

**ECONOMIC IMPACT OF THE EFFECTS OF POLLUTION  
ON THE COASTAL FISHERIES OF THE ATLANTIC  
AND GULF OF MEXICO REGIONS  
OF THE UNITED STATES OF AMERICA**



With the cooperation of the  
United Nations Environment Programme



**FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS**



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UNITED NATIONS ENVIRONMENT PROGRAMME

ECONOMIC IMPACT OF THE EFFECTS OF POLLUTION ON THE  
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REGIONS OF THE UNITED STATES OF AMERICA

by

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Abstract

This report reviews and evaluates the economic impact on the fisheries of the Atlantic and Gulf of Mexico coasts of the United States of other human activities. Four types of impact were considered: production of oil and gas; direct fish mortalities caused by effluent; habitat deterioration; and closure of molluscan fisheries for health reasons. An attempt is made to obtain quantitative (dollar) estimates of the impacts, both negative and positive. The main quantifiable effects are of habitat destruction on species requiring estuaries and similar areas as nurseries (particularly in the Gulf and Middle Atlantic region), and molluscan fisheries (again the Gulf region is particularly affected). Fish kills seem highly variable from year to year. A massive kill (including large-scale destruction of valuable surf clam stocks) occurred in the New York Bight in 1976, associated with anoxic conditions. These conditions were at least partly due to natural, environmental events.



## 1. INTRODUCTION

The impact of human activities on fisheries resources may be direct, causing mortality and reduced productivity or may be indirect or sublethal in which case the impact may result in habitat alteration or removal and gradual decline in populations. There are numerous activities that generate pollution, particularly:

- (1) industrial and municipal waste discharge;
- (2) energy development;
- (3) waste heat disposal;
- (4) shipping and commerce;
- (5) dredging;
- (6) combustion and processing.

Specific pollutants from these activities such as domestic sewage, chlorinated hydrocarbons, pulp mill effluent, food processing wastes, agricultural run-off, chemical wastes, petroleum production, radioactivity and thermal pollution are enumerated and discussed by Waldichuk (1974); Bernhard and Zattera (1975); U.S. National Academy of Sciences (1975); Chu-fa Tsai (1975); Wood and Johannes (1975); and Sindermann (1976). Reviews of environmental qualities and recommendations on quantities of input are found in reports such as: U.S. National Academy of Sciences Water Quality Criteria (1972); Annual Reports of the Council on Environmental Quality (1975, 1976); U.S. Senate Committee on Commerce report, "Effect of Man's Activities on the Marine Environment" (1975); and U.S. Environmental Protection Agency document, "Quality Criteria for Water" (1976).

### Scope of this Study

This study attempts to review and evaluate four impacts of man's activities on fisheries resources from an economic viewpoint. These four impacts are:

- (1) energy development as oil and gas exploration and production;
- (2) effluent discharges resulting in direct fish mortalities;
- (3) habitat alteration and deterioration by dredging and filling;
- (4) public health considerations resulting in the closure of shellfish harvesting areas.

Beneficial aspects of pollutant sources are also discussed.

The geographical area considered in this report extends from the Mexican border in the Gulf of Mexico, around the tip of the state of Florida, up the east coast of the United States to the Canadian border. This broad area is divided into regions: Gulf of Mexico; South Atlantic (southeastern states); Middle Atlantic States (including Chesapeake Bay); and North Atlantic (the "New England States"). The overall geographical range is shown in Figure 1. Physical boundaries and parameters as presented for each region as well as a broad discussion of pollution sources. The four pollution impacts and beneficial aspects are evaluated as they pertain to the region.

A number of United States federal laws effect environmental quality and marine resources, among the more important are: Oil Pollution Control Act of 1961, National Environmental Policy Act of 1969, Coastal Zone Management Act of 1972 and the Marine Protection, Research and Sanctuaries Act of 1972. Two major acts should be noted: The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) sets forth discharge criteria and a wastewater treatment level upgrading timetable. The Fishery Conservation and Management Act of 1976 (Public Law 94-265) establishes the 200 mile jurisdiction zone for fishing off U.S. coasts and also directs that fisheries research on the impact of pollution on fish be conducted. Numerous state laws also affect localized environmental quality with these statutes equalling or surpassing federal regulations.

Individuals from over 40 international, federal, state and local agencies and their divisions, numerous academic institutions and legislative bodies have contributed material for evaluation in this study. Their cooperation and continued interest are gratefully acknowledged.



Figure 1. The geographical area of the United States considered in this report



## 2. THE GULF OF MEXICO REGION

### 2.1 Introduction

This region extends from the southern tip of Florida to the Mexican border (see Figure 2). The surrounding land mass encompasses the west coast of Florida and the states of Alabama, Mississippi, Louisiana and Texas. The shoreline, excluding barrier islands, totals 2 544 km. A wide continental shelf, ranging from 32 to 160 km in width, is present along the entire coast, offering considerable petroleum and natural gas reserves. Because of its lower latitude and the influence of components of the Gulf Stream, warm tropical waters exist with small tidal ranges. The estuarine system covers almost 3 million hectares. The open surface area is 1.6 million km<sup>2</sup>.



Figure 2. The Gulf of Mexico Region



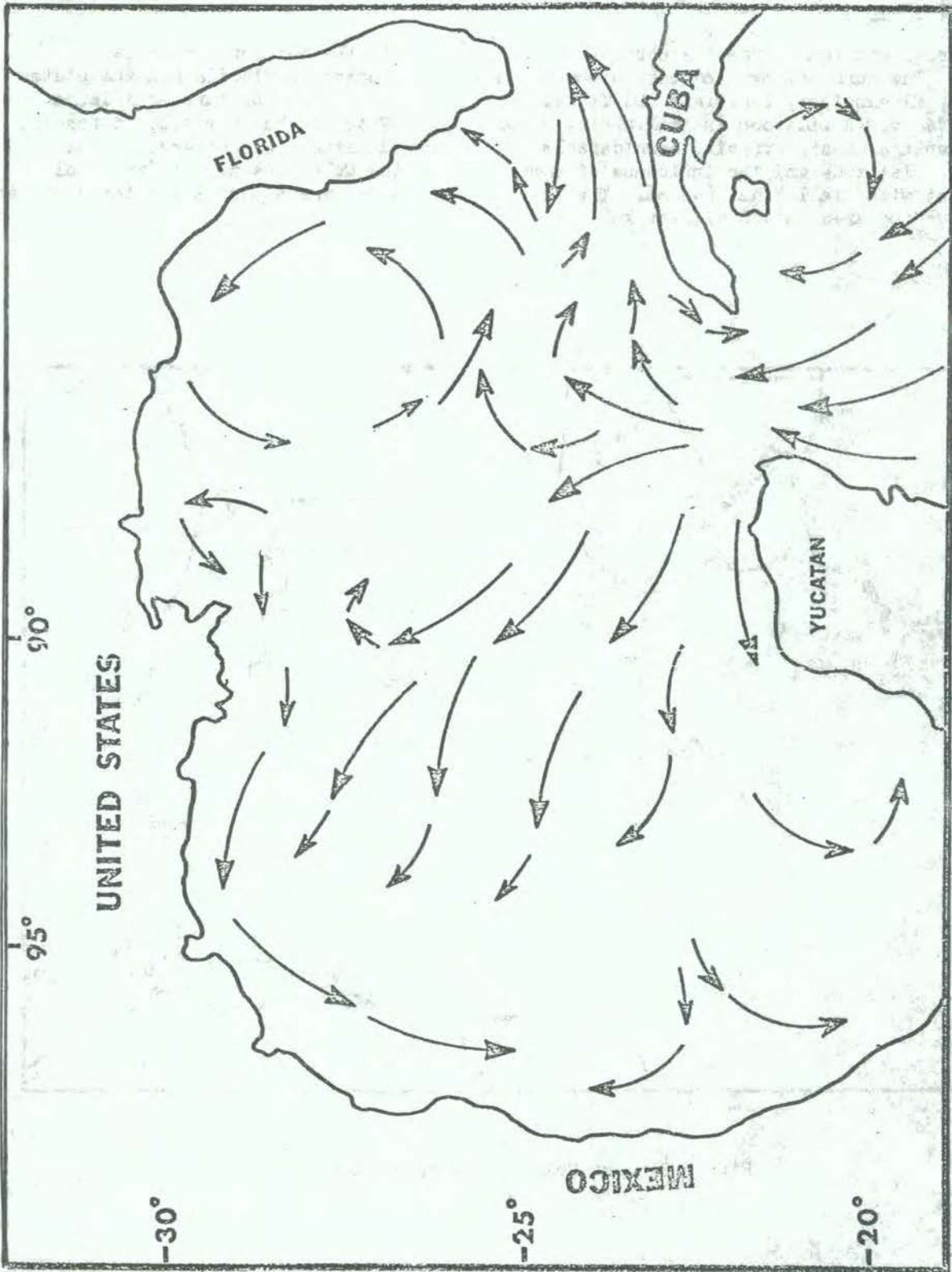


Figure 3. Generalized Winter Surface Circulation of the Gulf of Mexico (after Nowlin, 1971)



The Mississippi River, one of the major deltas of the world, divides the Gulf and drains an inland area of nearly 5.5 million km<sup>2</sup> or 41 percent of the land area of the United States.

As the oceanic inflow from the Caribbean Sea enters the Gulf of Mexico basin, at the Yucatan Straits, the surface waters spread. A portion of the water mass forms a clockwise loop and passes through the eastern Gulf, around the southern tip of Florida, to form the Gulf Stream. A smaller portion of the surface water flows counter-clockwise north and west of the Mississippi delta. This western area of the Gulf is relatively isolated from the overall Gulf water exchange and receives a major portion of the run-off and wastes reaching the Gulf coast by way of the Mississippi River. The generalized winter surface circulation of the Gulf of Mexico is shown in Figure 3.

Water pollution problems are associated with extractive industries and development. In addition to large petroleum and natural gas reserves, sulfur and phosphate rock are mined in large quantities. Over 3 million hectares are presently under lease for petroleum and gas exploration and potential extraction on the outer continental shelf. Over 14 000 wells have been drilled in this area. The well platforms provide a focus for a large sportfishing activity. Chemical and allied industries onshore utilize these raw materials obtained from the Gulf waters and add to the potential pollution problems. Two major dump areas, both west of the Mississippi River delta, have been identified and 14 disposal sites are approved for chemical disposal and dredge spoil sites. Paper production and allied activities also pose a potential threat to water quality.

The Gulf of Mexico coastal zone supports a biomass of estuarine-dependent species that are of recreational and commercial fishery importance. The coastal fishery is a dominant economic influence in the Gulf. In some areas of this region commercial fishing is rated among the top five commercial activities. For the latest year of available data for the region, 1970, marine recreational fishermen landed 220 000 metric tons of fish. In 1975 commercial fishermen landed, in the Gulf, 746 000 metric tons of fish and shellfish with an ex-vessel value of U.S.\$ 209 million. A large portion of the commercial finfish landing was for industrial use as fish oil, solubles and fishmeal. Table 2.1 summarizes the landings and values of the commercial marine catch, 1975.

Over sixty species of fish and 20 species of invertebrates are landed. The major shellfish products are shrimp, blue crab and oysters with the major finfish fisheries being menhaden, croaker, black mullet and spotted seatrout.

Table 2.1  
Gulf of Mexico Region

Landings (1 000 Metric Tons) and Value (U.S.\$ 1 000)  
of Commercial Marine Catch, 1975 (Preliminary)

State	Finfish		Shellfish		Total Finfish & Shellfish	
	Landings	Value	Landings	Value	Landings	Value
W. Coast Florida	29.4	16 897	23.4	40 444	52.8	57 341
Alabama	6.9	2 283	7.4	18 703	14.3	20 986
Louisiana	463	31 541	38.1	50 829	501.1	82 370
Mississippi	136	9 811	2.8	4 536	138.8	14 347
Texas	3.5	2 416	35.5	89 806	39.0	92 222
Total	638.8	62 948	107.2	204 318	746.0	267 266

Source: Individual State Summary and U.S. Department of Commerce, 1976. Fisheries of the United States, 1975. Current Fishery Statistics No. 6900



2.2 Oil and Gas Exploration and Production

In 1938 the first open water oil field was established in the Gulf of Mexico. Off the Louisiana coast in 1947 the first offshore drilling was instigated. From 1954 to 1974 over 12 000 wells were drilled on 3 887 752 hectares with production of over 3 billion barrels of oil and 600 000 steres of natural gas. In 1974 there were 711 911 hectares leased for oil and gas with 344 000 barrels of oil produced. Value of lease production in 1974 was U.S.\$ 5 564 million. Royalty payments and bonus bids received by the U.S. Treasury in 1973 amounted to U.S.\$ 3 480 million. This revenue provides funding for the Land and Conservation Fund used to purchase parks, refuges and recreational lands. Table 2.2 summarizes Gulf of Mexico outer continental shelf energy activity (U.S. Department of Interior, 1974 Bureau of Land Management/Geological Survey). In 1974 approximately 62 percent of outer continental shelf (OCS) U.S. production of crude oil took place in Louisiana and Texas.

Table 2.2

Gulf of Mexico Outer Continental Shelf Activity

	1954-1974	1974
Tracts Leased	2 153	1 514
Hectares Leased (1 000's)	3 888	712
Number of Wells Drilled	12 389	2 054
Oil Production (1 000's barrel)	3 487 021	361 000
Gas Produced (1 000's cubic metre)	600	88
Value of Production <sup>a/</sup> (U.S.\$ 1 million)	18 829	2 512

a/ Average value per barrel U.S.\$ 6.96

Source: U.S. Department of Commerce, Environmental Data Service, 1976

In the State of Louisiana 124 400 men were estimated to be employed as a result of OCS activity (Outer Continental Shelf Oil and Gas Development and the Coastal Zone, Committee on Commerce, U.S. Senate, 1974). Investment in Louisiana by industry in oil/gas drilling and associated refining and chemical manufacturing was U.S.\$ 78 321 million from July 1969 to December 1974 (Nicholls State University, 1975).

Three sources of petroleum hydrocarbon associated pollution exist: Chronic input of petroleum hydrocarbons and associated drilling brines; direct physical damage due to pipelines and construction facilities; indirect physical alteration by erosion of wetlands with accompanying altered tidal flow patterns.

Chronic input of petroleum hydrocarbons (oil spills) included 20 major spills in 1971 and a seven-year total (1964-1971) of 40 425 metric tons. There were 839 minor spills (1-50 barrels) during 1972 totaling 122 metric tons (U.S. National Academy of Sciences, 1973). Table 2.3 summarizes the major accidental spills in the Gulf of Mexico.



Table 2.3

Review of Oil Spills, Gulf of Mexico 1964-1974

Location	Volume	Oil Type	Year
Dry Tortugas, Florida	521 kl	Fuel	1964
Tampa Bay, Florida	38 kl	Not Given	1971
Coral Reef, Florida	Slick - 75 miles		1970
Florida Keys, Florida	434 metric tons	Crude	1975
Oil Rig off Louisiana Coast	9 420 metric tons	Crude	1975
Oil Rig fire, Louisiana Coast	Burned for 1 month	Crude	1970
Oil Rig off Mississippi River	39 kl	Diesel	1972
Mississippi River Mouth	1 159 metric tons	Crude	1974
Mississippi River (Pipe)	290 metric tons	Not Given	1974
Houston, Texas, Dock	477 kl	Crude	1973
Texas City, Texas	1 900 kl	Crude	1975
Corpus Christi, Texas	4 387 kl	Crude	1974
Corpus Christi, Texas (Pipe)	135 kl	Crude	1974

Data taken from Baker, J.M., 1976. Review of World Oil Spillage 1960-1970

Formation water (brine/oil mixture used during drilling) probably contributes to the environment twice the amount of oil production. For the 1972 production figures, the addition of petroleum hydrocarbons to the environment amounts to 334 101 metric tons. (National Academy of Sciences, 1975.)

Associated with offshore oil platforms there are approximately 3 100 km of pipeline in the Gulf of Mexico. Disruption of pipeline by ships anchors causes the release of the greatest quantity of oil into the world's oceans. About 3 000 km of canals and pipeline right-of-way extends in the coastal marshes. Approximately 1 400-3 800 cubic metres is disturbed per km of pipeline burial. This results in a minimum of 4 200 000 cubic metres of disturbed and resuspended sediment. With the accompanying erosion, alteration of the tidal current patterns result and salinity intrusion compresses the low salinity nursery grounds necessary for estuarine-dependent fisheries.

Total landings for oysters and shrimp have varied since petroleum extraction began. However, some changes are evident in distribution, species composition and area yield. Oyster beds were decimated by influx of higher salinity waters and accompanying disease and predators. The new oyster grounds produced a lower yield, when compared to pre-drilling yields. Shrimp catch composition was formerly 95 percent white shrimp (*Penaeus setiferus*) and 5 percent brown shrimp (*P. aztecus*). In 1975 white shrimp and brown shrimp landed in Louisiana were approximately the same percentage of the catch (46 percent and 42 percent respectively). The apparent reason for the change in species composition of the catch is that availability of the brackish nursery area has been considerably reduced by coastal zone industrial development to the disadvantage of white shrimp that prefer lower salinity nursery areas. White shrimp brought an average price of U.S.\$ 3.64 per kg and brown shrimp only U.S.\$ 2.09 per kg.



Vessel Transportation of Crude Oil

During 1974 transportation of crude oil to refineries in Texas and Louisiana amounted to 30.6 million metric tons of domestic crude oil and 21.1 million metric tons of foreign crude oil. With the advent of the supertanker (> 70 000 dwt) and increased petroleum dependence on foreign supplies two deepwater port complexes applied for licences to construct and operate offshore oil terminals in the Gulf of Mexico. In December 1976 the applications were approved and Table 2.4 summarizes the predicted impact of the terminals as derived from the Environmental Impact Statements (Dames and Moore, 1975, SEADOCK and Louisiana Offshore Port Applications).

Table 2.4  
Impact of Offshore Oil Terminals in the Gulf of Mexico

	LOOP, Inc. (Louisiana)	SEADOCK, Inc. (Texas)
Sea bed Disturbance (hectares)	566	485
Sediment Suspension m <sup>3</sup>	993 200	993 200
Annual Projected Oil Spills (metric tons)	725	493
Area Removed from Fishing (km <sup>2</sup> )	6.4-42.2	6.9-31.2
Coastal Zone-Wetland Impact (hectares disturbance)	1 414	335
Additional	Leaching of salt dome Increased salinity	Additional hydrocarbon emission: to Houston- Galveston Air Quality Region

Source: U.S. Department of Commerce, Environmental Data Service, 1976

The State of Florida, in 1976, applied for "adjacent coastal state" status in an effort to impose additional requirements on the construction and operation of the offshore oil terminals. Analyses were made of the risk of damage to Florida from each of the terminals. Resource value ratios (Florida/Louisiana) and exposure ratios were determined. It was concluded that the risk of damage to the Florida coastal environment is 1.3 to 6 times as great as the risk of damage to the coastal environment of Louisiana for commensurate values (beach use, boating, sportfishing and commercial fishing).

The selected recreational resource valuation was based on user-occasion values and the commercial fishing valuation was determined by selecting vulnerable commercial fisheries landed in the impact areas.

Resource value ratios (Florida/Texas) and exposure ratios were also determined for the SEADOCK, Inc. offshore oil terminal. Here the conclusions were that the risk of damage to the Florida coastal environment is 2.1 to 10 times as great as the risk of damage to the coastal environment of Texas for commensurate values (beach use, boating, sportfishing and commercial fishing). Table 2.5 gives the estimated values in determining the resource value ratios for impact of the two terminals.



Table 2.5

Estimated Values of Selected Vulnerable Commensurate Resources for Florida, Texas and Louisiana, 1975 (U.S.\$ '000)

Resource	Florida	Texas	Louisiana
Beach Use	376 459	31 113	7 454
Boating	446 081	50 629	168 656
Sportfishing <sup>a/</sup>	526 530	168 022	69 900
Commercial Fishery Stocks	22 450	45 879	57 713
TOTAL	1 371 520	295 643	303 723

a/ Based on an average valuation of U.S.\$ 21.58/user-day

Source: U.S. Department of Commerce, Environmental Data Service, 1976

### 2.3 Fish Kills

Toxic levels of pollutants may act by themselves to cause mortality. Degradation of water quality may also increase susceptibility of the organisms to other causes of mortality and synergistic action between man-related pollution and naturally-caused aberrations may result in mortalities. Acting singly or in concert with other factors, pollutants can cause large numbers of organisms to die, more or less simultaneously, i.e., result in "fish kill".

The U.S. Environmental Protection Agency publishes compilations of fish kills throughout the United States from records submitted by the individual states. Such a "voluntary" reporting system has obvious faults but gives information on major fish kills and identifies the main affected areas and major types of pollutants. It can also be useful in establishing trends. However, the numbers reported will be underestimates of the actual total kill. In the Gulf of Mexico, Texas, waters have yielded the highest number of fish mortalities for the years 1973-1975. The data base for 1976 is not complete. In 1972-1974 the greatest cause for the kills was municipal works - sewerage. The largest, major fish kill in Gulf of Mexico waters occurred in the Houston Canal of Texas and involved 10 million fish.

