980). Compared with normal seasonal trends and natural year-to-year variation, plant effects on zooplankton community composition and abundance were small (Grant and Berkowitz 1979a, 1979b; Grant *et al.* 1980; EA 1981b). Thermal effluents at Crane affected benthic populations by reducing winter mortality of cold sensitive forms, increasing summer mortalities of heat-sensitive species and enhancing growth and development of heat-tolerant species (Jordan *et al.* 1979, 1980; Jordan and Sutton 1984; Shaughnessy 1983).

As with the mesohaline power plants, fish were attracted to or avoided the Crane discharge region depending upon season (TI 1981). However, fish migration routes were not impeded, and discharge effects on local fish movements did not adversely impact regional populations (Holland *et al.* 1978; EA 1981c). The tributaries near Crane are not important spawning areas for striped bass and shad. White perch and yellow perch spawn in the area and use the region as nursery grounds (Holland *et al.* 1978; EA 1981c); however, power plant operations did not adversely impact these nursery or spawning activities.

BG&E established an experimental waste heat aquaculture facility at Crane in 1983. Striped bass are cultured at this facility using the heated effluents. Fish reared at the Crane aquaculture facility are stocked into the Chesapeake Bay and its tributaries in a cooperative program with the Maryland Department of Natural Resources.

BG&E has proposed construction of a coal-fired power plant at Perryman on the Bush River in Harford County. Because of limited sources of water for once through cooling (Jacobs and Richkus 1984), the plant will probably employ cooling towers and may discharge only blowdown water from the closed-cycle system into the Bush River. One likely source for the makeup water for the cooling system is Conowingo Reservoir on the Susquehanna River, with the water being conveyed to Perryman by the City of Baltimore's emergency water supply pipeline. Susquehanna River water is relatively rich in nitrogen and phosphorus, raising the possibility that the closed cycle system would increase the concentrations of these nutrients in the blowdown water by a factor of about 5 (Jacobs and Richkus 1984). The subsequent discharge of this water into the Bush River might further enrich the already eutrophic estuary, potentially increasing algal biomass to a point where dissolved oxygen depletion would be a problem (Rose *et al.* 1986).

In response to the potential discharge problem, PPRP sponsored a detailed waste load allocation study for the proposed Perryman plant that included: a critical examination of a previous study (CH2M Hill 1983) of the likely enrichment of the estuary caused by the expansion of Harford County's publicly owned treatment works (POTW) discharging into the Bush River adjacent to the site of the proposed Perryman discharge; field studies of the annual cycle of nutrient and algal concentrations, and rates of community oxygen metabolism in the estuary (CBL 1984); and simulation modeling of the likely combined effects of the Perryman plant plus the expanded Harford County POTW (Rose *et al.* 1986). This study indicated that the relatively high concentrations of algae presently found in the estuary do not result in oxygen depletion, and the likelihood of encountering large increases in algal biomass due to the combined effects of the POTW expansion and the proposed power plant was small.

- Conclusions for Tidal Fresh-Oligohaline Power Plants

Entrainment losses at Crane do not affect regional RIS populations. At Possum Point and Vienna, entrainment losses affect striped bass and other harvested fish populations, but the losses are small (only a few percent of baywide catches). The consequences of impingement at oligohaline plants are similar to those at mesohaline plants: many organisms survive impingement, and the major species impinged are ubiquitous and abundant throughout Maryland's tidal waters.

Impingement losses appear too small to have a detectable effect on regional stock sizes or fisheries. Power plant operations at Crane play a role in defining the salinity and temperature regimes of the receiving water body, especially during summer when high temperatures, low freshwater flows and high generating loads occur. Local plant-related thermal effects were frequently detected under these conditions. Discharge effects at Possum Point apparently are similar to those at Crane, but do not have an impact on Maryland waters. Discharge effects at Vienna are negligible. The operations of power plants in the tidal fresh-oligohaline zone therefore do not significantly affect biotic resources in this habitat zone.

Effects on the Bush River estuary due to the discharge of cooling tower blowdown water from the proposed coal-fired power plant at Perryman are likely to be small, even when combined with the effects of the increased discharge of an adjacent POTW now undergoing expansion. Even if the plant draws nutrient-rich makeup water from the Susquehanna River and discharges it into the estuary, the discharge is unlikely to cause significant increases in algal biomass over levels observed at present. Further, any reduction of the adequate dissolved oxygen concentrations presently observed there is unlikely.

<u>Nontidal Freshwater Power Plants</u>

Two steam electric stations are located on riverine waters -- R.P. Smith and Dickerson, both on the Potomac River (Table IV-2). Each facility uses, at times, a substantial portion of river flow for cooling purposes. These plants are relatively old, of low to medium generating capacity, and located in areas inhabited by typical warm water riverine biota (EA 1974; ANSP 1981; MMEC 1981).

- Entrainment

Entrainment of phytoplankton and zooplankton is not major concern at steam generating stations located on Maryland's nontidal freshwater habitats because of the minor role of these biota in biological productivity and system dynamics of this habitat (EA 1974; ANSP 1981; MMEC 1981). Ichthyoplankton entrained at R.P. Smith and Dickerson are mostly forage species. Economic and ecological losses due to this entrainment have been projected to be small and unlikely to have regional consequences (EA 1974; ANSP 1981).

- Impingement

Impingement at R.P. Smith was projected to have negligible effects on regional fish populations, the monetary loss being estimated at less than $500 annually (EIA 1980; MMEC 1981). Impingement at Dickerson was negligible except in March and May when sporadic high impingement episodes occurred and up to 8,000 spottail shiners were impinged over a 24-hr period. These losses, however, have little economic consequence (ANSP 1981).

- Discharge Effects and Habitat Modification

Plant-related changes in the number of benthic taxa, in density and biomass of some invertebrates, and in life history characteristics (i.e., growth rate and timing of emergence) of some insects have been measured within regions thermally affected by R.P. Smith and Dickerson (ANSP 1981; MMEC 1981; Vannote and Sweeney 1985). Fish were attracted to or repelled from the thermal plumes of Dickerson and R.P. Smith, depending upon the season (ANSP 1981; MMEC 1981; PEPCO 1981, 1984). Feeding habits and the physiological condition of fish collected in thermally influenced areas also differed slightly from those of fish collected from nearby reference areas (PEPCO 1984). These differences were not large enough to suggest that the plant had changed the structure of the Potomac food web. Changes in biota from the long-term degradation of water quality of the Potomac far exceeded the measured power plant effects (ANSP 1981).