The highest number of fish killed in this period was in 1973 with the monetary loss estimated at U.S.\$ 1.6 million. Texas alone accounted for U.S.\$ 1 million of the total. During 1975, fish loss value in this region was slightly more than U.S.\$ 1 million with Texas again having a loss of U.S.\$ 1 million. A survey of major pollutants and the fishery accounted with fish kills (Bell and Canterbury, 1976) found that in Texas the main pollutant source was petro-chemicals and the main fishery affected was the spotted seatrout. In Florida, municipal waste was the major pollutant and menhaden the fishery affected. Agricultural chemicals were the pollutant source in Alabama but affected no major fishery.

Bell and Canterbury(1976) conclude that fish kills are primarily random and due to local accidents (exceptions where trends were evident and not random were Alabama and Massachusetts).



The average value of U.S.\$ 0.10 per fish has been used by Tihansky (1973) in determining the value of commercial marine fishery losses due to water pollution. He reported that commercial fishery revenue loss in 1970 was U.S.\$ 6.95 million for the United States. It is obvious that values per fish would vary greatly and be dependent not only on species but numerous economic factors.

Bell and Canterbury (1976) cite the U.S. Federal Water Quality Administration estimate that two thirds of the fish killed have commercial value (Bale, 1971). If we use this ratio and a value of U.S.\$0.10 per dead fish counted, the pollution-caused fishery-revenue loss can be determined as follows for the Gulf states:

1973	U.S.\$	1 073 622	revenue lost
1974	U.S.\$	138 798	revenue lost
1975	U.S.\$	662 046	revenue lost

Table 2.6 summarizes the reported fish kills and their value for the Gulf states. The table was constructed from U.S. Environmental Protection Agency file records for 1974, 1975 and the first six months of 1976 and the publication, "Fish Kills Caused by Pollution in 1973" (issued 1975). Note: The fish kill file records reflect the difficulty in obtaining such information. Moribund fish may surface for counting, may sink to the bottom of the water body or may be removed from the area, making tallies difficult and/or inaccurate. Without timely and proper water analyses the determination of cause and source of the kill may be a matter of judgement. It is evident that extrapolation must be carried out judiciously.

#### 2.4 Dredging and Filling Activities

Dredging and filling operations are components of estuarine alteration. Filling activities are involved in the reclamation of wetlands for industrial or residential development. In the Gulf of Mexico filling and dredging is closely related to increased petrochemical activities to make use of land nearer to extractive aspects of the industry. It is anticipated that reclaiming low-lying and shallow submerged lands for housing, recreation, harbours and airports will also increase (U.S. Department of Interior, 1976). Filling operations are detrimental to living resources because of elimination of prime habitats (tidal flats, marshes and shallow submerged lands).

Dredging operations to deepen and improve harbours and shipping channels will also increase due to greater emphasis on deep-draught tankers and container bulk shipping. Development of more efficient dredging equipment and channelization for housing and recreational purposes will increase the impact of such operations. Dredging not only removes suitable substrate but alters water flow patterns and resuspends sediment particles thus changing water quality levels that will reduce or eliminate estuarine habitats. Dredging spoils disposed in the Gulf of Mexico amounted to 13 million tons (Lacy and Ray, 1974). On a national scale, studies have shown a 7.1% loss in estuarine areas has occurred from 1947-1966 (U.S. Commission on Marine Sciences, Engineering and Resources, 1969).

Estimates of the percentage of estuarine-dependent species in commercial catches vary from 63% for the U.S.A. generally (McHugh, 1966) to 97% in the Gulf of Mexico (Gunter, 1967). Using the 63% figure (Stroud, 1973) determined that for each acre of estuary that was removed from productivity there would be a corresponding loss on the continental shelf in biological production of 959 kg of finfish and a loss in yield of 226 kg of fisheries products (based on 1970 levels). The percentage of estuarine-dependent species in sport (recreational) catches has been estimated to exceed 90% (Stroud, 1973). Table 2.7 summarizes the loss and value of the loss due to dredging and filling of estuarine areas in the Gulf of Mexico. The loss has been calculated by multiplying the area lost by dredging and filling by the value per hectare, i.e., the value of that part of annual catch made up of estuary-dependent species, divided by the total area of important habitat.



Table 2.6

Fish Kills and Values - Gulf of Mexico Coastal Zone

Year	Location	Water Type	Number of Fish (1000's)	Cause	Value U.S.\$
1976 (6 months)	Alabama	Estuary	206	Low D.O.	
	Florida	Estuary	<u>242</u>	Not Given	
	1976 Total		448		
1975	Florida	Coastal	Unknown	Dredging	
	Mississippi	Estuary	30	Chemical	
	Texas (2)	Estuary	<u>10 031</u>	Low D.O	
1975 Total		10 061		1 006 100	
1974	Mississippi	Coastal	3	Sewerage	
	Texas	Estuary	710	Sewerage	
	Texas	Estuary	900	Unknown	
	Texas	Estuary	<u>10</u>	Unknown	
1974 Total		2 103		210 300	
1973	Texas	Estuary	10 000	Unknown	
	Texas	Coastal	3 800	Unknown	
	Texas	Coastal	1 000	Unknown	
	Texas	Coastal	100	Sewerage	
	Texas	Coastal	300	Sewerage	
	Texas	Estuary	100	Petroleum	
	Texas	Estuary	700	Poisons	
	Mississippi	Estuary	5	Sewerage	
	Alabama	Estuary	250	Sewerage	
	Florida	Estuary	1	Not given	
	Florida	Estuary	<u>1</u>	Not given	
1973 Total		16 267		1 626 700	
Grand Total			28 878		2 887 800

Source: U.S. Environmental Protection Agency, 1976 and file records



Table 2.7

Loss of Estuary Habitat due to Dredging and Filling Gulf of Mexico

State	Total Estuary Area (ha)	Area of Important Habitat (ha)	Area Lost by Dredging & Filling	Percent <sup>b/</sup>	Annual Catch Value/ha (U.S.\$)	Loss <sup>a/</sup> (U.S.\$ 1 000)	Reduction in Capitalized Value <sup>c/</sup> (U.S.\$ 1 000)
Florida (W. Coast)	212 342	160 832	12 059	(7.5)	175.50	2 116	21 404
Alabama	214 120	53 651	808	(1.5)	32.10	25.7	570
Mississippi	101 484	30 825	686	(2.2)	66.70	45.7	799
Louisiana	1 432 220	839 067	26 421	(3.1)	66.70	1 762	30 806
Texas	542 976	132 552	27 512	(8.2)	143.40	3 945	57 362
Totals	2 503 142	1 216 927	67 485			7 894	110 941

a/ 1973 prices in U.S.\$

b/ Number in brackets indicates percent of important habitat lost

c/ As calculated in studies cited

Based on a combination of: National Estuary Study, U.S. Department of Interior, 1970 and Tihansky and Meade, 1976. Economic Contribution of Commercial Fisheries in Valuing U.S. Estuaries

## 2.5 Closure of Mollusc Fisheries

Large areas of the estuarine complex in the Gulf of Mexico provide habitat for oysters - all fished for within 5 km of the coast. Oyster landings on the Gulf coast increased slightly in 1975 yielding 8 892 metric tons of meats (U.S. Department of Commerce, 1976, Fisheries of the United States, 1975).

The National Shellfish Sanitation Program monitors the water quality overlying the oyster beds. The coastal states' shellfish control agencies designate the water classifications and determine the boundaries. Generally classifications are based on, but not limited to, bacteriological standards. (Median value of total coliforms cannot exceed 70 MPN/100 ml.) Monitoring is also carried out for paralytic shellfish poison and other public health contaminants. In the eastern Gulf of Mexico (west coast of Florida) areas have been closed periodically as a result of "red tides" caused by dinoflagellate blooms. Some waters have been closed until further notice (classified here as "closed") and others that are closed periodically for any reason are categorized as "conditional". Bacteriological contamination is considered a result of discharge of run-off from areas of human habitation. No known closures, up till 1975, have occurred due to contamination of heavy metals or radionuclides.

Florida had the largest loss of available shellfishing grounds (45%) while Mississippi had the smallest closed area (7%). Table 2.9 summarizes the shellfish area classification for the Gulf States. (Data revised from U.S. Environmental Protection Agency, 1975. National Shellfish Register of Classified Estuarine Water, 1974.)

Since the areas closed are productive shellfish grounds (non-productive areas are also surveyed and classified) an estimate can be made of the value of shellfish lost through fecal coliform contamination. Louisiana led in oyster production (6 170 metric tons, 1975) and had the highest estimated loss, U.S.\$ 2.23 million, with Florida a close second with U.S.\$ 2.2 million estimated loss. Table 2.10 summarizes the estimated loss in value from closed oyster grounds (U.S. National Marine Fisheries Service, 1977. Comprehensive Review of Commercial Oyster Industries in the United States).

Table 2.9

Shellfish Area Classification in Hectares  
(U.S. Environmental Protection Agency, 1975. National Shellfish Register, 1974.)  
U.S. Portion of the Gulf of Mexico

State	Open	Conditional	Closed
Florida	267 902	33 975	414 086
Alabama	33 102	75 755	34 578
Mississippi	30 798		11 182
Louisiana	808 047		187 521
Texas	332 268		115 207
Total Area (hectares)	1 472 108	109 730	762 574

Open Waters: Approved by state agency for direct market harvesting  
Conditional: Meet "OPEN" standards but are subject to periodical closure  
Closed: Closed for harvesting of shellfish due to hazardous levels of contamination



Table 2.10  
Estimated Loss in Value from Closed Oyster Areas -  
U.S. Portion of Gulf of Mexico

State	Productivity Factor	Closed Area (ha)	Lost Weight (Metric Tons)	Price/kg (U.S.\$)	Annual Value Lost (U.S.\$ 1 000)
Florida	9.3	414 086	1 749	1.26	2 204
Alabama	26.9	34 578	422	1.98	836
Mississippi	26.9	11 182	137	1.08	148
Louisiana	16.8	187 521	1 429	1.56	2 230
Texas	5.4	115 207	282	1.08	304
Total Loss:					5 722

Productivity factor: 1975 production divided by 1975 open area (ha)  
Price/kg: 1975 ex-vessel prices used for each state

Source: U.S. Department of Commerce, National Marine Fisheries Service, 1977

## 2.6 Beneficial Aspects of Pollution

### Petroleum Extraction

There are conflicting reports and conclusions regarding the benefits accrued as a result of exploration and exploitation of offshore oil in the Gulf of Mexico.

Offshore sportfishing barely existed until the late 1940s. By 1970 over 220 000 metric tons of finfish were harvested in the Gulf of Mexico, over two million fishermen were involved and expenditures related to sportfishing in the Gulf exceeded U.S.\$ 400 million (U.S. Department of Commerce, 1976. Fisheries of the United States). What portion of this resource is directly related to the petro-chemical complex is not clear. Red snapper, spadefish and grouper were seldom caught in Louisiana waters before oil drilling platforms were erected. These artificial "reefs" attract fish, provide food from attached organisms and offer shelter (Gusey and Maturgo, 1974). Gulf Universities Research Consortium (GURC, 1974) reported that drilling operations have a negative localized effect on bottom fishes. Groupers and king whiting temporarily moved out of the drilling sites. In the same GURC Report, J.B. Thompson found no beneficial or harmful effects on shelf fauna resulting from exploration and extracting by oil platforms.

Each oil drilling platform occupies 0.5 ha and with a navigational safety zone around the platform of 1.5 ha each platform will take up 2.0 ha of substrate. 1972 figures show for the Gulf of Mexico, with an area of 6 879 000 ha out to the 1 900 metre depth, there were 7 575 offshore wells. The Gulf of Mexico has an area of nearly 7 million ha out to the 1 900 metre depth. The wells (platforms) with safety zone, occupy 15 150 ha or 0.002 percent of the trawlable substrate.



Thompson utilized bottom trawl data (1950-1965) of the north central Gulf of Mexico across the continental shelf off Louisiana. Both bottomfish and invertebrates (crabs, shrimp) were included and no trends were apparent in either quantity or distribution of the species studied. Fish species included croaker, sea catfish, sea trout and mullet. In the same study, GURC, 1974, it was reported that the drilling platforms showed an increase in biomass due to the reef effect when compared to other biotopes. The increase in biomass was due to the fouling organism community and the fishes that this community attracts.

Oyster culture was attempted on a petroleum platform 6 km offshore from High Island, Texas and compared to bay oysters. Mean biomass, length and growth of oysters from the platform was comparable to oysters from the estuary and the diversity of fouling organisms on the shells was greater offshore. Oysters from the bay completely depurated fecal coliforms within 7 days of their transfer to the offshore platform (Ogle, Ray and Wardle, 1977).

Comparing inshore and offshore reefs with oil drilling platform fish populations, Sommier *et al.*, 1976, found that many of the species common around the platforms also appeared on the inshore reefs. Of 49 species recorded from the platform, 19 were absent from the inshore reefs, 22 were absent from the offshore reefs and 12 species found only at the platforms. They found the fish fauna of the area was clearly tropical and comparable to Caribbean reefs. Vertical stratification was documented by Hastings *et al.*, 1976 at an offshore platform in the northeastern Gulf of Mexico. In the upper strata larger predatory species fed on the schools of forage species with typical benthic assemblages occupying the substrate below and the area immediately surrounding the platform.

Table 2.11 compares the biomass of an inshore site, an oil platform and a control site. Table 2.12 summarizes selected aspects of sportfishing activity in the Gulf of Mexico.

Table 2.11

Biomass Comparison of Selected Sites in the Northern Gulf of Mexico

Parameter	Inshore Bay (Timbalier Bay)	Oil Platform	Offshore Control
Organic Carbon in Water (g/m <sup>3</sup> )	8-14.5	5.8	5.1
Hydrocarbon in Water (mg/m <sup>3</sup> )	6.2	3.3	1.2
Hydrocarbons in Sediment (mg/100g)	161-341	145-412	145-412
Amphipods (g/m <sup>2</sup> )	8.75	24.2	17.7
Zooplankton (g/m <sup>3</sup> )	0.02-0.2	0.3	0.3
Platform Growth (g/m <sup>2</sup> )	Not applicable	3 000	Not applicable

Source: GURC, 1974



Table 2.12

Estimated Weight of Selected Sportfish Caught in the Gulf of Mexico, 1970

Species	Weight (metric tons)
Catfishes	22 590
Croaker	28 490
Black Drum	13 203
Red Drum	24 067
Groupers	7 648
Grunts	5 186
Kingfish	7 161
King Mackerel	12 458
Porgies	12 248
Seatrout	36 912
Sharks	7 111
Red Snapper	5 280
Total	182 354

Adapted from 1970 U.S. Marine Recreational Catch of Finfish, CFS no. 6900, 1975

Thermal Addition

Electric power plant condenser water discharge presents a new energy source with potential for aquaculture and reducing environmental control costs. Modern power plants release 1.5 to 2.0 units of heat to the atmosphere for every unit of heat converted to usable electricity with an efficiency rate of 35 percent. Annual waste heat available in the United States is approximately  $10^{16}$  Btu's (Bond, Geery and Russ, 1975).

A number of aquaculture pilot projects have been carried out in the Gulf of Mexico coastal zone utilizing heat discharged from power generation plants. Holt and Strawn (1975), cultured floating cages of finfish in the cooling lake of a power plant, Galveston Bay, Texas. Acute salinity changes adversely affected growth and survival of all species. One species, black drum, grew sufficiently for commercial production but did not adapt to prolonged low salinities and did not survive. Margraf (1977) held American oysters in the discharge canal of a Galveston Bay power plant. Growth rate was significant but the oysters suffered from disease and high summer temperatures proved to be lethal. Cage culture of finfish in heated effluent has had difficulty in overcoming gas bubble disease (GBD) mortalities. Supersaturation of atmospheric gases occurs during entrainment and with subsequent heating, the power plant effluent may exceed 120 percent total gas saturation during winter months. Experiments were carried out in the discharge canal of a steam-electric plant in Galveston Bay, Texas. Surface and submerged cages were utilized to evaluate hydrostatic

pressure as a remedy for GBD. Seven estuarine, commercially important finfish species were held in surface and bottom cages. Winter growth rates in the submerged cages surpassed those cultured at ambient temperatures. Eightyone percent survival was recorded in the bottom cages after 12 weeks. Surface cage survival was 4 percent after two weeks. Level of gas saturation was found to be reduced by 10 percent for each metre of depth. Organisms trapped on the intake screens were piped to the condenser effluent and served as an additional food supply. Higher winter effluent temperatures increased the growth of fouling organisms on the cages. No GBD was observed on species in the submerged cages but thermal death occurred during the summer months when temperatures ranged up to 40°C. Salinity shock also was detrimental and caused mortality in some species (spadefish). Velocity of the discharged effluent caused mortality in the young of some species (red drum fingerlings).



### 3. SOUTH ATLANTIC REGION

#### 3.1 Introduction

This region encompasses the southeastern coastal states bordering on the Atlantic Ocean. It extends from North Carolina, just south of the mouth of the Chesapeake Bay, to the island chain at the southern tip of Florida, the Florida Keys. The shoreward boundary of the states of North Carolina, South Carolina, Georgia, and the east coast of Florida are contained in this region. The shore area is marked by open and semi-enclosed embayments, drowned river valleys, barrier islands, tidal marshes and extensive wetlands on the coastal plain. Figure 4 illustrates the extent of the South Atlantic Region.

The ocean shoreline for this four state region is 1 917 km with the east coast of Florida possessing 49% of this shoreline. The bay/estuary shoreline is 12 955 km. Almost 50% of the total bay/estuary shoreline is within the State of North Carolina (5 367 km) with South Carolina containing 35% of this shoreline (4 627 km). Private ownership accounts for 68% of the ocean shoreline and 40% of the bay/estuary shoreline (U.S. Army Corps of Engineers National Shoreline Study, 1973).

The continental shelf ranges from a width of 33 km off Cape Hatteras, North Carolina, to a maximum width of 135 km off Georgia and then narrows gradually southward along the east coast of Florida. Lease areas along the shelf from Jacksonville, Florida (at the northern boundary of the state of Florida) to near the South Carolina - North Carolina border are scheduled for exploratory drilling sites because of the high potential of oil and natural gas reserves.

The estuarine system includes the embayments (primarily in the northern sections) coastal marshes and drowned river valleys. The estuarine area of this region is 1.4 million hectares. North Carolina with its extensive embayments contains 66% of the estuarine area (0.9 million ha). Major harbour estuaries such as Wilmington, North Carolina; Charleston, South Carolina; Savannah, Georgia; and Jacksonville, Florida are located on drowned river valleys. Miami, Florida, unlike the others, is located on an embayment (Biscayne Bay). The urban population centres and industrial developments on the coast of this region are located on these natural harbours.

Four major water masses have been identified in this region and the surface circulation patterns vary with the seasons. From shore seaward these masses are: Coastal Water, Shelf Water, Mixing Water, and North Atlantic Central Water. The coastal water exhibits large seasonal variation of both temperature and salinity. In winter there is a northerly drift from Georgia to Cape Hatteras (North Carolina) and a southerly flow along the Florida coast. During spring the southerly components are discontinuous and a northerly drift prevails over most of the shelf from Cape Canaveral, Florida northward. In summer the shelf currents are northerly and nearshore circulation is southerly. The dominant surface circulation pattern is one of southerly flowing coastal currents inshore of a predominantly northeasterly current.

Bottom currents off the Carolina Bays are northerly on the outer shelf and southerly near the coast. In Florida waters the drift is northerly but fluctuates from north to south (Bumpus, 1973). Such water mass circulation patterns tend to indicate that impact of riverine contamination could be widespread and also would increase the potential of onshore impact of oil spills resulting from outer continental shelf exploration and production.

Sources of pollutants in this region are associated with industrial and municipal wastewater discharges. Some point source discharges are into confined harbours or estuaries. Areas around the harbours of Charleston, South Carolina; Savannah, Georgia; and Jacksonville, Florida exhibited low dissolved oxygen levels partially due to pulp and paper-mill wastes. Because of extensive marshes and wetlands the natural waters of this region contain a high level of organic matter further reducing the natural oxygen levels (Wastler and Wastler, 1972). Ocean outfalls are also used for discharging wastewaters, especially in the southern



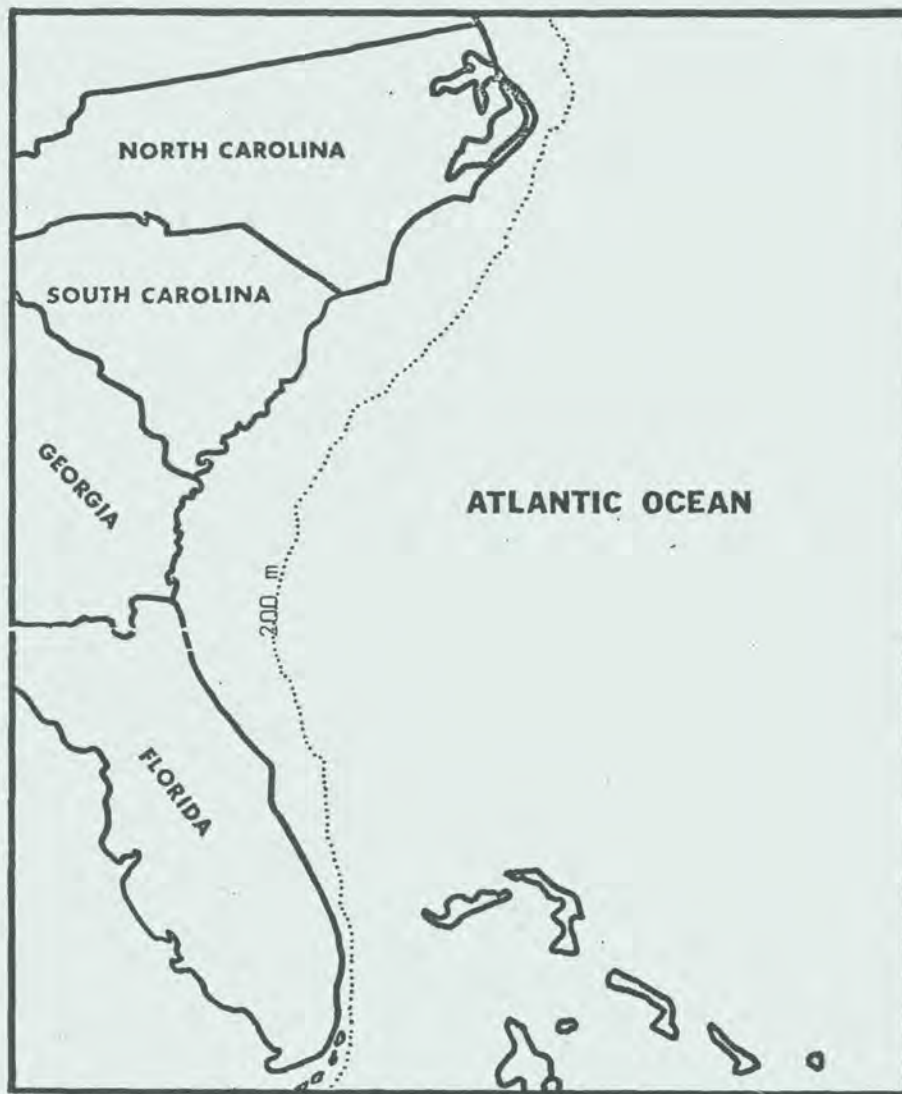


Figure 4. The South Atlantic Region



portion of this region. Some thermal addition, resulting from electrical power generation, is presently being discharged and proposed floating nuclear power plants situated in the coastal waters of this region would add to the thermal load. High nutrient loading (primarily nitrogen and phosphorus) of wastewater discharges are found locally throughout this region. Inadequate municipal wastewater treatment can and does cause high fecal coliform counts in the productive estuary ecosystem. The Environmental Protection Agency has approved 17 interim dump sites off the South Atlantic Coast. These dump sites are primarily for sand, shell and silt deposition. The approved dump sites are within 32 km of shore. A chemical waste dump site is located off Savannah, Georgia, approximately 80 km offshore.

An increased need for waterfront residential areas in Florida and recreational waterfront property along the South Atlantic shoreline has resulted in the urban development of shallow coastal areas and subsequent removal of estuarine area from marine resources productivity.

The South Atlantic region coastal zone, along with the extensive estuarine and coastal plain ecosystem contains extensive estuarine-dependent resources (approximately 400 species of fish) that support sizeable recreational and commercial fisheries. A South Atlantic angling survey was conducted by the National Marine Fisheries Service for the area from Cape Hatteras to the Florida Keys (Duel, 1973). The survey estimated that almost two million anglers landed over 180 000 metric tons of fish. The primary method of fishing was by private or rented boats and this was followed by bridge, pier or jetty fishing and party or charter boat. Beach or bank fishing was rated fourth in importance. The principal area of fishing was the ocean (59 percent of the fishermen) with sounds, rivers, and bays second in popularity. In 1975 commercial fishermen landed 142 000 metric tons of finfish and shellfish worth U.S.\$ 60.5 million (ex-vessel prices) in the southeastern Atlantic states. The greatest volume of landings were finfish, menhaden (used for reduction and industrial purposes) comprised 38-65 percent of the total volume, depending on the state. Shellfish only accounted for 20 percent of the total catch but made up 68 percent of the total value (U.S.\$ 40 million). Shrimp are the most valuable fishery resource for this region. In 1975, 7 percent of the total U.S. landings of shrimp and 13 percent of their total U.S. value was landed in the Southeast Atlantic states. In 1975, North Carolina led the states in this area in total landings (73 percent) and also led in value of catch at U.S.\$ 20 million. Table 3.1 summarizes landings and value of commercial marine catch for South Atlantic States for 1975 (source of landing and value data, U.S. Department of Commerce, 1976 and individual state summary).

In the South Atlantic region over 50 species of finfish and 11 species of invertebrates are landed. The most important (based on landings) finfish species, ranked in decreasing landing levels, are menhaden, flounder, spot alewives, mullet, grey sea trout, croaker, thread herring, king mackerel and bluefish. The major shellfish species, ranked in decreasing landing levels, are blue crab, shrimp, spiny lobsters, oysters, calico scallops and hard clams.

Table 3.1  
South Atlantic Region

Landings (1 000 Metric Tons) and Value (U.S.\$ 1 000)  
of Commercial Marine Catch, 1975 (Preliminary)

State	Finfish		Shellfish		Total Finfish & Shellfish	
	Landings	Value	Landings	Value	Landings	Value
N. Carolina	96.5	11 964	7.8	7 194	104.3	19 158
S. Carolina	1.4	507	7.5	12 488	8.9	12 995
Georgia	0.3	234.5	7.7	11 669	8.0	11 903
E. Coast Florida	15.8	6 777	5.2	9 613	21.0	16 390
Total	114.0	19 482.5	28.2	40 964	142.2	60 446

Source: Individual State Summary and U.S. Department of Commerce, 1976. Fisheries of the United States, 1975. Current Fisheries Statistics No. 6900



### 3.2 Oil and Gas Exploration and Production

No oil is currently produced in the region, but major production is planned following the proposed sale and development of oil and gas tracts off the southeast United States. The predicted effects of this development have been reviewed in the Draft Environmental Impact Statement for Oil and Gas Lease Sale No. 43, U.S. Department of Interior, 1976. In this area, the Southeast Georgia Embayment, a total of 299 524 ha located approximately 48 to 120 km offshore from South Carolina, Georgia and Florida and in water depths of 13 to 165 m will be offered for lease sale. The area's projected recoverable resources range from 0.28 to 1.0 billion barrels of oil (one barrel equals 159 l) and 50 to 190 billion m<sup>3</sup> of gas. The lower figures are based on a low resource estimate and the higher figures are based on a maximum projected recovery. Peak daily oil production could be between 56 and 170 thousand barrels. Development and production life of the project is estimated to be 25 years. There will be between 255 and 720 wells and between 10 and 25 working platforms.

Onshore impact will be primarily at Charleston, South Carolina and Jacksonville, Florida (44 to 108 ha for onshore facilities) and transport of oil will be by tanker up to 70 000 barrels/day and pipeline installations will occur if production is above the tanker volume (257 to 515 km of 61-91 cm diameter pipeline). No refinery is expected to be constructed since crude oil will be handled by existing facilities.

Projections have been made of civilian employment for a series of options depending on yields and onshore activity. Initial employment for high recovery level would be low (585 persons) while exploratory drilling is taking place. Maximum employment would take place 12 years after onset of exploratory drilling and would produce 4 203 jobs in South Carolina and a total of 7 818 jobs in the four state area. Maximum total population increase to the area is estimated to be 10 800 persons, with no county receiving more than 5 000 persons. The average annual royalties for oil and gas lease production will range from U.S.\$ 35.7 to 125 million. Gross value of oil and gas will range from U.S.\$ 5.0 to 17.9 billion (based on U.S.\$ 11/barrel and U.S.\$ 1/MCF). The average annual operating costs will range from U.S.\$ 63 to 236 million. It should be noted that values presented are estimates and are based on resource projections and the present economic conditions.

Petroleum hydrocarbon associated pollution will impact on the environment in three general ways: chronic input of hydrocarbons and associated drilling brines; direct physical damage due to pipelines and onshore construction; and indirect physical alteration by erosion of wetlands.

Oil spills are one of the major elements of environmental impact in the exploration and production of offshore oil. Because there is no present production taking place in the South Atlantic, probability and trajectory models have been developed based on incidents occurring in other areas of production (Gulf of Mexico) and estimated production in the area. From such models the potential volumes of oil, direction of movement and resources affected have been determined. At least one major spill (>1 000 barrels) has a 96% probability of occurring in the South Atlantic lease area, and possibly three may occur. Sixteen to thirty-two medium spills (between 50 to 1 000 barrels) have more than a 99% possibility of happening during the 25 years of production. Minor spills (<50 barrels) from platforms and pipelines could number over 2 000 at a probability greater than 99%. Table 3.2 summarizes estimated oilspill frequency by source for this lease area.

The volume of oil spilled by pipeline accidents in the Gulf of Mexico accounts for 0.0014% of total production. If we apply this percent to estimates of oil resources in the South Atlantic, then approximately 4 000 to 14 000 barrels might be spilled in this area. Due to low total resource estimates, economic considerations, and relative drilling tract positions, it is likely that tankers will be used instead of pipelines. Tanker oil spillage during the field life of production is estimated to be 1.27 to 4.56 million barrels.

A trajectory model, using wind and current data, was developed to analyse movement and point of arrival on the shoreline. According to the Environmental Impact Statement cited



above, 44% of the spills trajected ashore on the Florida coast, 3% on the Georgia shore, about 12% on South Carolina, and about 23% on the North Carolina coast. Major ocean front recreation sites are located in areas where spills are most likely to reach the shore.

Commercial fishing grounds have a 95-97% probability of being affected by one or more major spills. Commercial scallops, crabs, and oysters have a 43-65% probability of being affected. Shrimp have a 62-69% probability of impact. Trawling operations will be hampered in a minor way. Platforms occupy about 0.4 ha and up to 101 ha in this lease area will be unavailable to trawlers. This area amounts to less than 2 percent of the total lease area. Oil spills may also physically prevent fishing or may affect the fisheries sublethally to reduce productivity. Estuarine areas have a 55-62% probability of suffering from a major oil spill. It should be noted that if a spill occurs less than 16 km from a resource there is insufficient time to effect clean-up operations.

Table 3.2

Predicted Oil spill Frequency in South Atlantic Lease Area No. 43 during expected 25 year production period

Volume and Source	Expected Number	Probability of at least One Spill
a) Spills >1 000 barrels		
Platforms	1.5	0.78
Pipelines	1.7	.81
Tankers	2.2	.89
Platforms and Pipelines	3.2	.96
Platforms and Tankers	3.8	.96
b) Spills: 50-1 000 barrels		
Platforms and Pipelines	32	> 0.99
Tankers	16	> .99
c) Spills: 0-50 barrels		
Platforms and Pipelines	2 338	> 0.99
Tankers	277	> .99

Source: Draft Environmental Impact Statement for Oil and Gas Lease Sale, South Atlantic OCS Sale No. 43, U.S. Department of Interior, 1976

### 3.3 Fish Kills

In addition to the nationwide reports (see 2.3) supplemental information on fish kills in this region is available from the states (e.g., biennial report from the Department of Natural Resources, State of Florida 1977) and universities (Fish Pathology Project, University of Miami Sea Grant Program, Florida, personal communication, 1977). For the years 1973-1976 the east coast of Florida (Atlantic Coast) had a total of 45 000 fish mortalities. Low dissolved oxygen is cited as the primary cause for those kills for which a probable cause has been determined. Though the reason for the low dissolved oxygen was usually not clearly stated, low values are associated with increased biochemical oxygen demand resulting from wastewater effluent and nutrient run-off. Generally values of dissolved oxygen below 2 parts per thousand are not conducive to species propagation and survival. None of the other states in the South Atlantic region reported estuarine or coastal water fish kills although all states reported numerous freshwater kills during



the 1973-1976 period. No major kills occurred (according to the Environmental Protection Agency, a major kill is one involving more than 100 000 fish) in the entire region in the years 1973-1976. A major kill was stated to cause a loss of U.S.\$ 2 million in the vicinity of Jacksonville, Florida, in 1970 (Tihansky, 1973).

In a survey of coastal state Water Quality Administrators, conducted by Florida State University, information was obtained on the major pollutants and the fishery associated with fish kills (Bell and Canterbury, 1976). In North Carolina the major pollutant is paper mill wastes and its effect is not restricted to a particular fishery. South Carolina reported the prime pollutant source is run-off containing pesticides and the fish affected are shad and menhaden. The state of Georgia's primary pollutant source is municipal wastes and the impact is on shellfish. Florida also cites municipal waste as the major pollutant resulting in fish kills and menhaden the fishery most affected.

The monetary loss caused by fish kills was estimated using the methods of Bell and Canterbury (1976) and Tihansky (1973). If we assume two thirds of the fish killed are of commercially valuable species, and the value of 10 cents per fish, the value of fish lost through kills from the South Atlantic region is U.S.\$ 3 000. Table 3.3 summarizes the fish kills and their values for the South Atlantic states. The table was constructed from Environmental Protection Agency file records, State of Florida 1975-1976 report, and fish kill records from the University of Miami Sea Grant Fish Pathology Project.

Table 3.3  
Fish Kills and Values - South Atlantic States Coastal Zone

Year	Location	Water Type	Number of Fish Killed (1 000's)	Probable Cause	Value (U.S.\$) <sup>a/</sup> (1 000's)
1976 (Not Complete)	Florida	Estuary	2.5	Low D.O.	
	Florida	Coastal	2.0	Unknown	
	Florida	Estuary	10.0	Unknown	
	Florida	Estuary	1.0	Low D.O.	
	Florida	Estuary	1.0	Chemicals	
	Florida	Coastal	5.0	Unknown	
	Florida	Estuary	1.0	Low D.O.	
1976 total			> 22.5		1 500
1975	Florida	Estuary	5.4	Unknown	
	Florida	Estuary	5.0	Unknown	
	Florida	Estuary	2.0	Low D.O.	
	Florida	Coastal	5.0	Unknown	
	Florida	Estuary	2.1	Chemicals	
1975 total			19.5		1 300
1974	Florida	Estuary	1.0	Sewerage	
1974 total			1.0		67
1973	Florida	Estuary	2.0	Not Given	
1973 total			2.0		133
1973-75 total			45.0		3 000

<sup>a/</sup> Assuming two thirds of the fish are commercially valuable, worth 10 cents each



Table 3.4  
 Loss of Estuary Habitat due to Dredging and Filling  
 South Atlantic Coast of United States

State	Total Estuary Area (ha)	Area of Important Habitat (ha)	Area Lost by Dredging & Filling (ha)	Annual Catch <sup>a</sup> / Value/ha	Loss (U.S.\$)	Reduction in Capitalized Value (U.S.\$)
North Carolina	891 466	320 654	3 232 (1.0) <sup>b</sup>	37.64	122	2 127
South Carolina	173 150	108 837	1 737 (1.6)	75.22	131	2 258
Georgia	69 003	50 500	323 (0.6)	145.49	47	470
Florida East Coast	212 342	160 832	12 059 (7.5)	64 20	774	13 542
Total	1 558 303	640 823	17 351 (2.6)		1 074	18 397

a/ Value determined by: 1. From published value, when available or  
 2. Landings, ex-vessel value (1975) x 0.63

= value/ha

b/ Number in ( ) indicates percent of Important Habitat lost

Based on a combination of: National Estuary Study, U.S. Department of Interior, 1970, and  
 Tihansky and Meade, 1976, Economic Contribution of Commercial  
 Fisheries in Valuing U.S. Estuaries



### 3.4 Dredging and Filling Operations

There are fifteen dredge projects to improve and maintain shipping and recreational navigable waters (the latter is the Intercoastal Waterway). Dredging to maintain these channels removes  $20 \times 10^6$  m<sup>3</sup> of material each year, half of it at four major dredging sites in South Carolina. Charleston Harbor requires  $6.5 \times 10^6$  m<sup>3</sup> dredging at a cost of U.S.\$ 4.75 million. Dredge spoils are either dumped at sea or removed to diked areas. A Charleston Harbor deepening project will generate  $20 \times 10^6$  m<sup>3</sup> of additional dredge spoils. The state of Georgia also has four major dredging areas with total removal amounting to  $7.3 \times 10^6$  m<sup>3</sup>. Savannah Harbor alone produces  $5.3 \times 10^6$  m<sup>3</sup> with 85% of this spoil being deposited in five major disposal areas in the harbour, ranging from 40-124 ha in extent. North Carolina has two dredging operations to maintain harbour shipping channels with a total annual production of spoils at  $1.37 \times 10^6$  m<sup>3</sup>. The material, composed of shell and sand is deposited offshore in a water depth of 12 m. The east coast of Florida has numerous local dredging activities with five major operations with dredge spoil removal totaling  $1.04 \times 10^6$  m<sup>3</sup>. In Florida, spoils are deposited offshore, in diked areas, or are used as beach nourishment. Removal costs for Jacksonville Harbor, with  $0.38 \times 10^6$  m<sup>3</sup>, is U.S.\$ 784 000 (U.S. Army Corps of Engineers, 1976, cited in Department of Interior, Environmental Impact Statement, Oil and Gas Lease Sale No. 43, 1976). Increases in the size of cities result in increased development of shoreline properties for both private and commercial uses. Although localized, the drainage, filling and bulkheading for stability, remove bottom land from inshore productivity, change flow patterns and contribute to water quality degradation. North Carolina has sizeable agricultural developments in coastal locations which required drainage and filling. Run-off from this activity could add to estuarine degradation.

Recreational fishing in this region is part of a major industry. Both residents and tourists utilize estuarine and nearshore locations for sport-fishing and in the state of Florida this industry earned U.S.\$ 175 million (Taylor *et al.*, 1973 and Florida Department of Natural Resources). Estimates of participation and of the number of user-days vary. Drel (1973), gives values of 1.8 million saltwater anglers in 1970 for the area from Cape Hatteras, North Carolina to the Florida Keys with a total landing estimated at 183 000 metric tons. A value of 4.4 million man/days engaged in saltwater fishing in 1971 for the state of Florida was cited by the Department of Interior, Bureau of Land Management, 1976.

It was stated in a previous section (2.4) that estimates of the portion of estuarine-dependent species that contribute to commercial landings vary from 63% to 93% of the total catch. Each estuarine acre has been estimated to provide nursery grounds or other support for fish which when caught weigh 226 kg (Stroud, 1973). Blue crab and shrimp (two species absolutely estuarine-dependent) dominated shellfish landings of all states in the region, making up in North Carolina, 94%; South Carolina, 94%; Georgia, 94% and east coast of Florida, 60% of the total shellfish landings. Table 3.4 summarizes the loss and value of the loss due to dredging and filling in the South Atlantic states. Value per hectare is based on either published values or the unit value is derived as a ratio of 1975 ex-vessel landing value, adjusted to a 63% estuarine dependency, to the area of important habitat. Losses are greatest for the Florida east coast, followed by South Carolina, North Carolina and Georgia.

### 3.5 Shellfish Area Closures

The northern section of this region (North Carolina and South Carolina) with its barrier islands, low-lying tidal marshlands, and extensive estuarine habitat provides a good habitat for molluscan shellfish production that is more suitable than Georgia and the east coast of Florida. This northern section contains 77% of the region's bay/estuary shoreline, 95% of the open shellfish area and accounted for 92% of the oyster production and 86% of the hard clam production for the region in 1975. Hard clams and oysters are harvested within 5 km of shore (data derived from state summaries, U.S. Department of Commerce and Fisheries of the United States, 1975). The production of oyster meat in 1975



was 719 metric tons, down from 835 metric tons in 1974. The value of oyster landings in 1975 was U.S.\$ 1.05 million compared with U.S.\$ 1.22 million in 1974. Reductions in landings ranged from 7 percent (South Carolina) to 32 percent (Georgia).

Table 3.5 summarizes the shellfish area classification for the southeastern United States coastal Atlantic region (data revised from the U.S. Environmental Protection Agency, 1975 National Shellfish Register of Classified Estuarine Waters). (See section 2.5 for definitions of classification and discussion of monitoring programmes.)

During the four years between the latest 1975 National Shellfish Register and previous Register (1971) the state of Georgia experienced the largest percentage of change in classified water. A total of 29 909 hectares (36 percent of the total shellfish area) was removed from the open category and closed. Presently 75.7 percent of the shellfishing areas in Georgia are closed to harvesting. On the other hand the closed areas in South Carolina changed by less than 1 percent in the four years. In terms of actual size of the closed areas North Carolina is worst off, with almost a quarter of a million hectares closed to shellfishing. North Carolina reassigned 32 320 ha from open to prohibited status during the period 1971 to 1975. South Carolina, with the largest oyster production, 470 metric tons, has the largest percentage of area open to harvesting, 72 percent.

Using the same procedures as in section 2.5, the losses due to closing contaminated areas have been estimated. Table 3.6 summarizes the estimated losses from closed oyster grounds for the South Atlantic states (based on: U.S. Department of Commerce, 1977, Draft of Comprehensive Review of Oyster Industries in the United States). Because of their high productivity indices or large closed areas, North Carolina and South Carolina exhibited the highest losses due to shellfish closures. The total estimated lost revenue due to reduction in shellfish harvesting area is U.S.\$ 0.58 million or 48 percent of the actual value of oyster landings for the South Atlantic region.

Table 3.5

Shellfish Area Classification in Hectares  
(U.S. Environmental Protection Agency, 1975, National Shellfish Register)  
South Atlantic States

State	Open	Conditional	Closed	% Open	% Condit.	% Closed
N. Carolina	558 528		244 550	65.2		28.5
S. Carolina	80 698	544	30 331	72.3	0.5	27.2
Georgia	20 038		65 540	24.3		75.7
Florida (E. Coast)	8 949	1 135	13 832	37.0	0.05	58.0
Total Area (Hectares)	668 213	1 679	354 253			

Open Waters: Approved by State agency for direct market harvesting

Conditional: Meet "OPEN" standards but are subject to periodical closure

Closed: Closed for harvesting of shellfish due to hazardous level of contamination



Table 3.6  
Estimated Loss in Values from Closed Oyster Areas  
South Atlantic States

State	Productivity Factor	Closed Area (ha)	Meat Wt. (Metric Tons)	Price/kg (U.S.\$)	Value Lost (U.S.\$ 1 000)
N. Carolina	0.8	244 550	89	1.72	153
S. Carolina	12.8	30 331	176	1.30	228
Georgia	2.2	65 540	65	1.28	83
Florida (E. Coast)	8.9	13 832	56	2.14	120
Total Loss					584

Productivity factor: 1975 production divided by 1975 Open Area (ha)

Price/kg: 1975 ex-vessel prices for each state

Source: Draft of Review of Commercial Oyster Industries in the United States, National Marine Fisheries Service, Washington, D.C., 1977

### 3.6 Beneficial Aspects of Pollution

#### Dredge Spoils

Dredging activities and dredge spoils can be used to create or enhance recreational facilities. There are several examples of beneficial uses of dredge spoils in this region, but the effects on fish or fisheries are small.

#### Artificial Reefs and Oil Platforms

In inshore areas where substrate is barren sand and silt with a relatively flat profile (large inshore areas of North Carolina and sections of South Carolina, Georgia and Florida) the addition of artificial fishing reefs made of various waste materials has increased recreational fishing activity. Rehabilitation of areas that have become unproductive due to pollution such as dumping of waste materials, thermal addition, or dredging operations may be enhanced by artificial reef placement. Materials used for reefs include scrap tyres, surplus ships, car bodies and concrete culverts. Such reefs exist off North Carolina (3), South Carolina (6), Georgia (4) and Florida (8). These 21 artificial reefs in the South Atlantic are predominately constructed of scrap tyre units and contain slightly more than 250 000 tyres (Stone, Buchanan, and Steimle, 1974). In studying a scrap tyre reef in the Biscayne National Monument, in the Upper Florida Keys, it was found that biomass is increased by the placement of the artificial reef (Richard Stone, Personal Communication, 1977). Randall (1963) found that artificial reefs in the Virgin Islands provide protection, food sources, spawning sites and orientation for fishes and that these reefs attract fishes from adjacent areas and increase some populations because of added protection and food. He found that 28 months after installation the standing crop of fishes on the artificial reefs was 11 times that of an adjacent natural reef.

An inshore artificial reef, 5 km from Murrels Inlet, South Carolina, was evaluated for impact on the marine sportfishery and local economy (Buchanan, 1973). From this survey it was estimated the artificial reef received approximately 35 percent of the offshore angler-hour effort and harvested nearly 40 percent of the catch, although the artificial reef occupied an area of only 0.02 km<sup>2</sup> while the natural bottom habitat area was 57 km<sup>2</sup>.



Non-resident anglers who fished in the ocean spend U.S.\$ 36 000 during the summer in the area, and 10 percent of this expenditure was by anglers who would not return if the artificial reef did not exist. In a later study of the same area (Buchanan, 1974) two artificial reefs were evaluated, the second being installed after the 1973 survey report. Anglers caught more fish from the artificial reefs than the natural bottom in all but two months of the summer season and caught more overall from the two reefs (54%). Private boat anglers expended 66 percent of their time over the reef area and the fishing intensity (angler hours per sq unit of area habitat) on the reefs was almost 6 000 times that on live bottom. Bottom fishing efforts doubled between the two years of the survey but pelagic fishery success did not increase. It is evident that the artificial reefs increased bottom fishing opportunities and success.

The South Atlantic region, unlike the Gulf of Mexico, has no active or expired lease areas for exploration and production of oil and natural gas on the continental shelf. The effects of oil platforms on fishing productivity are discussed in the Gulf of Mexico section (2.2).

The oil and gas lease sale area as described in a previous section extends roughly from the Florida-Georgia border to off Charleston, South Carolina. It involves some 300 000 ha and will contain from 10 to 25 platforms. In the open sea such platforms will provide food and protection and serve as artificial reefs. Each platform will have a surface area of about 0.8 ha and its high profile will provide habitats for a variety of organisms. The platforms are quite visible and easily located. However the tracts in the South Atlantic Lease Sale No. 43, extend from 50 to 120 km offshore in water depths from 20 to 200 m. Considering time and safety factors involved in the predominately small boat recreational fishery, the sportfishing effort due to platforms acting as artificial reefs will be minimally affected (Draft Environmental Impact Statement, Proposed 1977 Outer Continental Shelf Oil and Gas Lease Sale, South Atlantic Sale No. 43, U.S. Department of Interior, 1976). Deep-sea fishing charter boats and other boats suitably equipped may find the platforms attractive after suitable colonization by sportfish species. Shinn (1974) reported that "hundreds of small boats" fish at the established platforms 48 km from shore in the Gulf of Mexico.

#### 4. MIDDLE ATLANTIC REGION

##### 4.1 Introduction

For the purposes of this report the region extends from the Atlantic shore of Long Island, New York, to the southern shore of the mouth of Chesapeake Bay (see Figure 5). The surrounding land mass includes the southern shore area of Long Island and the remainder of New York, and the states of New Jersey, Delaware, Maryland and Virginia. The shorelines, excluding barrier islands, total 5 414 km, including 4 283 km in Chesapeake Bay. Approximately 51 percent of the shoreline is privately owned (2 760 km) and the remainder (2 600 km) is government-controlled for recreation and fish/wildlife uses. A wide continental shelf ranges from approximately 200 km wide in the north to 125 km off the mouth of the Chesapeake Bay to the south. This shelf extends seaward to a water depth of 100 to 200 m and is cut by a number of submarine canyons (Hudson, Wilmington, Baltimore, Washington and Norfolk canyons). The estuarine system includes the Hudson River estuary, Delaware and Chesapeake Bay and the coastal zone behind the banks and barrier islands that exist throughout the region, with a total area of some 1.7 million ha.



Figure 5. The Middle Atlantic Region



Delaware Bay is an extensive estuary system extending 209 km from the tidewater area to the mouth. This bay varies in width from 2 to 45 km and is extensively utilized for industrial transportation. About 40 000 ha of swamp and marshland are along the shore. Chesapeake Bay, the largest estuarine system in North America, extends some 310 km in length and is from 5 to 40 km in width. The surface area of the Chesapeake and its tributary estuaries is  $11.5 \times 10^9 \text{ m}^2$  and its mean tidal range is 1.25 m.

Three water masses are evident in the Middle Atlantic Region. Over the continental shelf is the coastal or shelf water mass. Further from shore and over the slope is the slope water mass. Furthest from shore and on a northeast axis is the Gulf Stream. The shelf water mass experiences large seasonal fluctuations and receives input from the river run-off, land drainage and atmosphere (Fisher, 1973). Its general flow is southerly. The shelf waters have been described as a two-celled system (Bumpus, 1973). The northern cell extends from Nantucket where it receives offshore input along the southern shore of Long Island, and then turns offshore east of the Hudson Canyon. Bottom water circulation tends to flow inshore. The southern cell runs from Hudson Canyon south to Cape Hatteras. It receives inflow from rivers and bays along the coast. Near Cape Hatteras the southern cell turns offshore. Cyclonic eddies are found off the northern New Jersey coast. The slope water mass currents flow in a southerly direction to Cape Hatteras. At Cape Hatteras the currents turn seaward. Slope water circulation in general is cyclonic but does possess warm anti-cyclonic eddies thought to be components of the Gulf Stream. Some characteristics of slope water fall between shelf and Gulf Stream water. The Gulf Stream, formed offshore of the South Atlantic states, runs parallel along the continental land mass and in the area of Cape Hatteras veers offshore and eastward toward Europe. Although generally stable, the Gulf Stream does meander north and south of its main axis. Inshore directed eddies may break off the main body of the Gulf Stream and form warm anti-cyclonic gyres. Summer surface circulation is depicted in Figure 6.

Water pollution problems of this region are directly related to the high concentration of urban population and industry with New York City water receiving the greatest amounts (U.S. Department of Interior 1976). Heavy manufacturing and primary metal industries along with petro-chemical complexes contribute industrial waste effluents to the estuary systems and coastal waters. Unlike the Gulf of Mexico and the South Atlantic region, off-shore oil production is not carried out, or planned for the immediate future. Because of contaminant levels (PCB's) striped bass and American shad fishing was restricted, especially in the Hudson River system. In 1973, landings of American shad in New York State were 71 metric tons worth, a value of U.S.\$ 51 000. In 1974, landings were 0.16 metric tons with a value of U.S.\$ 85 and in 1975 there were 0.12 metric tons with an ex-vessel value of U.S.\$ 46. In other states of the region, value of shad landings increased. Municipal sewage discharges from large population centres (New York City, 7.9 million people; Philadelphia, 1.9 million people; Baltimore, 0.91 million people; Washington, 0.76 million people) also constitute a major input to the coastal waters. Long Island has a population density of 13 721 people per  $\text{km}^2$ . Atmospheric fall-out from air masses over population centres and industrial complexes provide sizeable loads. Organic waste load from non-industrial and industrial sources is a contributor to degradation (EIS, Oil and Gas Lease No. 40, Mid-Atlantic States, U.S. Department of Interior, 1976). Energy production with subsequent thermal discharges may present local water quality alteration problems.

Two clusters of dump sites exist in the Middle Atlantic region. The primary dump sites in the New York Bight receive sludge, acid wastes, dredge spoils and construction debris. Further details are given under appropriate sections for this region. Sludge deposit sites off the southern New Jersey coast and a proposed deeper water dump site also contribute to changes in water quality and its subsequent effect on marine resources. Extensive shipping tonnage into industrial complexes and transportation centres with the resultant traversal of bays, rivers, and estuary systems also could be considered an input to water pollution problems.



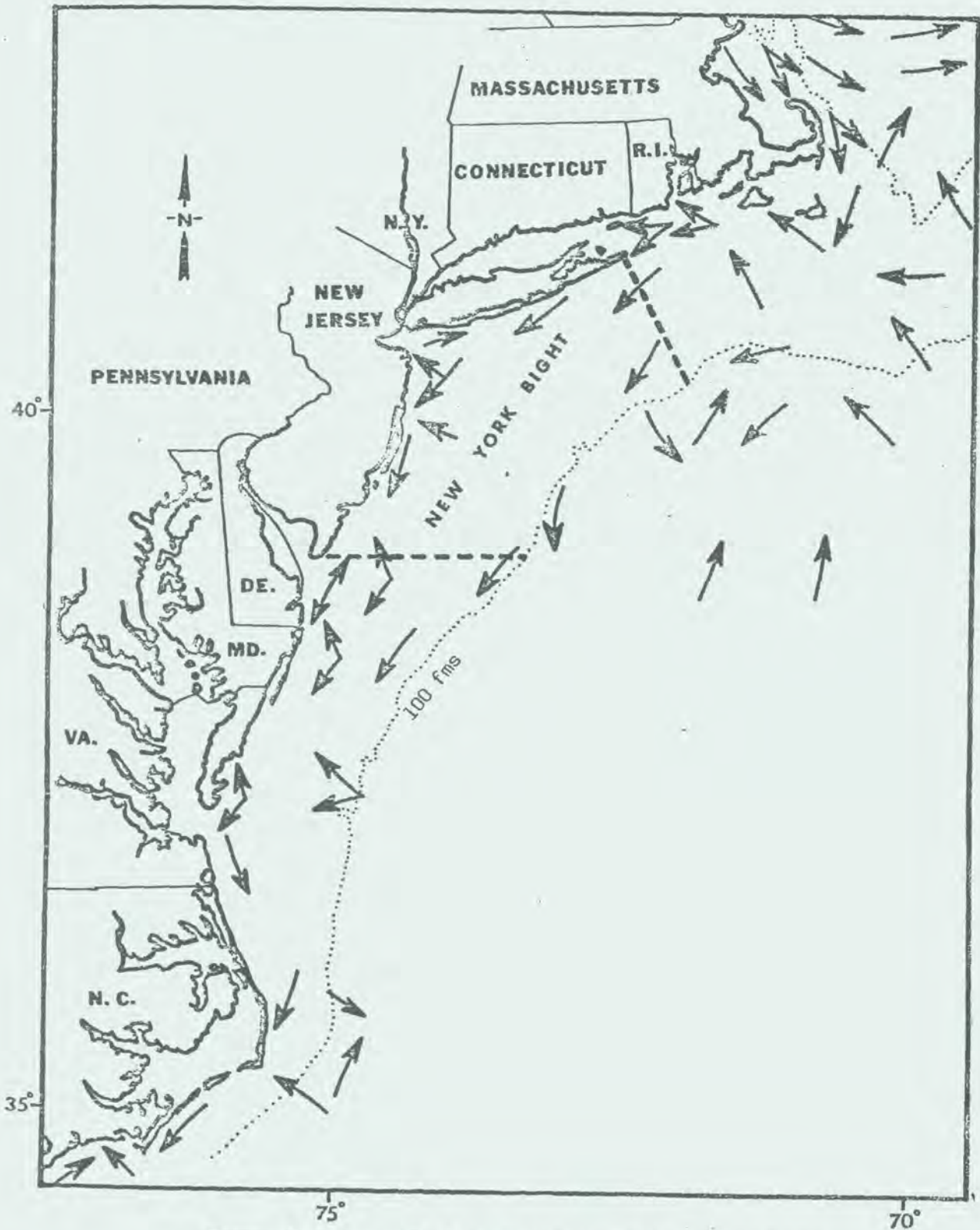


Figure 6. Summer Surface Circulation Mid-Atlantic Bight (after Bumpus and Lauzier, 1965).



The Middle Atlantic region coastal zone, along with the large estuarine system (Hudson, Delaware and Chesapeake) supports extensive estuarine-dependent resources that are of importance to recreational and commercial fisheries. For the latest year of available data 6.6 million (1973-1974) marine recreational fishermen in the states of this region landed 111 000 metric tons of finfish (U.S. Department of Commerce, 1976). In 1975 commercial fishermen landed, in the Middle Atlantic states, 187 000 metric tons of fish and shellfish with U.S.\$ 96.8 million (ex-vessel prices). A substantial portion of this marine catch was for industrial and reduction use as fish oil, solubles, and fish meal. Table 4.1 summarizes landings and values of commercial marine catches in 1975.

Over forty species of finfish and 13 species of invertebrates are landed. The most important finfish species, ranked in decreasing volumes of landings, are menhaden, flounders, gray sea trout, scup or porgy, striped bass, whiting, alewives and croaker. The major shellfish species, ranked by volume, are surf clams, oysters, blue crabs and hard clams.

Table 4.1  
Middle Atlantic Region  
Landings (1 000 Metric Tons) and Value (U.S.\$ 1 000)  
of Commercial Marine Catch, 1975 (Preliminary)

State	Finfish		Shellfish		Total Finfish & Shellfish	
	Landings	Value	Landings	Value	Landings	Value
New York	8.8	5 070	7.9	23 047	16.7	28 117
New Jersey	45	8 566	20	11 239	65	19 805
Delaware	0.4	200	2.8	1 426	3.2	1 626
Maryland	6.3	1 975	22	20 313	28.3	22 288
Virginia	36	5 881	38	19 122	74	25 003
Total	96.5	21 692	90.7	75 147	187.2	96 839

Source: Individual State Summary and U.S. Department of Commerce Current Fisheries Statistics No. 6900, 1976

#### 4.2 Kepona Pollution

One of the tributary systems on the western shore of Chesapeake Bay is the James River. Illness among workers at a Kepone (chlordecone) production plant on this river caused the plant to be closed in the summer of 1975. Kepone, a pesticide, was found to be both an atmospheric and aquatic pollutant in the James River basin, extending to the mouth of the Chesapeake Bay. Fishing was banned in the basin after high residue values were found to exist in both the freshwater species upriver and the marine species of commercial importance. The ban on harvesting most commercial species was issued in December 1975, extended in June 1976, and was to have been lifted 31 December 1976. In March 1977, the ban was extended to July 1977, for all shellfish and finfish with the exception of catfish, male hard crabs (primarily blue crabs), shad, herring and turtles (freshwater). Shad and herring will be subject to continual residue analysis and the fishery may be closed if action level for Kepone is exceeded. Levels of Kepone not to be exceeded under the original closure order were: finfish - 0.1 ppm; shellfish (clams, mussels, oysters) - 0.3 ppm; crabs - 0.4 ppm. In March 1977, the allowable Kepone level in finfish was raised to 0.3 ppm while the remaining allowable species action levels remained the same (Emergency Rule, Virginia State Board of Health, 1977). Finfish and blue crabs had higher Kepone residuals than clams and oysters. Levels of Kepone in finfish range from 0.02 to 14.4 ppm. Oysters and clams had



lower residuals of the species tested, ranging from 0.21 to 0.81 ppm. Oysters contained the lowest Kepone levels of all species tested at 0.22 to 0.29 ppm. It should be noted that the standard deviation of residue levels reported may be an order of magnitude from the mean (O'Mara and Reynolds, 1976).

Action levels are the levels of a substance, in this case Kepone, that cannot be exceeded in a food product. If the level is exceeded for a food item in an area then production or harvesting is stopped until the residual value drops to the safe level. Statistical standard deviations become important as the upper residue level should not exceed the action level determined for the product. When results of chemical analysis for residue fall below or equal the "safe" level, then consumption, i.e., harvesting, is permitted. Table 4.2 summarizes the levels of Kepone residue in selected species.

Table 4.2

Kepone Residue (ppm) in Commercially Important Seafood  
in James River, 1976

Species	Kepone Residue		Residue Level Exceeded in 5% of Species (95% Confidence Level)
	Mean	Standard Dev.	
Butterfish	0.075	only 1 sample	
Croaker	3.0	only 1 sample	
Gizzardshad	0.35	only 1 sample	
Hickoryshad	10.1	only 1 sample	
Spot	1.49	only 1 sample	
Eels	2.94	2.83	780.5
Blue Crab	2.8	1.19	11.6
Oysters	0.29	1.17	0.418

Taken from: O'Mara and Reynolds, 1976

The economic impact of the Kepone pollution and subsequent ban on fishing is felt in several areas - commercial fishing, recreational or sportfishing, recreation-associated industries, lost tax revenue and unanticipated expenditures for regulatory actions and clean-up (Gabel, 1976). Only the first two are relevant to this discussion.

Commercial Fishing

The Chesapeake area supports large commercial fisheries. Table 4.3 gives detailed statistics of landings in Virginia, which were most directly affected by Kepone pollution. Losses to these fisheries included direct reduction in production because of the ban on fishery, and lost confidence in fish products by the public. These may have different long-term effects. The drop in fishing effort may allow fish stocks to increase, and hence produce greater catches when fishing is allowed to resume, but lost public confidence may mean reduced demand even when the product is safe.

From a survey of the Virginia wholesale seafood industry it was determined that the average decline in sales attributed to Kepone pollution was 15 percent. Over two thirds of the wholesale companies that responded did less than 50 percent of their business in the Virginia market. Most of the seafoods landed in the states are exported and this out-of-state business remained strong. Local demand (within the state of Virginia) is lower but the export trade is a much larger percentage of the total seafood market thus somewhat reducing the overall economic impact (Gabel, 1976a).



Table 4.3

Summary of Annual Catch (Metric Tons) and Value (U.S.\$ 1 000)  
of Selected Major Finfish and Shellfish in Virginia, 1974

Species	Landings	Value
Alewives	6 053	431
Bluefish	1 423	262
Butterfish	84	39
Croaker	681	205
Eels	659	405
Flounder	1 411	784
Gray Trout	1 389	467
Menhaden	9 562	485
Scup	215	59
Sea Bass	390	255
Shad	711	230
Spot	1 021	349
Striped Bass	1 163	613
Finfish Total	24 762	4 584
Blue Crabs	18 534	4 254
Soft Crabs	369	403
Clams	27 058	8 165
Oysters	3 057	4 844
Scallops	396	1 277
Shellfish Total	49 414	18 943
Grand Total	74 176	23 527

Taken from: Virginia Landings, December 1975, C.F.S. No. 6953  
U.S. Department of Commerce

Using wholesale values (2.5 times dockside value) and a 6 percent inflation rate the expected commercial wholesale value of fish and shellfish for 1976 from the Virginia Chesapeake Bay area would be U.S.\$ 46.8 million. The 15 percent decline in sales attributed to Kepone pollution therefore represents a loss of U.S.\$ 7.03 million (calculated after Gabel, 1976a).

Utilizing a fixed percent reduction in evaluation the impact on commercial fisheries however does not take into consideration two factors: (1) Differential closure in which shellfish, a greater market than finfish, was less affected; (2) Market value dependency on supply and demand. Although the catch of crabs was lower in 1976 than 1975 (11 800 metric tons compared to 15 880 metric tons) there was little difference in the ex-vessel value U.S.\$ 5.0 million against 5.1 million). Seed oysters, which are moved routinely for depuration, exhibited an increase in value for 1976 over 1975 ( U.S.\$ 865 000 in 1976 as compared to U.S.\$ 700 000 in 1975) (Virginia Marine Resources Commission, personal communication, 1977).

Finfish landings for the Kepone-affected area had a 65 percent drop due to prohibited landings in 1976. Only catfish, shad, herring and elvers were allowed for commercial catch. Finfish catch was composed of 90 percent catfish and shad and decreased in value from U.S.\$ 630 000 to 221 000. Inability to market 136 metric tons of crabs led to a loss of some U.S.\$ 140 000 (Virginia Marine Resources Commission and U.S. National Marine Fisheries Service, 1977). Lost wages and jobs in commercial fishing activities, for fishermen and



wholesalers, by the end of 1976 would be U.S.\$ 7.2 million and 1 980 jobs (based on 15 per-cent decline in sales and figures from the Virginia Marine Resources and Employment Commission). Table 4.4 is a summary of Annual Catch and Value of Commercial Finfish and Shellfish from the James River basin and the total Virginia landings for 1976.

Table 4.4

Summary of Annual Catch (Metric Tons) and Value (U.S.\$ 1 000)  
of James River Basin and Total Virginia Landings, 1976  
(Preliminary Data)

Species	James River Basin		Virginia	
	Landings	Value, Ex-vessel	Landings	Value, Ex-vessel
Finfish Total	310 <sup>a/</sup> (499)	221 (630)	31 388 (36 664)	5 822 (6 253)
Shellfish Total	269 ( )	545 ( )	22 912 (38 164)	24 752 (19 234)
Total	579	766	54 300	30 574

a/ Finfish landings exclude menhaden purse-seine fishery

Note: Catfish accounted for 145 metric tons of total finfish  
Numbers in ( ) are figures for 1975

Source: Virginia Marine Resources Commission, March 1977  
National Marine Fisheries Service, March 1977

#### Sport Fishing and Recreation-Associated Industries

The sport fishery is estimated to have experienced a larger loss (in U.S.\$) than the commercial fishing and revenues will decrease by 10 percent. The sport fishing industry in the Chesapeake Bay area employs some 4 500 people. How many of these individuals will seek and have found employment in other industries is not known. According to the Virginia Marine Resources Commission (p. 13 in Gabel, 1976a) there were, in the Chesapeake Bay area in 1975, 1.15 million sport fishery participants. Participants being defined as "... all persons 12 years or older spending no less than U.S.\$ 7.50 and fishing for at least part of 3 consecutive days". Total projected expenditures (U.S.\$ 1.15 million x 7.50) is U.S.\$ 8.6 million. Predicated on a 10 percent loss the revenue reduction will be U.S.\$ 860 000.

It should also be pointed out that how many of these anglers carry out their recreational fishing activity in non-Kepona polluted areas is not known. However purchase of goods and services will be lost to the region if their fishing effort is relocated. There are 30 marinas in the affected area. In law suits filed against the producer of Kepone the average monthly losses since December 1975 have been estimated at U.S.\$ 3 000 per marina. On this basis the total loss to marina operators in 1976 would be U.S.\$ 1.1 million.

The manufacturer of Kepone was fined by a federal judge U.S.\$ 13.2 million for discharging Kepone and other chemical wastes into the James River. The company has created a U.S.\$ 8 million endowment fund for research and related activities to alleviate the effects of contaminating the James River Basin.

#### 4.3 The New York Bight

The New York Bight, an area of approximately 39 000 km<sup>2</sup> is the coastal area extending from the eastern tip of Long Island, New York, to Cape May, New Jersey. The Bight extends to the edge of the continental shelf at the 182 in depth isopleth. Its north seaward boundary is a line, approximately 120 km long, extending southeast from Montauk Point (eastern



tip of Long Island) to the edge of the shelf and its south seaward boundary is a line, approximately 160 km long, extending due east from Cape May, New Jersey to the 182 m depth contour. The shoreward boundary contains the sandy and barrier beaches, estuaries and inlets of New Jersey and Long Island with major population centres and the metropolitan New York City area and harbour. Figure 7 depicts the New York Bight area.

For the evaluation of the contaminant inputs into the New York Bight, Mueller *et al.*, (1976) divided the geographical area into four zones. The four zones are: the Bight Proper, Transect Zone, New Jersey Coastal Zone and Long Island Coastal Zone. The New York Bight itself receives input from barge dumping (dredge spoils, municipal sludge, acid waste and rubble) and atmospheric fallout. In 1974, the New York Bight received 83 percent (by volume, excluding dredging) of the wastes discharged through ocean dumping in the United States coastal waters (Report to Congress on Ocean Dumping Research, U.S. Department of Commerce, 1975).



Figure 7. New York Bight Area Showing Zones and Dump Sites (after Mueller *et al.*, 1976)



In addition there is a large input of atmospheric fallout to the New York Bight (see Table 4.7). The Transect Zone drains the Hudson River system and the heavily populated (15 million people) metropolitan New York City area. The Transect Zone contains large municipal wastewater discharges. Although most of the discharges are subject to primary or secondary sewage treatment levels, New York City has raw waste discharges scheduled for improved treatment when treatment facilities become operative. Wastewater discharges from the New York - New Jersey metropolitan region (sewered municipal and industrial sources) amounted to  $54 \times 10^6$  kl per day. Of this total,  $8 \times 10^6$  kl was from municipal sewage,  $42 \times 10^6$  kl was from electrical generation, and  $4 \times 10^6$  kl was derived from manufacturing industries. Of the liquid effluents discharged, about 85 percent flows into New York Harbor and the New York Bight Apex (Gross, 1976). Table 4.5 summarizes the wastewater discharges according to source and level of treatment. The New Jersey Coastal Zone input into the New York Bight ecosystem is primarily through estuary drainage into the Bight. The New Jersey Coastal Zone contains those drainage basins just south of Sandy Hook Bay and extending to Cape May, New Jersey at the mouth of Delaware Bay. Numerous small communities along the shore discharge wastewater directly into the ocean but there are relatively few industrial outfalls. New Jersey is the most densely populated state in the United States and the coastal zone and estuaries are used for recreation and shellfishing.

The Long Island Coastal Zone is composed of the southern shore of Long Island from Jamaica Bay to the eastern end of the island, Montauk Point. Major streams flow into a barrier estuary system which is heavily used both for shellfishing and recreational activity. There has been a decrease in the amount of wastewater discharged into the groundwater with an increase in the number of treatment plants along the coast. Little industrial discharge occurs in the barrier estuaries other than the duck farms on eastern Long Island. Population of this zone is approximately 1.4 million people.

Mueller *et al.*, 1976a and 1976b, considered four primary sources of contaminants to the New York Bight: barge dumps, atmospheric fallout, wastewater inputs and run-off inputs. The major inputs were from discharges directly into the Bight and Transect Zone. Groundwater sources are negligible by comparison. Twenty-two parameters were utilized in the evaluation of waste sources. Six parameters were used by Mueller (*op. cit.*) to depict input of the various zones of the Bight area: suspended solids (effect on light penetration and sediment deposition), organic carbon (measure of oxygen demand), nitrogen and phosphorus (nutrients for algae growth), lead (typical heavy metal) and fecal coliform counts (microbial contamination). Segar and Cantillo, 1976, found that contaminant metals do not accumulate in the apex but are rapidly removed either to the estuaries or the surrounding shelf waters. They also found that dissolved metal concentrations are higher in the apex than on the shelf in the summer suggesting slower flushing rates during that season.

The flow input to the Bight is primarily atmospheric (rainfall, 59 per cent) with gauged run-off from the Transect Zone supplying approximately a third of the flow. Most of the suspended solids (68 percent) are from direct barge discharges into the Bight with the majority coming from dredge spoils. The main sources of total organic carbon are dredge spoils (25 percent) and municipal wastewater (29 percent). Municipal wastewater is a prime source of nitrogen (40 percent) and phosphorus (35 percent) with barge disposal responsible for 50 percent of the phosphorus input. Gauged run-off supplies five times the amount of nitrogen than urban run-off (25 percent versus 4 percent). Dredge spoils supply the major amount of lead (44 percent) with automotive emissions contributing to the lead supply from urban run-off (19 percent). Fecal coliform loads originate from municipal wastewater discharge (> 84 percent) (unchlorinated sewage) and sewer overflows reflected in urban run-off levels, 15 percent (Mueller *et al.*, 1976). Some estimates of nutrient inputs via the Hudson and Raritan Rivers show riverine input as much as five times the nutrients supplied by sewage sludge (Report to Congress on Ocean Dumping Research, U.S. Department of Commerce, 1976). Segar and Berberian (1976) discuss the oxygen depletion in the New York Bight apex and their conclusions are especially applicable to considerations involving the "marine resources kill" correlated with anoxic conditions. Their findings point out that low oxygen concentrations are the most critical environmental problem in the apex and the depletion of dissolved oxygen is due primarily to the decomposition of photosynthetically produced organic



Table 4.5

Wastewater Discharge in the New York-New Jersey Metropolitan Region  
(Sewered Sources)

Source	m <sup>3</sup> /s	kl/d, 10 <sup>3</sup>	Flow %
<b>Municipal Sewage: (treatment level)</b>			
None	14.0	1 212	2.2
Primary	28.5	2 462	4.6
Secondary	51.8	4 470	8.3
<b>Industrial:</b>			
Manufacturing	50.4	4 356	8.1
Electrical Generation	480.0	41 666	76.8
Approximate Total	625	54 166	100

From: Gross, 1976. Sources of Urban Wastes. Am.Soc.Limnol. and Ocean.  
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matter. Midsummer primary productivity in the apex region is high due to high nutrient levels, especially of nitrogen. The bulk of the nitrogen supply comes from sewage treatment plant effluents discharged to the rivers systems. They felt that ocean dumping does not cause the low oxygen levels and that nutrient removal during the wastewater treatment process would have reduced or eliminated the anoxic conditions. Table 4.6 summarizes total mass loads of six parameters into the New York Bight and for each load the percent due to each source.

The impact on organisms of contaminant discharges into the New York Bight area have been cited by O'Connor, 1976, and reviewed by Sindermann, 1976. Examples include: (1) Fin rot disease in the winter flounder, Pseudopleuronectes americanus and a statistically significant higher incidence of infection is found on specimens caught within the apex; (2) Exoskeletal "shell disease" of American lobster, Homarus americanus and the rock crab Cancer irroratus, on appendages where spoil sediment accumulated (Pearce, 1972); (3) Rarity of commercial sizes (over 7.6 cm) surf clams, Spisula, in an area of 1 550 km<sup>2</sup> surrounding the dump sites and an unusually low density of macrofauna compared to unpolluted areas; (4) High concentrations of coliform bacteria in shellfish near the sewage sludge site. An area of 383 km<sup>2</sup> around the sewage sludge area was closed for harvesting shellfish. Because of ocean outfalls and run-off the ban was extended to shore bringing the total closure area to 838 km<sup>2</sup>.

There were "fish kill" incidents off New Jersey in 1968, 1971 and 1974 (U.S. Department of Commerce, Middle Atlantic Coastal Fisheries Center, 1976). During the summer of 1976 reports from divers, commercial fishermen, and scientists from the Middle Atlantic Coastal Fisheries Center at Sandy Hook, New Jersey indicated that massive mortalities of fish and shellfish were occurring along the New Jersey Coastal Zone of the New York Bight. A persistent anoxic layer of water was found below the thermocline. In addition to dissolved oxygen levels below two parts per thousand, high concentrations of hydrogen sulfide (1.76 parts per thousand) were present even as high as 15 m above the bottom. Water samples indicated that bottom waters in depths of at least 20 m had oxygen levels below 0.05 parts per thousand. Surface waters were well oxygenated. A flocculent layer was observed at least 1 cm thick on the bottom in the fish kill area. The flocculent material was present throughout the area



Table 4.7

Atmospheric Emission and Estimated Metals Fallouts

Parameter	Mass Emission Rate <sup>a/</sup> , Metric Tons/Day
Particulates	537
Sulfur oxides	1 450
Nitrogen oxides	1 690
Hydrocarbons	3 380
Carbon monoxide	12 800
Total Fallout <sup>b/</sup> , Metric Tons/Day	
Aluminum	45.6
Cadmium	0.13
Iron	39.6
Lead	6.4
Zinc	8.7

a/ EPA, Air Quality Control Region 043, 1972

b/ Estimated at three times dry fallout

Source: Mueller et al., 1976

and was identified as predominately a mass of the dinoflagellate, Ceratium tripos. In mid-depth and even in surface layers varying concentrations of Ceratium were found. Additional input of inshore blooms of other phytoplankton species was found in the affected area. Decomposition of this phytoplankton mass was considered sufficient to depress the dissolved oxygen levels near the bottom (Malone, 1976 cited in Mortalities of Fish and Shellfish Associated with Anoxic Bottom Water in the Middle Atlantic Bight, U.S. Department of Commerce, National Marine Fisheries Service, Mimeo Report 27 pp. 1976a). Cumulative nutrient input from coastal urban population centres could provide nutrients to support the massive phytoplankton bloom which developed in the Bight during the spring and summer. The only unusual physical environmental factor was uninterrupted predominately southwesterly winds along the New Jersey coast for over a month before the fish kill was discovered. Upwelling of colder, low oxygenated water coupled with the phytoplankton bloom and subsequent decay could have amplified the anoxic conditions (U.S. Department of Commerce, 1976, op. cit.). Figure 4.6 illustrates the general surface water circulation during the summer months. "While these blooms may be due to several environmental factors in addition to organic loading from sewer effluents, it is apparent that blooms are now annual occurrences off some parts of the coastline" (Sindermann, 1976). It should be pointed out that the proportionate influence of natural phenomena and man-made inputs into the New York Bight and the subsequent impact on biological systems, including fisheries, is not clearly delineated. It is clear that several factors contributed to the massive mortality experienced by marine organisms on the New Jersey coast.



Table 4.6

Total Mass Loads of Six Parameters Entering New York Bight and Percent of Loads by Source

	Direct into Bight			Percent				From Coastal Zone	
	Mass Load Metric Tons/Day	Barge	Atmos- pheric	Municipal	Wastewater	Industrial	Run-off Gauged	Urban	
Flow (m <sup>3</sup> /s)	2 340	0.02	59	5	0.4		33	2	
Suspended Solids	24 000	63	5	4	0.2		16	12	
Total Organic Carbon	2 600	25	12	29	1		18	15	
Total Nitrogen	520	16	13	40	2		25	4	
Total Phosphorus	138	50	0.7	35	1		9	4	
Lead	12.7	44	9	19	3		6	19	
Fecal Coliform <sup>a/</sup>									
Winter	5.6 x 10 <sup>7</sup>	< 0.01	0	87	0.2		0.01	13	
Summer	4.9 x 10 <sup>7</sup>	0.01	0	85	0.2		0.01	15	

a/ Coliform load = 10<sup>10</sup> organisms/day

After: Mueller et al., 1976 Contaminants Entering the New York Bight: Sources, Mass Loads, Significance Am.Soc.Limnol. and Ocean. Special Symposium 2



#### 4.4 Impact of Anoxic Bottom Water

The anoxic water conditions that occurred off the coast of New Jersey principally had an impact on Monmouth, Ocean, and Atlantic counties but also affected Cape May and Cumberland counties where marine resources-dependent industries are located. The ocean area affected was 7 767 km<sup>2</sup>. Mortalities, numbering in the billions of organisms, included the following commercial species: lobster, surf clams, crabs, hakes, flukes, winter flounder and sea bass. Normal migrations of summer and winter flounder were disrupted, causing them to concentrate in areas which then were heavily fished by sportfishermen. Recovery in the lobster and surf clam is not expected for four (lobster) to seven (surf clam) years (New Jersey Department of Environmental Protection, 1976). Table 4.8 lists species reported in mortality observations, July-August 1976.

Table 4.8

Species Reported in Mortality Observations, July-August 1976  
Only Species Reported by 2 or More Observer Groups

Species	Reports			
	MACFO <sup>1/</sup> Survey	Sport Dives	Commercial Fishermen	Beach
Silver Hake ( <u>Merluccius bilinearis</u> )	X	X	X	
Red Hake ( <u>Urophycis chuss</u> )	X	X	X	
Ocean Pout ( <u>Macrozoarces americanus</u> )	X	X	X	
Tautog ( <u>Tautoga onitis</u> )			X	X
Cunner ( <u>Tautogalabrus adspersus</u> )		X	X	
Summer Flounder ( <u>Paralichthys dentatus</u> )			X	X
Blue Mussel ( <u>Mytilus edulis</u> )		X		X
Surf Clam ( <u>Spisula solidissima</u> )	X	X	X	
Lobster ( <u>Homarus americanus</u> )	X	X	X	
Rock Crab ( <u>Cancer irroratus</u> )	X	X	X	X
Jonah Crab ( <u>Cancer borealis</u> )	X	X	X	

1/ Middle Atlantic Coastal Fisheries Center,  
National Marine Fisheries Service, Sandy Hook, New Jersey

Source: Middle Atlantic Coastal Fisheries Center.  
National Marine Fisheries Service, Sandy Hook, New Jersey, 1976



The number of commercial fishermen employed in the state of New Jersey in 1973 was 2 978 and the number of fishing licenses issued in 1974 was 2 633 (New Jersey Department of Labor and Industry). In a survey conducted by the Division of Fish, Game and Shell Fisheries of New Jersey, 7.2 percent of the total finfish fleet was sampled and economic losses were calculated on reports of 9.8 percent of the commercial finfish boats in the area affected. The average loss per boat sampled was U.S.\$ 17 625. Expanding the average loss to the 82 boats located north of Cape May county results in an estimated loss of U.S.\$ 1.45 million to the finfish fleet for the four months, July-October 1976. In addition, the state of New Jersey economy lost U.S.\$ 3.61 million in finfish-related expenditures due to lost landings (New Jersey Department of Environmental Protection, 1976).

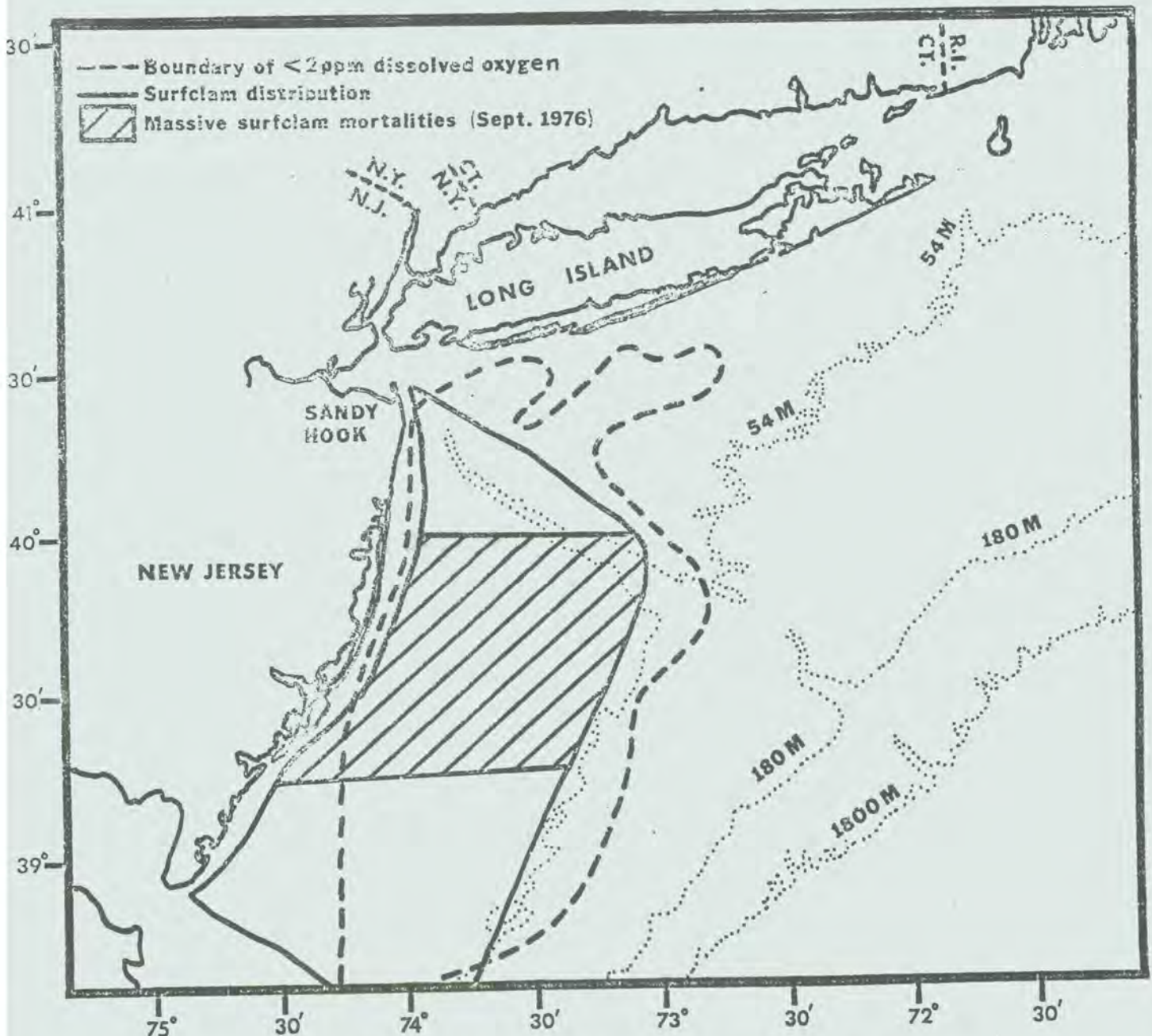


Figure 8. Surf Clam Mortality and Low Oxygen Area, New York Bight (after National Marine Fisheries Service, 1976)



The surf clams, Spisula solidissima, account for 80 percent of the shellfish landings and 42 percent of the shellfish value in the state. In a resource survey in April-May 1976 prior to the onset of the anoxic conditions, the commercial surf clam population was estimated at 84 845 metric tons in the 5 500 km<sup>2</sup> area affected. Mortality levels rose from 10 percent in August to over 50 percent in mid-September and in some areas 100 percent mortality was found. Based on biomass estimates, 59 000 metric tons of surf clams have been lost and this loss off the New Jersey coast (July-August) has been estimated to be 5 percent of the total surf clam resource in the Middle Atlantic Bight (Middle Atlantic Coastal Fisheries Center, 1976, Red Flag Report No. 76-2). The impact is further amplified because the spawning period extends from June to mid-August. This was the peak period of anoxic water conditions and highest mortalities.

According to Halgren, Pyle and Critchlow 1976, the estimated mortality of 7 million bushels represents 32 percent of the available surf clam stock of New Jersey. The landing value per bushel is U.S.\$ 1.30, resulting in a potential loss to commercial surf clam fishermen of U.S.\$ 9 million per year. Since the surf clam reaches market size in seven years an annual loss for the seven-year recovery period could represent a total U.S.\$ 63 million loss to the commercial fishermen. Annual harvest in New Jersey, primarily from the area affected by the anoxic water conditions, has been 2.1 million bushels or 16 130 metric tons (New Jersey Department of Environmental Protection, 1976). Figure 8 shows the surf clam harvest area affected by the anoxic water conditions.

The American lobster, Homarus americanus, accounts for about 15 percent of the value of the shellfish landings in New Jersey (1975). There was a 28 percent reduction in lobster catch from June to September 1976 in the area affected by the anoxic water mass (New Jersey Department of Environmental Protection, 1976). Lobster landings in two counties declined 50 percent compared to 1975 (Middle Atlantic Coastal Fisheries Center, 1976). Applying the 28 percent rate to the time period of September-December, there will be a catch reduction of 84 metric tons for 1976. Using a dockside price of U.S.\$ 4.34 per kg, the net loss for 1976 will be U.S.\$ 365 000. Since it takes four years for lobsters to reach marketable size the 28 percent mortality if applied equally to under-sized lobsters will be felt in stock reduction for the next four years because of reduced recruitment. According to Halgren and Figley, 1976, this loss of recruitment will result in losses amounting to U.S.\$ 516 102 in 1977 and proportionate losses, with price increase adjustments for subsequent years. Other economic factors may ameliorate this impact. Table 4.9 summarizes the estimated commercial fishing losses due to anoxic water conditions.

Marine sportfishing is a major recreational activity in the state of New Jersey. Party and charter boats exhibited an average economic decline of 22 percent during the most active portion of the season. The loss of revenue for party boats was an average U.S.\$ 13 607 (18 percent of the fleet were sampled). There are 76 party boats in the affected area thus resulting in an economic loss valued at U.S.\$ 1.03 million. The charter boats sampled (10 percent of total fleet sampled showed economic losses averaging U.S.\$ 3 976). There are 174 charter boats in the area that felt the effects of the "marine resource" kill, giving a total economic loss of U.S.\$ 0.69 million. A total of 93 men lost their jobs (New Jersey Department of Environmental Protection, 1976).

During the previous year (July-September 1975) a total of 104 223 private fishing trips were made in the affected area. If we assume three things: (1) Private boat ocean fishing declined to the same extent as party and charter boat fishing (22 percent), (2) Expenditures of U.S.\$ 10.77 per man/day (according to U.S. Department of Interior, 1971), (3) There will be four fishermen per boat then the economic losses of the private ocean fishing would be U.S.\$ 0.99 million for the summer period of the "fish" kill. Table 4.10 summarizes recreational fishing losses attributed to the fin and shellfish mortalities.



Table 4.9

Summary of Estimated Commercial Fishing Losses Due to Anoxic Water Conditions  
New Jersey 1976

	Estimated % Stock Affected	Reduction in Landings (Metric Tons)	Total Estimated Loss (U.S.\$ 1 000)
Surf Clam Fishery	32	59 000	9 000
Lobster Fishery	28		366
Finfish Fishery <sup>a/</sup>	17	8 000	1 450
Total		67 000	10 816

a/ Value of loss for finfish calculated on an average loss per boat. Value of reduced landings is the product of percent affected fishermen X 1975 finfish catch

Based on: Report by State of New Jersey, Department of Environmental Protection, Division of Fish, Game and Shell Fisheries, 1976

4.5 Other Fish Kills

From fish kill records compiled by the U.S. Environmental Protection Agency it is evident that apart from the anoxic conditions noted in the previous section the leading causes for such kills in the Middle Atlantic states are sewerage and industrial wastes (1973-75). Together they account for 75 percent of the number of reports that identify the source. Such causes are indicative of the urban development and industrialization of the region. The Virginia and Maryland estuarine ecosystem account for the highest number of fish mortalities for the years 1973-75. In 1973, Virginia waters gave the highest mortalities (based on one massive incident). This massive kill (7.5 million fish) was due to over-chlorination of waste effluent. Many sportfish were affected and exhibited broken vertebra. A reduced fish kill occurred for the same reason in 1974 (Bellanca and Bailey in press). In 1974, Maryland had the higher number of mortalities and the higher number of incidents reported (six). Maryland and Virginia had equal numbers of kills but Virginia a higher number of mortalities in 1975. The data base for 1976 is not complete. In the Middle Atlantic states, Maryland waters yielded the highest number of fish mortalities for the years 1972-75. In 1974, one county in Maryland, during one month (August), reported 101 million fish killed due to discharge from a sewage plant. The largest single kill reported in Maryland was 47 million fish.

In 1974 the Middle Atlantic states coastal zone experienced a monetary loss estimated at U.S.\$ 10.2 million. Maryland alone accounted for U.S.\$ 10 million of the total. During 1973 fish loss in this region was U.S.\$ 839 000 with Virginia having U.S.\$ 750 000 loss. A survey of major pollutants and the fishery associated with fish kills (Bell and Canterbury, 1976) found that all the Middle Atlantic states that responded cited municipal waste (sewage) to be the major pollutant. In Maryland the major fishery affected was menhaden and in New Jersey shellfish were affected.

As in the evaluation of fish kills in the Gulf of Mexico the methods used by Bell and Canterbury (1975) and Tihansky (1973) were applied. Reservations on the recording and reporting system must also be kept in mind. If we utilize the two-thirds ratio assumption and the value of 10 cents per dead fish reported the fishery revenue loss in fish kills can be determined as follows (for the Middle Atlantic states):

1973	-	U.S.\$	839 200
1974	-	U.S.\$	10 211 600
1975	-	U.S.\$	10 700



Table 4.10  
 Summary of Estimated Recreational Fishing Economic Losses Due to Anoxic Water Conditions  
 New Jersey, 1976

Category	Number Affected %	Range in Decline %	Average Value of Decline (U.S.\$)	Total Estimated Loss (U.S.\$ 1 000)	Jobs Affected
Party Boats	94	20-62	13 607	1 034	54 Lost 23 Reduced
Charter Boats	70	15-60	3 976	691	39 Lost 87 Reduced
Private Fishing (all types)	assume all in some manner	22	10.77/man	985	Not Applicable
Total				2 710	93 Lost 110 Reduced

Source: State of New Jersey, Department of Environmental Protection, Division of Fish, Game and Shell Fisheries, 1976



Table 4.11 summarizes the reported fish kills and their values for the Middle Atlantic states. The table was constructed from U.S. Environmental Protection Agencies file records and U.S. Environmental Protection Agency, 1975 "Fish Kills Caused by Pollution in 1973".

Table 4.11

Fish Kills and Values - Middle Atlantic States Coastal Zone

Year	Location	Water Type	Number of Fish (1 000's)	Cause	Value (U.S.\$)
1976 (1st 6 months)	New York	Estuary	2-3	Not Given	
	New York	Estuary	1	Unknown	
	Delaware	Estuary	<u>225</u>	Low Dissolved Oxygen	
		1976 Total	229		22 900
1975	New Jersey	Salt	12	Unknown	
	Delaware	Salt	1	Low Dissolved Oxygen	
	Maryland	Estuary	1	Fuel Oil	
	Maryland	Estuary	10	Sewerage	
	Virginia	Estuary	80	Chlorine	
	Virginia	Estuary	<u>3</u>	Ammonia	
	1975 Total	107		10 700	
1974	New Jersey	Salt	10	Raw Sewerage	
	New Jersey	Estuary	20	Thermal	
	New Jersey	Estuary	200	Sewerage	
	Virginia	Estuary	9	Chlorine	
	Maryland	Estuary	77	Sewerage	
	Maryland	Estuary	10 700	Sewerage	
	Maryland	Estuary	47 700	Sewerage	
	Maryland	Estuary	11 000	Sewerage	
	Maryland	Estuary	31 900	Sewerage	
	Maryland	Estuary	<u>500</u>	Heavy Metal	
		1974 Total	102 116		10 211 600
1973	New Jersey	Estuary	5	Power Co.	
	New Jersey	Estuary	112	Power Co.	
	New Jersey	Estuary	1	Power Co.	
	New Jersey	Salt	543	Unknown	
	Maryland	Estuary	125	Metals	
	Maryland	Estuary	30	Metals	
	Maryland	Estuary	31	Metals	
	Maryland	Estuary	45	Metals	
	Virginia	Estuary	<u>7 500</u>	Sewerage	
	1973 Total	8 392		839 200	
Grand Total			110 844 x 10 <sup>3</sup>		11 084 400

Source: U.S. Environmental Protection Agency, 1975 and file records



#### 4.6 Dredging and Filling

Dredging and filling operations are prime components of physical alteration of estuarine ecosystems. Dredging activities to improve and maintain shipping operations are present throughout this area. Four major port systems are found in the Middle Atlantic region: New York-New Jersey (the nation's largest with 579 km<sup>2</sup> of harbour), Delaware River Port (large petrochemical processing plants nearby), Baltimore Harbor (at the head of Chesapeake Bay with 200 piers and wharves), Hampton Roads (18 km of developed waterfront facilities). In 1973 these ports handled 21.2 million metric tons of cargo, including 38 000 metric tons of crude oil and petroleum products (U.S. Department of Interior, 1976). Dredging not only removes what may be suitable substrate, but it alters flow patterns (evident in Chesapeake Bay), resuspends sediment and in addition the dredge spoils must be deposited elsewhere. Dredge spoil input to the New York Bight area is in excess of 7 million m<sup>3</sup> per year (O'Connor, 1976). Dredge spoils deposited along the Atlantic coast amount to 14 010 metric tons and 79 percent of the total wastes disposed (Lacy and Rey, 1974). Maintenance dredging of the Baltimore Harbor complex in 1973 removed 228 000 m<sup>3</sup> at a cost of almost U.S.\$ 300 000. Maintenance dredging of the New York area averaged 4.2 million m<sup>3</sup>/year (1971-75) and the 1976 cost was projected to be U.S.\$ 9 million. Cost for open ocean disposal is U.S.\$ 7.14 per m<sup>3</sup>; disposal in the New York Bight costs U.S.\$ 1.67 per m<sup>3</sup> (Skjel, 1976). Table 4.13 summarizes input to New York Bight.

Reclamation of wetlands for urban development and creation of sites for industrial complexes involves channelization, dredging and filling of productive tidal and submerged areas.

Population centres of the Middle Atlantic states exert pressure for the development of additional housing. Sizeable coastal areas are apportioned for recreational activities, state and federal lands, or are not accessible to development. Recreational fishing in the five-state area, based on state and federal surveys, amounted to over 31 million user-days annually. These figures combine data available for 1973 and 1974 (U.S. Department of Interior, 1976b). Large areas are under agricultural development and expansion of this use may require drainage, filling and the subsequent channelization will add to run-off associated pollution.

As stated in the Gulf of Mexico section, estimates of the proportion of estuarine-dependent species in commercial landings varies from 63 to 93 percent of the total catch. This proportion may not be the same in all regions; it may be higher in the Gulf of Mexico than in the Middle Atlantic. For the present purpose the same proportion and the same method of estimating the value of commercial catch corresponding to each ha of estuary has been used as in the Gulf of Mexico (see Table 2.7). The latter figures of value are not inconsistent with the yield per ha of 92 kg estimated by Stroud (1973). Table 4.12 summarizes the loss and value of the loss due to dredging and filling in the Middle Atlantic states. Value per ha is based primarily on shellfish resources harvested.



Table 4.12

Loss of Estuary Habitat Due to Dredging and Filling Middle Atlantic States, U.S. A.  
(Area in Hectares)

State	Total Estuary Area	Area of Important Habitat	Area Lost by Dredging and Filling	Annual Catch Value/ha	Loss in Value (U.S.\$ 1 000)
New York	152 407	53 622	8 013 (15) <sup>a/</sup>	330.00	2 644
New Jersey	315 014	166 451	21 813 (13.1)	74.95	1 634
Delaware	160 057	61 675	3 440 (5.6)	22.31	76
Maryland	569 040	152 286	404 (0.3)	92.20	37
Virginia	675 839	173 249	971 (0.6)	90.92	88
Totals	1 872 357	607 283	34 641 (6.9)		4 479

<sup>a/</sup> Number in ( ) indicates percent of important habitat lost

Based on a combination of: National Estuary Study, U.S. Department of Interior 1970 and Tihansky and Meade, 1976, Economic Contribution of Commercial Fisheries in Valuing U.S. Estuaries

Table 4.13

Contaminant Input to New York Bight  
(Area Population: 18 Million People)

Material	Amount
Dumping: (m <sup>3</sup> /year)	
Sewerage Sludge	3-4 x 10 <sup>6</sup>
Dredge Spoils	7 x 10 <sup>6</sup>
Acid Wastes	2 x 10 <sup>6</sup>
Construction Debris	4.5 x 10 <sup>5</sup>
Cellar Dirt	
Atmospheric Fallout: (metric tons/year)	
Cd, Cr, Cu, Fe, Pb, Zn	3 940- 32 000
Suspended Solids: (metric tons/year)	49 000-500 00
Total Nitrogen: (metric tons/year)	24 000
Wastewater: (metric tons/year)	
Oil and Grease	72 000
Total Nitrogen	79 000
Run-off and Groundwater: (metric tons/year)	
Oil and Grease	124 000
Total Nitrogen	55 000

Source: O'Connor, 1976



#### 4.7 Shellfish Area Closure

This area with its open coastal beaches, low-lying tidal marshlands and the tributary estuarine system of Chesapeake Bay provides prime habitat for molluscan shellfish. In 1975, the Middle Atlantic region supplied 86 percent of the national surf clam (Spisula) harvest, 59 percent of the hard clam (Mercenaria) landings, 40 percent of the oyster (Crassostrea) catch. Hard clams and oysters are harvested within 5 km of the shore. About half the surf clams are located in the 0-5 km area and 45 percent were found offshore, 19-321 km. Table 4.14 summarizes major Middle Atlantic molluscan shellfish catch (U.S. Department of Commerce, Fisheries of the United States, 1975).

Table 4.15 summarizes the information on the different classes of shellfish grounds, using the classification of the National Shellfish Sanitation Program previously described (see Section 2.5).

New Jersey had the largest percentage loss (30.3 percent) of available shellfishing grounds while New York State had a larger area of closed grounds (61 172 ha) and was second in percent loss (14.8 percent). Maryland and Virginia, 7.3 and 8.0 percent closed areas respectively, each contain almost 0.5 million ha of shellfishing area.

Since areas that are classified as closed are productive shellfish grounds an estimate can be made of the value of shellfish lost through fecal coliform contamination. It should be noted that all potential grounds are surveyed and non-productive areas are also classified in the National Register. Maryland and Virginia led in production of oysters for the Middle Atlantic states (7 259 metric tons and 2 495 metric tons respectively). Virginia had the larger closed area than Maryland and twice the lost revenue (U.S.\$ 747 000) than did the Maryland oyster fishery. Table 4.16 summarizes the estimated loss in value from closed oyster grounds in Chesapeake Bay (U.S. Department of Commerce, 1977. Draft of Comprehensive Review of Commercial Oyster Industries in the United States).

Several regions have reported closures and estimates of losses due to industrial as well as domestic pollution. New York has accounted for 63 percent of the ex-vessel value of all hard clams landed in the past ten years. New York reports that 25 percent of the 232 699 ha is closed to hard clam harvesting because of poor water quality due to storm-water run-off and sewage outfalls (Ritchie, 1976). This represents 1 315.6 metric tons of lost landings. Value of the landings due to pollution would amount to U.S.\$ 3.9 million (based on and assuming 1975 ex-vessel prices would prevail). New Jersey reported that 36 746 ha of a total 93 241 ha of oceanic water within the 5 km limit is closed to surf clam harvest due to pollution. In the apex of the New York Bight (area between Long Island, New York and New Jersey) 310 km<sup>2</sup> is closed to surf clamming because of industrial pollution. An area offshore from Maryland and Delaware is also closed for surf clams due to ocean dumping of industrial waste and sewage sludge (Sugihara, 1976. In Ritchie, 1976).

In Raritan Bay, between New Jersey and Staten Island, New York, a large shellfish industry existed until 1961. A large portion of the bay was closed to shellfishing because of bacteriological contamination. An outbreak of hepatitis was traced to shellfish from the bay. Hard clams (Mercenaria) are primarily consumed raw or lightly steamed. About 5 percent of the 233 km<sup>2</sup> area was harvested (11.7 km<sup>2</sup>). Using the lower conservative yield figures from Wasserman, 1970, the annual yield (1 000 bushels/ha at U.S.\$ 1.50/bushel) value would be U.S.\$ 4.3 million. In another portion of the bay complex, with a limited open area, the annual harvest is U.S.\$ 40 000.



Table 4.14  
Summary of Major Middle Atlantic Mollusc Catch 1975  
Value in Metric Tons

	New York	New Jersey	Maryland	Virginia	Total
Surf Clam	2 077	16 152	426	17 735	36 390
Hard Clam	3 947	726	26	493	5 192
Oysters	956	441	7 259	2 495	11 151
Total	6 980	17 319	7 711	20 723	52 733

Source: U.S. Department of Commerce, 1976. Fisheries of the United States, 1975.  
Current Fisheries Statistics No. 6900

Table 4.15  
Shellfish Area Classification in ha (U.S. Environmental Protection Agency, 1975,  
National Shellfish Register, 1974)  
Middle Atlantic States

State	Open	Conditional	Closed	% Open	% Condit.	% Closed
New York	193 214	107	61 172	47	Trace	14.8
New Jersey	99 066	3 054	48 413	62	1.9	30.3
Delaware	83 057	61	11 437	75	0.1	10.3
Maryland	491 326		4 582	79		7.3
Virginia	532 473	293	48 692	88	Trace	8.0
Total Area (ha)	1 399 136	3 515	174 296			

Open Waters: Approved by state agency for direct market harvesting

Conditional: Meet "OPEN" standards but are subject to periodic closure

Closed: Closed for harvesting of shellfish due to hazardous levels of contamination

Table 4.16  
Estimated Loss in Value from Closed Oyster Areas Middle Atlantic States, U.S. 1975

	Productivity Factor	Closed Area (ha)	Meat Wt. (Metric Tons)	Price/kg (U.S.\$)	Value Lost (U.S.\$ 1000)
Maryland	52.1	3 111	181	1.96	357
Virginia	8.24	72 237	667	1.11	747
Total Loss					1 104

Productivity Factor: 1975 production divided by 1975 Open Area (ha)

Price/kg: 1975 ex-vessel prices for each state

Source: U.S. Department of Commerce, National Marine Fisheries Service, 1977  
Draft of Review of Commercial Oyster Industries in the United States



#### 4.8 Beneficial Aspects of Pollution

##### Dredge Spoils

Dredge spoils can be used for the construction of recreational facilities or the expansion of already existing sites. These sites can be used for a variety of purposes: beaches, marinas, parks, cultural and sport facilities, which may include fishing.

Several recreational uses of dredged material are proposed for the New York Bight area. Dredged material and construction rubble are planned for use in the construction of a 60-ha recreational facility in Long Island Sound. Also a diked disposal site is proposed just offshore of Staten Island. Portions of the site would re-create the original regional environment and this would present finfishing and shellfishing opportunities. Value of the site for fishing activity would be dependent upon success of the environmental restoration and the level of visitation.

##### Artificial Reefs

It has been quantitatively demonstrated that biomass is increased with placement of an artificial reef (Richard Stone, 1977, personal communication). Although such a man-made habitat does obtain recruitment from adjacent areas where carrying capacity has been exceeded, the additional food supply, protective riches and spawning sites enhance the productivity of such an artificial substrate.

Most man-made reefs are a composite of solid waste materials. In descending order of construction composition artificial reefs are made up of: old tires, surplus scrap ships, car bodies and concrete culverts. There are 21 artificial reefs in the Middle Atlantic Region (Stone, Buchanan and Steimle, 1974). Scrap tire units are the predominant construction material and the 21 reefs of the region contain 132 440 tires.

Comparison of fishing success between natural and artificial habitats must be carefully evaluated. A number of factors not related to the habitat itself tend to bias such an evaluation (i.e., access, fishing techniques variation, angler preference, species occurrence, fishing pressure). A comparison survey in the New York Bight area found that party boat anglers, engaged in bottom fishing, spent only 14 percent of their angler hours over man-made habitats (including ship wrecks) and caught 25 percent of their catch from such habitats. Fishermen caught twice as many fish (based on angler-hours) from these artificial reefs compared to natural habitats but fewer species were caught than over natural bottom habitat (Buchanan, 1972). Stone *et al.* (*op. cit.*) found that artificial reefs increased angler catch for species associated with rocky habitats but showed no improvement in catch success for pelagic species or species associated with open bottom substrate.

Though the Middle Atlantic region has no active or expired lease areas for exploration of oil and natural gas on the continental shelf, lease areas totaling 86 000 ha were sold in August 1976 for U.S.\$ 1.13 billion to 39 gas and oil companies. Implementation of lease sales for this region has been blocked by federal judicial action because of environmental law violations.

The lease area extends roughly in a northeast direction on the edge of the continental shelf inside the 200 m depth curve and south of the main New York Port shipping separation zone. The closest lease tract to shore is 64 km at sea and the tracts extend to 144 km offshore. The U.S. Geological Survey estimates that between 5 and 20 drilling rigs will be employed at one time (25-year field life) and that between 10 and 50 platforms will be present. These platforms will serve as artificial reefs and no doubt will provide sportfishing habitats as has been evidenced in the Gulf of Mexico. Because of the distance to shore (64-144 km) and since sportfishing in the Middle Atlantic region is primarily a small boat, day-use activity, the fish population enhancement quality of the platforms will not significantly increase sportfishing activity (U.S. Department of Interior, 1976a. Environmental Impact Statement, Lease Sale No. 40). In contrast, Gulf of Mexico drilling and



production platforms are as close as 4.8 km from shore. Charter and some private sportfishing boats do engage in deep-sea fishing from New Jersey, Maryland and Virginia making trips of 25-62 km offshore to the Hudson and Baltimore Canyons. Billfish (white and blue marlin, swordfish), tuna, tilefish and sharks are primary species landed. Even with increased size and number of available vessels the costs involved and the accessibility of existing sportfishing grounds will minimize sportfishing usage of the platforms. Quantification of the impact of the offshore platforms as artificial reefs is not practical.

#### Thermal Addition

The Middle Atlantic region contains the major population centres on the eastern coast of the U.S.A. with over 11 million people in these metropolitan areas. Vast quantities of waste heat is produced in generating the electricity to supply this population, and much of it is dissipated as cooling water discharged into coastal waters.

There are 13 thermal discharges (in operation or planned) into the coastal zone in this region (New York, 5; New Jersey, 5 and Maryland, 3). Benefits from utilization of thermal additions for marine aquaculture are: increased periods of growth, accelerated growth, ability to control water temperatures and raising species outside their normal range. There are some serious drawbacks such as: possible interruption of heated effluent, increased risks of diseases and parasites, gaseous supersaturation, and uptake of contaminants from the power plant (Huguenin and Ryther, 1974). Several experimental or demonstration aquaculture programmes are underway along the United States eastern seaboard.

A commercial project using thermal seawater discharge is the Long Island Oyster Farm Operation. The discharge from the Long Island Lighting Company power plant is about 11°C above ambient and is uncontaminated because no chemicals are used to prevent fouling in the cooling coils. Spawning is induced throughout the year in breeding tanks and after six weeks in the hatchery the oysters are placed into trays in the cooling water lagoon next to the power plant. Lagoon water temperature does not fall below 10°C in the winter or rise above 29.4°C in the summer. The oysters remain in the lagoon from 2 to 4 months and number between 30 and 40 million oysters. The young oysters are then moved to open bay waters and placed in beds within a 4 000 ha area operated by the farm. The time spent in the hatchery and the lagoon accelerates the natural growth rate of these stages so that maturity and harvest will occur in three instead of five years. The company processes its own oysters, produces on a year-round basis, and they are marketed as whole, shucked or frozen on the half shell. This company has 125 permanent employees and has sales exceeding U.S.\$ 4 million (Peterson and Seo, 1977). For comparison, New York State oyster landings in 1975 were 953 metric tons with a value of U.S.\$ 5.2 million.



## 5. NORTH ATLANTIC REGION

### 5.1 Introduction

The North Atlantic region for the purposes of this discussion extends from the Canadian-Maine border to the western end of Long Island Sound. (See Figure 9) The land portion of the region includes the New England states of Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut. The inshore water bodies include Long Island, Block Island, Rhode Island, Vineyard and Nantucket Sounds and Narragansett, Buzzards, Cape Cod, Massachusetts, Saco, Casco and Penobscot Bays. Offshore areas include the Gulf of Maine and the Georges Bank. The shoreline is extensive and totals 6 998 km with Maine (4 022 km) and Massachusetts (1 931 km) containing 85 percent of the total shoreline. Approximately 87 percent of the shoreline is in private ownership, primarily in the state of Maine, (97 percent privately held). The wide continental shelf ranges from approximately 240 km to 320 km and extends to depths of 100-200 m. A number of submarine canyons cut its seaward slope. Lease areas in the Georges Bank embayment region are scheduled for sale for petroleum and gas exploration and production. Figure 10 shows the proximity of oil and gas lease tracts to major fishing grounds on the Georges Bank. There are 5 major river basins in the estuarine system and the North Atlantic estuaries total some 155 000 hectares (U.S. Department of Interior, 1970).

There are four separate water masses off the northeast coast of the region. These masses are: coastal water, slope water, Gulf Stream and ocean water. Most of the water over the continental shelf is coastal water. Seaward of this coastal mass is the slope water which does at times mix with the coastal water. Beyond the slope water mass lies the Gulf Stream which meanders in eddies toward the continental slope and shelf. Further offshore are the deeper water of the North Atlantic Basin.

Coastal waters have a complex and seasonally-dependent circulation pattern. Seasonal winds and coastline influence cause formation of eddies and gyres. The Georges Bank eddy has one of these seasonally-dependent patterns with a cyclonic circulation and a generally southern drift. North of the Georges Bank another eddy, encompassing the Gulf of Maine, is formed. This Gulf of Maine eddy is anticyclonic and receives water from the Atlantic, off Nova Scotia. The eddy flow then may diverge, with one portion flowing into the Bay of Fundy and the remainder flowing westerly to the coastal margin and turning southerly, either into Massachusetts Bay or complete the gyre by flowing eastward. The eddy slows during the summer and in autumn and winter moves into the northeastern section of the Gulf of Maine. Offshore winds tend to break up the Georges Bank eddy. Figure 11 depicts the surface currents along the North Atlantic coast.

Water pollution problems stem from industrialization and inadequate municipal wastewater treatment. Rural uses make up 85 percent of the total coastal area. Population density of the estuarine zone (persons per sq km) ranges from a low of 12 (Maine) to 315 persons per sq km in Rhode Island (Wastler and Wastler, 1972). Of all the rural land uses in this area, forest occupies 47 percent of the total (2.2 million ha). Paper mill effluent affects the estuarine zone in Maine. High organic mill wastes cover shellfish beds and provide media for bacterial pathogens. Pulp and paper mill discharge is 550 000 kl per day. There are fifteen major fishing ports and 9 major shipping ports. Petroleum shipments made up from 75 percent to 93 percent of commerce in these ports and 88 percent to 99 percent of the crude petroleum was of foreign origin.





Figure 9. The North Atlantic Region



PRINCIPAL DOMESTIC TRAWLING GROUNDS  
GEORGES BANKS WITH TRACTS SUPERIMPOSED

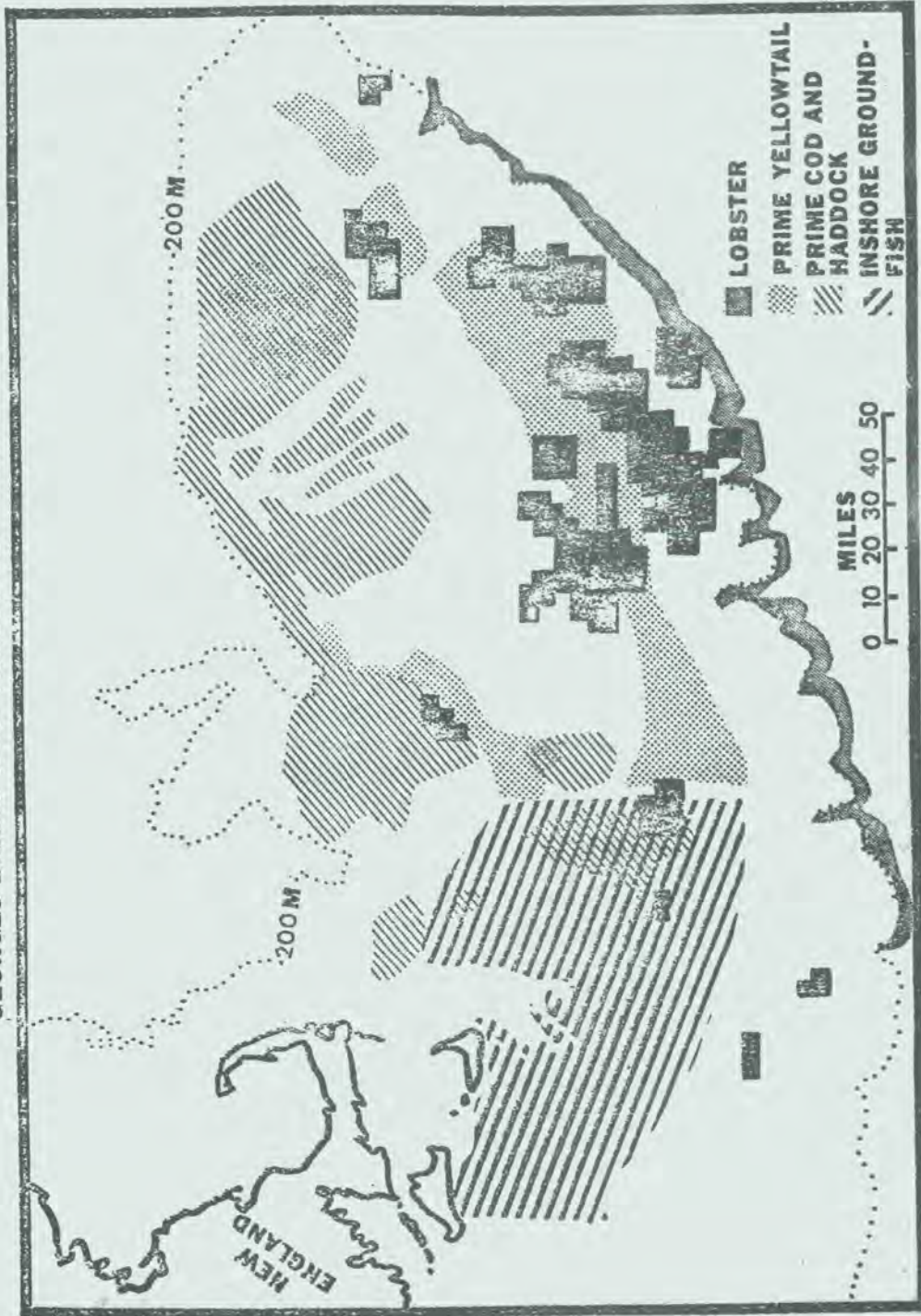


Figure 10. Proximity of Oil and Gas Lease Tracts to Major Fishing Grounds on Georges Bank (after Olson and Seila, 1976)





Figure 11. Surface Circulation of the North Atlantic Region (after U.S. Department of Commerce, 1973)

Even though shoreline urbanization is low, inland developed areas and the incidence of inadequate or untreated sewage ocean discharge affects the inshore region. Connecticut requires that all wastewater discharged into the ocean is treated to at least primary level but only 40% of the communities have treatment plants. Only 64% of the Rhode Island population have sewage treatment and some untreated sewage reaches the inshore area. In Massachusetts 2.27 million kl of municipal wastewater is discharged daily. In the Boston metropolitan area (population 641 000) combined sewer overflows enter the estuaries. Raw sewage outfalls are present in New Hampshire and in Maine and less than 15% of the wastewater plants have secondary treatment (TRIGON, 1974). Because of high coliform bacteria levels, more than 60 estuaries in this region are closed to shellfishing. Depuration from bacterial contamination is possible but it requires transportation and control over the process (Berg, 1974).

Electrical power generation has increased the thermal load in the estuarine zone. There are 6 nuclear electrical generating plants in this region. In Connecticut, cooling water from power generating amounts to 15 million kl/day and this is more than 10 times the amount of municipal and industrial wastewater discharged daily. Cooling water discharge in New Hampshire is nearly 2 million kl daily and in Maine this amounts to 4.85 million kl/day, slightly less than the total industrial wastewater production (U.S. Department of Interior, 1977). Chlorine and other antifouling chemicals used in power plant cooling operations



combine with metabolic waste products and both can impinge on the aquatic environment and pose a public health hazard. Release and build-up of such chemicals has been involved in fish kills.

The easternmost extension of the U.S. continental shelf is the Georges Bank. This bank, approximately 42 000 km<sup>2</sup> in area (280 km long by 150 km wide) is one of the most productive fishing areas of the world. Fishing by more than 17 nations harvests nearly a million metric tons of seafood annually (TRIGOM, 1974). Estimated finfish biomass from the Hudson Canyon to the south end of Nova Scotia is 5.4 million metric tons or 913 kg/ha (Edwards 1968). For the five-year period (1968-1972) the U.S. landings from the Georges Bank, Rhode Island Sound and the Gulf of Maine averaged 0.85 million metric tons annually with an estimated value of U.S.\$ 28 million with 57% of this catch coming from the Georges Bank area. The primary methods of commercial offshore harvesting is by trawling. Such species as yellowtail flounder, gray sole, cod, haddock, summer flounder and butterfish are harvested by trawlers. Dredges are used for sea scallops. Lobsters and crabs are caught by pots. Longline fishing, purse seining and gillnetting are also carried out. In 1975 there were nearly 31 000 commercial fishermen employed in the New England area. U.S. fisheries in the North Atlantic region, in descending order of value, are: menhaden, yellowtail flounder, sea herring, ocean perch, cod, whiting, American lobster, northern shrimp, black back flounder and pollack. Shellfish such as hard clams, soft clams, sea scallops and oysters are harvested inshore. Table 5.1 summarizes the landings and values of the commercial marine catch, 1975, for this region. Brown (1976) identified only yellowtail flounder and mackerel as being under environmental influences. Quotas and gear regulation have been determined by the International Commission of the Northwest Atlantic Fisheries (ICNAF). Both Canada and the United States have declared a 200-mile fishery jurisdiction zone.

Recreational fishing is significant in the North Atlantic states with 3.8 million participants during the 1973-74 period. Massachusetts had the greatest non-resident fishermen at 700 000 persons, while in Maine 71% of the fishermen came from out of the state (U.S. Department of Commerce, 1975. Participation in marine recreational fishing, 1973-74). In the 1970 Salt Water Angling Survey (U.S. Department of Commerce, 1973) sport-fishermen from the North Atlantic caught over 267 million pounds of finfish.

Table 5.1  
North Atlantic Region  
Landings (1 000 Metric Tons) and Value (U.S.\$ 1 000)  
of Commercial Marine Catch, 1975 (Preliminary)

State	Finfish		Shellfish		Total Finfish & Shellfish	
	Landings	Value	Landings	Value	Landings	Value
Maine	46	7 305	17	41 194	63	48 499
New Hampshire	0.8	327	0.3	979	1.1	1 306
Massachusetts	111	50 973	5.6	14 766	116.6	65 739
Rhode Island	32	9 900	3.8	8 870	35.8	18 770
Connecticut	2.7	956	0.6	1 679	3.3	2 635
<b>Total</b>	<b>192.5</b>	<b>69 461</b>	<b>27.3</b>	<b>67 488</b>	<b>219.8</b>	<b>136 949</b>

Source: Individual State Summary and U.S. Department of Commerce. Fisheries of the United States, 1975. Current Fisheries Statistics No. 6900, 1976



## 5.2 Oil and Gas Exploration and Production

The following material, dealing with the proposed oil and gas lease sale located offshore of southeastern New England, is derived primarily from the Draft Environmental Statement for Oil and Gas Lease Sale No. 42, U.S. Department of Interior, 1977.

The proposed lease sale area, in the Georges Bank Basin, comprises 474 626 hectares and is located approximately 76-332 km offshore in water depths of 36-210 metres with the nearest landfall being the Cape Cod area of Massachusetts. Projected undiscovered recoverable resources range from 0.18 to 0.65 billion barrels of oil and 33.9 to 121.7 billion m<sup>3</sup> of gas. The range of figures represent the estimated low resource production and the maximum projected recovery. Peak daily production may yield between 53 000 to 181 000 barrels of oil and 13.3-43.6 million m<sup>3</sup> of gas. There are estimated to be between 128 to 400 production wells and between 10 and 25 platforms. Production life of the field is estimated to be 20 years, with peak drilling to take place in the early and mid 1980s with peak production occurring about 1990.

Potential onshore impact will depend on the extent of recoverable resources. An estimated 663-885 ha will be utilized for onshore operations bases, terminal and storage facilities and gas processing plants. Potential onshore operating bases include New Bedford, Boston and Gloucester in Massachusetts; Davisville, Rhode Island; Portsmouth, New Hampshire and Portland, Maine. All have adequate facilities and are conveniently located.

Because of quantity of potential resources and the present lack of refineries in New England, it is most probable that oil will be tankered to existing Mid-Atlantic refineries in New Jersey and Delaware. Gas will be piped through corridors in southeastern Massachusetts or south Rhode Island. One to three pipelines would run from offshore production units to onshore facilities. The pipelines would traverse 440-1 575 km from tracts to onshore areas. New gas processing facilities may necessitate additional onshore pipeline. There is at least one oil product pipeline presently in the coastal region of each of the North Atlantic states except New Hampshire. Natural gas transmission lines are to be found in the coastal regions of each state in the area. New oil refineries may be constructed, depending on yield, in either southeastern New England or northern Massachusetts Bay and oil production pipelined to the refinery location. Location of new refineries in other North Atlantic areas will necessitate tankering.

Employment projections have been made for the New England coastal region based on recoverable resources and onshore activity. On a regional basis, changes of less than 1% from base levels could be expected. The proposed lease sale would increase the number of jobs in the region from approximately 6 800 to 10 250 persons (1 000 to 2 100 would be directly related to oil and gas production). It could be expected that the population increase for the region would amount to 12 700 to 25 500 persons. The greatest economic changes are expected in areas of Rhode Island and coastal southeastern Massachusetts, especially in private investment.

Oil and gas exploration will affect the fisheries in two general ways: chronic input of hydrocarbons and associated drilling brines and physical obstruction or removal of areas from fishing by pipeline corridors and platform placement.

The primary hazard in the development of oil and gas resources is the probability of oil spills. Spills can result from accidental discharges, intentional discharges and tanker casualties. Accidental discharge is considered the major source. A proximity scale for spills was developed for use in analysing impacts and discussed in the environmental statement cited above. The proximity scale was based on distance in days a spill was located from a significant resource (velocity of a spill was calculated to be 19.3 km/day). An oil spill occurring in the closest tract from shore (76 km) would take an average of 4 days to reach shore. Offshore structures were also assigned a proximity value, recognizing that an oil rig or platform lies within a significant resource or multiple use area or lies outside such an area.



All of the tracts (206) have a high proximity value for oil spills and structures affecting commercial fishing. This indicates that all lease blocks represent a high disruption potential to commercial fishing activities. Using fall distribution of certain fish species two tracts are contained in areas of greatest relative abundance of fish (191-260 fish/tow) and 123 tracts lie within the area of next highest relative abundance (126-190 fish/tow). Species evaluated were demersal spawners with pelagic eggs and included cod, haddock, pollock, whiting, red hake, dab and yellowtail flounder (Olson and Sails, 1976). A spill from a platform in the autumn would have over a 60% chance of occurring in one of the two areas of highest relative abundance. Using spring distribution pattern of the same species it was found that no tracts lie within the area of greatest relative abundance (126-325 fish/tow) and only two tracts lie within the next highest relative abundance (76-125 fish/tow). Thus a platform spill in the spring would only have a 1% chance of occurring in an area with a high density of fish. According to a report from the Marine Policy and Ocean Management Program, Woods Hole Oceanographic Institution, 1976, the most productive 10% of the fishing area produces 37% of the catch or expanded 16% of available space produces 50% of the domestic catch. This report also concluded that, using their criteria, the hypothetical reduction in catch would be 0.06% and if space between platforms would be unavailable for fishing the catch reduction would be 0.7%. Mortalities could also occur in early life stages of commercially important species. Combining spawning area data with tract location it can be seen that 9% of the total tracts (41 000 ha) are contained within cod and herring spawning grounds and 15% of the total lease sale area (71 000 ha) lie inside the whiting and red hake spawning grounds.

Formation waters (brines) are produced during the oil and gas production phase. These waters have virtually no oxygen, high concentration of sodium chloride, suspended solids and trace metals and may contain up to 30 ppm of oil. In general the ratio of formation water to oil produced is 1:1 and up to 181 000 barrels a day of formation water will be produced during peak oil and gas production. This volume will introduce 253-862 l per day of oil into the environment or a total of 2.6 million barrels of oil over the 20-year life expectancy of the oil field.

The probability of oil spill impact on the pelagic species on the Georges Bank is higher than for land-based resources. There is a 93% probability that at least one major spill will occur from platforms and tankers. The expected number of minor spills is 1 778 with 99% chance that at least one spill will occur. The probability of an oil spill impacting on cod, haddock, silver and red hake spawning grounds is from 32-61% depending on origin and tanker route. Table 5.2 summarizes predictions of the frequency of oil spills arising from the proposed development. The patterns of impact on fisheries of the spills and other events would presumably be similar to that of the oil industry in the Gulf of Mexico.

In addition to the possible impact of future offshore oil drilling, there is already appreciable oil pollution from other sources, particularly accidents to oil tankers bringing oil from outside the region. Table 5.3 summarizes the spills that occurred in the region from 1960 to 1974.

An oil spill of 246 metric tons of number 2 fuel oil in Buzzards Bay, Massachusetts, contaminated molluscan shellfish in the area and caused the closure of these beds. This closure, regardless of the rationale, resulted in an estimated shellfish harvest loss of U.S.\$ 150 000 (Blumer *et al.*, 1970).

The study of oil spill recovery in Penobscot Bay, Maine, reported only 22 out of 157 metric tons of the estimated standing crop of soft clams survived (Dow, 1976). The effects of this spill resulted in an 85% mortality up to three years after the initial accident. Using the 1975 ex-vessel price of U.S.\$ 1.75 per kg, the value of lost yield, as shucked meats, was U.S.\$ 236 250.



The grounding and breakup of the tanker ARGO MERCHANT off Nantucket Shoals in December 1976 led to the spilling of 22 million litres of industrial fuel oil. Easterly winds caused the spill to reach the Georges Bank with a large part of the oil sinking to the bottom and harvested sea scallops were unsalable because of contamination. The spill did not reach shore and no fish kills were reported but large numbers of birds were contaminated with oil. Some shellfish from the contaminated area have exhibited lower respiration rate than control animals and cod and pollack eggs collected from the affected area did not develop normally. Studies of the effects of the spill are continuing and thus far U.S.\$ 1.4 million has been spent on combating the effects of the spill (Coastal Zone Management, 1977). A report of studies and preliminary conclusions are in preparation by the U.S. Department of Commerce.

Table 5.2

Oil Spill Frequency Estimates by Source for North Atlantic  
Lease Area No. 42 During Production Period (20 Years)

Volume and Source	Expected Number	Probability of at least one spill
A. Spills: 1 000 barrels		
Platforms	1.1	0.65
Pipelines	1.3	0.69
Tankers	1.7	0.81
Platforms and Pipelines	2.4	0.89
Platforms and Tankers	2.8	0.93
B. Spills: 50-1 000 barrels		
Platforms and Pipelines	8.9	0.99
Platforms and Tankers	NA	NA
C. Spills: 0.50 barrels		
Platforms and Pipelines	1 778	0.99
Platforms and Tankers	NA	NA

Source: Draft Environmental Statement for Oil and Gas Lease Sale No. 42,  
U.S. Department of Interior, 1976



Table 5.3  
Summary of Oil Spills, North Atlantic 1960-1974

Location	Volume (kl)	Type	Year
Newfoundland, Canada	180	Bunker	1960
Newfoundland, Canada	114	Not Given	1967
New Hampshire Coast	758	Not Given	1969
Weymouth, Massachusetts	379	Not Given	1969
Buzzards Bay, Massachusetts	697	Diesel Fuel	1970
Gulf of St. Lawrence	3 787	Crude	1971
New Haven Harbor, Connecticut	1 462	No.2 Fuel	1971
New London, Connecticut	303	No.6 Fuel	1972
Portland Harbor, Maine	568	No.6 Fuel	1972
Salem Massachusetts Harbor	114	No.2 & No.5 Fuel	1972
New Haven, Connecticut	379	No.4 & No.6 Fuel	1973
Cape Cod, Massachusetts	833	Heavy Oil	1974
Bay of Fundy, St. John's, New Brunswick	125	Crude	1974
Saglek, Newfoundland	1 893	Diesel	1974
Dalhousie, New Brunswick	238-317	No.6 Fuel	1974
Gloucester, Massachusetts	52	No.2 Heating Oil	1974

Data from: van Gelder-Ottway and M. Knight, Review of World Oil Spillages, 1960-1975  
in: Baker, J.M., editor, Marine Ecology and Oil Pollution, 1976

### 5.3 Fish Kills

Table 5.4 summarizes the information on fish kills in the North Atlantic region for 1972-1976.

The primary source of reported fish kills in the New England states for the years 1972-1975 has been municipal operations. These operations include sewerage systems, refuse disposal, water systems and power generation. A large number of kills associated with power generation occurred (slightly more than 50% of those incidents which cited a cause). Mortalities were caused by either entrainment in cooling systems, fouling control chemicals, gas embolism or temperature shock. Massachusetts waters accounted for the greatest number of mortalities during the period 1972-1975, aided by the massive 1 million fish killed in the Cape Cod Canal in 1972. Although no fish kills were reported for the coastal area of Massachusetts during 1974, in the latest annual Environmental Protection Agency summary the state led in the number of reports for the period considered here.

For individual states the prime pollutant sources and associated fisheries were as follows: In Connecticut industrial discharge was the pollutant source and the affected fishery was menhaden. In Maine, pesticides were the major pollutant and the shad and salmon fisheries chiefly affected. Massachusetts cited municipal waste as the cause of kills and shellfish the fishery affected.



Using the same evaluation technique of fish kill value as in the Gulf of Mexico (section 2.3) the revenue loss due to fish kills can be estimated as follows:

1972	U.S.\$ 69 960
1973	U.S.\$ 30 954
1974	U.S.\$ 8 448
1975	U.S.\$ 4 686

**Table 5.4**  
Fish Kills and Values - North Atlantic Coastal Zone

Year	Location	Water Type	Number of Fish Killed (1 000's)	Cause	Value U.S.\$
1976 (1st 6 months)	New Hampshire	Estuary	<u>10</u>	Heavy Metals	
		1976 Total	10		1 000
1975	Connecticut	Estuary	15	Unknown	
	Massachusetts	Estuary	32	Unknown	
	Massachusetts	Estuary	15	Industrial Works	
	Massachusetts	Salt	<u>9</u>	Not Given	
		1975 Total	71		7 100
1974	Connecticut	Salt	100	Sewage	
	Connecticut	Salt	20	Sewage	
	Connecticut	Estuary	<u>8</u>	Heavy Metals	
			1974 Total	128	
1973	Connecticut	Estuary	9	Unknown	
	Massachusetts	Estuary	350	Unknown	
	Massachusetts	Estuary	75	Power Company	
	Massachusetts	Estuary	<u>35</u>	Unknown	
		1973 Total	469		46 900
1972	Connecticut	Estuary	25	Power	
	Massachusetts	Salt	1 000	Power Company	
	Massachusetts	Salt	20	Power Company	
	Massachusetts	Salt	10	Power Company	
	Massachusetts	Salt	<u>5</u>	Power Company	
		1972 Total	1 060		106 000
Grand Total			1 738 x 10 <sup>3</sup>		173 800

Source: U.S. Environmental Protection Agency, 1972-1976



#### 5.4 Dredging and Filling Operations

Dredging for harbour maintenance and improvement is less important in this region than in the other regions considered in this report. Portsmouth, Gloucester, Boston and New Bedford harbours do not require continuous maintenance dredging. There are 8 approved dredge spoil sites in the New England region and over 305 000 m<sup>3</sup> of dredged material was deposited during 1973-1974. Additional sites are designated in Long Island Sound.

Urban growth in the New England region will increase the need for water-related recreational facilities and resources. The loss of estuary habitat to these uses is, therefore, likely to increase.

Estuarine-dependent fisheries are prevalent in the North Atlantic region. Many species of shellfish are found only in this inshore environment and numerous finfish species spend varying portions of their life cycle there. The entire offshore winter flounder fishery of Rhode Island (except for Georges Bank stock) may be a result of salt pond and Narragansett Bay production (Saila and Pratt, 1973). The effect of the loss of estuarine habitat has been calculated in the same manner as for other regions. The results are given in Table 5.5.

#### 5.5 Shellfish Area Closures

Over 99 percent of all hard clams and all soft clams (the two major clam species in the region) are harvested within 5 km of shore. Both are estuarine, hard clams being sessile and soft clams intertidal and therefore they are subject to the impact of land-based and inshore pollution. These species are affected by the unpredictable but repeated occurrences of toxic dinoflagellate blooms in the New England area. Soft clam landings have overall been on the increase in this region except for the 1975 drastic drop in Rhode Island. The New England landings make up 74% of the total 1975 U.S. soft clam production. Hard clam harvest has increased appreciably, especially in Maine, with a minor reduction (-12%) in 1975 from Massachusetts. New England harvests 11% of the total 1975 U.S. hard clam landings. In 1975, the hard and soft clam landings of this region accounted for approximately 10% of total U.S. commercial clam landings and 25% of the national ex-vessel value (U.S. Department of Commerce, 1976. Fisheries of the United States. Current Fisheries Statistics No. 6900, and individual state annual summaries). Nearly all small hard clams are consumed raw or lightly steamed. Their habitat must be monitored because of potential public health hazards. Water pollution is a major problem of the clam industry. Sewage outfalls, contributing substandard treated and untreated waste water are the major sources for domestic pollution. In Maine, for example, less than 15% of municipal waste water has had secondary treatment. The state of Massachusetts discharges 2 271 million litres/day of waste water into coastal waters. Seventy percent of Rhode Island is rural and undeveloped with only 64% of the population being served by predominately primary treated sewage. Increased recreational use of shore sites imposes increased domestic pollution levels on inshore areas. Accumulation of industrial pollutants in Narragansett Bay has necessitated long-term closure to shellfishing of sections of the bay. Sections are rated conditional, depending on rainfall and storm sewer overflow.

Maine, Massachusetts and Maryland have been major soft clam producers over the past ten years (approximately 92% of total U.S. landings). New England resources for soft clams decreased in the late 1940s and early 1950s with the Maryland harvest increasing and peaking until the early 1970s. In 1975 Maryland landings were approximately 453 metric tons and New England harvest was 3 400 metric tons.

Soft clams are affected by much the same forms of pollution as hard clams. Soft clams may be more susceptible since the major segment of this resource occurs only in onshore intertidal areas. Because of toxic dinoflagellate blooms (*Gonyaulax* sp.) in 1972 and potential paralytic shellfish poisoning (caused by eating molluscs containing toxic concentrations of dinoflagellates) all soft clam harvesting areas north of Cape Cod were closed.



Table 5.5

Loss of Estuary Habitat due to Dredging and Filling -  
North Atlantic States (Area in hectares)

State	Total Estuary Area	Area of Important Habitat	Area Lost by Dredging & Filling	Annual Catch Value/ha	Value (U.S.\$ 1 000)	Capitalized Value (U.S.\$ 1 000)
Maine	15 917	6 181	404 (6.5)	279.20	112.7	2 504
New Hampshire	5 009	4 040	404 (10.0)	160.00	64.6	956
Massachusetts	83 628	12 524	808 (6.5)	192.35	155.4	2 296
Rhode Island	38 258	5 938	363 (6.1)	76.60	27.8	672
Connecticut	12 766	8 201	848 (10.0)	81.50	69.1	1 709
Totals	155 578	36 884	2 827		429.6	8 137

Based on a combination of: National Estuary Study, U.S. Department of Interior, 1970 and Tibbansky and Meade, 1976, Economic Contribution of Commercial Fisheries in Valuing U.S. Estuaries



Blooms of lesser intensity have also happened from 1974 to 1976. Nutrient input from waste water sources could be instrumental in bloom occurrence but there is some difference of opinion as to relative influence of human input. All New England clam-producing states carry out PSP (paralytic shellfish poisoning) monitoring to detect the appearance of toxic levels of dinoflagellates. Maine reported 29 000 ha closed to shellfishing for years due to domestic pollution. One productive soft clam area in Maine, because of fuel and jet fuel oil contamination, has been closed since 1971 (Dow, 1976). In Massachusetts, 64% of potential softshell clam grounds are closed due to domestic pollution.

The extent of closed areas, using the same classifications as for other regions, is given in Table 5.6.

Since the previous Shellfish Register (1971) the 5 state North Atlantic region has had only minor changes (approximately  $\pm 1\%$ ) in its classified waters with one exception. Connecticut had a decrease of almost 6% in the approved area category and an increase of almost 6% in the closed areas. New Hampshire does not harvest shellfish commercially, nor does it classify estuarine waters. All its areas are open for recreational harvesting which is open only to state residents for personal consumption. All other states have classified 100% of their estuarine waters.

Connecticut has the highest percentage (17.5%) of area closed to shellfish harvesting. Second in percentage but having the least actual closed area is Rhode Island. Maine has the largest closed area (41 000 ha) and the largest total open area.

Using the same methods as before, the economic impact of these closures has been estimated (Table 5.7).

Maine, with the largest closed area, had 0.6 million potential loss of soft clam harvest due to the closure and Rhode Island, with the smallest closed area of this region, showed almost half of Maine's lost revenue, U.S.\$ 0.29 million. The total estimated lost revenue due to closure of shellfish harvesting areas is nearly U.S.\$ 1.5 million.

## 5.6 Beneficial Aspects of Pollution

### Artificial Reefs and Oil Platforms

In comparison to other regions along the U.S. coast, few deliberate man-made artificial reefs exist in the North Atlantic region. There is one small, primarily scrap tire reef, in Massachusetts Bay and two artificial emplacements off the eastern end of Long Island (Stone *et al.*, 1974). There are, however, approximately 175 charted ship and warship wrecks that exist in this region within 5 km of shore that provide artificial substrate (U.S. Department of Interior, 1977, Visual 1). Bales of shredded and compacted solid waste have been used on an experimental scale in shallow waters off New Hampshire and Woods Hole, Massachusetts. Breakdown of the food wastes added nutrients to the water column and colonization was relatively rapid and it was concluded that with properly processed waste and monitoring the refuse was not an ecological hazard (Lodar *et al.*, 1974).

Placement of exploratory and production oil platforms on the lease tracts offshore from this region will not greatly affect sportfishing activity. Such offshore platforms would be expected to act as artificial reefs to enhance and concentrate fish populations. However, because of the distance to shore (closest tract to land is 76 km from shore) and the predominance of small boat, day-use, sportfishing that exists in this region, general fishing use of these platforms is not expected.



### Thermal Addition

Large volumes of water used for cooling of electrical generating plants and subsequently heated is available in this region for aquaculture. However, incidences of mortalities caused by power plant operations must be taken into consideration. Shutdown of the plant, with resulting extreme temperature fluctuations, use of biocides to reduce fouling and gas embolism because of water temperature increases are the prime causes of mortalities and must be taken into consideration in siting of aquaculture facilities (Huguenin and Ryther, 1974).

Maine Salmon Farms, Inc. uses thermal discharge from a fossil-fuel power plant for the grow-out of coho salmon. The grow-out area is located in the tidewater area of the Sheepscot River in Maine and water temperature is raised 3°C. This temperature increase stimulates growth during the cold months of the year and also maintains the area free from ice. Salmon eggs are flown from the west coast of the United States and after hatching fry are acclimated and moved to graduated mesh pens until harvest at 14 months. "Pan size" salmon are harvested weekly and distributed to restaurants from Maine to New York. Total production rose from 341 kg in 1974 to 18 182 kg in 1976. Price per kg was U.S.\$ 4.84 in 1976 for a value of U.S.\$ 88 000 (Peterson and Seo, 1977).

Experimental culture of the mussel, Mytilus edulis, was attempted at varying distances from the heated effluent from an electrical generating nuclear power plant in Maine. At increasing distances from the discharge waters the shell growth increased and mortality decreased. Both shell growth and survival were significantly lower in the discharge waters than at the control sites. There was also a reduction in total number of spat in the vicinity of the heated effluent. Growth rates and survival at the control site using rafting techniques indicated that this rafting could produce marketable mussels in 12-13 months when temperatures remained below 20°C (Lutz and Porter, 1977).

### Waste Water Utilization

Alga aquaculture on a pilot scale utilizing a recycling waste water system has produced potentially commercial yields. Two species of red algae were cultured in a three stage recycling system as final polishing step before discharge of the effluent. Mean annual dry weight production (10-15% of wet weight) was from 32.9 to 63.2 metric tons/ha when expanded from the pilot plant size. This operation took place in the North Atlantic region and production in warmer climates was estimated to exceed 50 metric tons /ha based on a 5-6 month growing season (DeBoer and Ryther, 1977).



Table 5.6

Shellfish Area Classification in Hectares  
(U.S. Environmental Protection Agency, 1975. National Shellfish Register)  
North Atlantic Region (New England States)

State	Open	Conditional	Closed	% Open	% Condit.	% Closed
Maine	376 650	2 644	41 004	89.0	0.6	9.7
New Hampshire	No commercial shellfish harvesting - Estuarine waters not classified					
Massachusetts	125 863	136	11 765	38.8	0.1	3.6
Rhode Island	38 874	4 387	8 151	75.6	8.5	15.9
Connecticut	100 709	902	27 917	63.3	0.6	17.5
Total Area (ha)	642 096	8 069	88 837			

Open waters: Approved by state agency for direct market harvesting  
Conditional: Meet "OPEN" standards but are subject to periodic closure  
Closed: Closed for harvesting of shellfish due to hazardous level of contamination

Table 5.7

Estimated Loss in Values from Closed Shellfish Areas  
Hard Clams (Mercenaria sp.) and Soft Shell Clams (Mya arenaria)  
North Atlantic States, 1975

State	Productivity Factor	Closed Area (ha)	Meat Weight (Metric Tons)	Price/kg (U.S.\$)	Value Lost (U.S.\$ 1 000)
Maine (Soft clams)	17.3	41 004	321	1.91	615
Massachusetts (Hard clams)	3.9	11 765	21	3.15	65
Rhode Island (Hard clams)	28.8	8 151	107	2.80	299
Connecticut (Soft clams)	12.1	27 917	153	3.00	458
Total Loss					1 437

Productivity Factor: 1975 Production divided by 1975 open area (ha)  
Price/kg: 1975 ex-vessel prices for each state

Source: Draft of Review of Commercial Oyster Industries in the United States (1977)  
and Annual Summary of Landings, of Individual States, for 1975



## 6. DISCUSSION

### 6.1 Summary of Effects

This section summarizes the four probable and documented impacts of man's activities on fisheries resources that have been discussed in this report. Although Wise, 1974, using only catch records, states that "pollution and damage to estuaries have not yet shown any measurable overall effect on the part of the marine resource which might be expected to show the first effects" he qualifies this remark by correctly pointing out that no good fishing effort data are available for estuarine species whose catch have remained constant. Catch records could remain level or even increase due to increasing fishing effort in time, area fished or technological efficiency and not reflect the effect of pollution. The catch trends of numerous species are indicative of changes or deficiencies in management of the resource.

It should be pointed out that the estimates presented herein for losses are conservative and the documentation used to substantiate them is uneven. Much of the data were collected for other purposes and suggestions for greater utilization of such related information is made in the "recommendations" section.

The estimates of losses should be seen against the total value, at the time of landing, of the commercial fishery, given in Table 6.1.

Table 6.2 presents a summary of the U.S.\$ value of fishery resources impacted by pollution in regard to type of impact and by geographical region. This impact on commercial fisheries amounts to nearly 8 percent of the total value of the finfish and shellfish catch for the Gulf of Mexico and the Atlantic coast of the United States.

The economic impact of pollution on sportfisheries is poorly documented. In some regions sportfishing catch is estimated to be equal to commercial landings so that in reality the sport fisheries subtotal in Table 6.2 may be an order of magnitude higher.

Large-scale mortalities "fish kills" caused by pollution and water quality degradation resulted in the highest U.S.\$ value losses. The middle Atlantic region was extremely vulnerable to this type of impact, with the biggest loss due to the estimated anoxia-caused mortalities during 1976 (U.S.\$ 10.8 million). This region contains the highest urban and industrial development of the entire coastline discussed in this report. Most resources mortalities are random with the exception of certain localized areas.

Physical removal and alteration of the substrate and subsequent unsuitability of the estuarine and similar habitat for resource development resulted in an estimated loss of nearly U.S.\$ 14 million. The Gulf of Mexico region accounted for over half the total loss due to this activity.

Closure of areas to the harvest of molluscs contributed 20 percent of the total commercial fisheries U.S.\$ loss due to pollution impacts (U.S.\$ 8.8 million). The Gulf of Mexico region accounted for nearly 65 percent of this loss. This public health consideration, for the most part, has little effect on the resource itself, but removes it from human consumption.

It should be pointed out that the impact of oil and gas production on the fisheries resources in Table 6.2 deals primarily with documented impact of the crude and refined products. At the present time there is no oil or gas offshore production in the Atlantic region but such activity is to be expected following federal lease sales now at various stages of completion. Discussion of probabilities and resources affected are presented in the text for the various regions.



Table 6.1

Summary of Landings (1 000 metric tons) and Value (U.S.\$ 1 000)  
of Commercial Marine Catch, 1975 (Preliminary)

Gulf of Mexico and Atlantic Coast of United States

Area	Finfish		Shellfish		Total Finfish & Shellfish	
	Landings	Value	Landings	Value	Landings	Value
Gulf of Mexico	639	62 948	107	204 318	746	267 266
South Atlantic States	114	19 483	28	40 963	142	60 446
Middle Atlantic States	96	21 692	91	75 147	187	96 839
North Atlantic States	193	69 461	27	67 488	220	136 949
Total	1 042	173 584	253	387 916	1 295	561 500

Source: Individual State Summary and U.S. Department of Commerce, 1976.  
Fisheries of the United States, 1975. Current Fishery Statistics, No. 6900

Table 6.2

Summary of Economic Assessment of Major Pollution Impacts  
on Fisheries Resources (U.S.\$ 1 000)

Region	Oil and Gas Production	Resource <sup>d/</sup> Mortalities	Dredging & Filling	Shellfish Closures	Inability to Market
Gulf of Mexico	local input	948	7 894	5 722	un
South Atlantic	<u>a/</u>	1 000	1 074	584	un
Middle Atlantic	<u>a/</u>	10 816 <sup>c/</sup>	4 479	1 104	549 <sup>b/</sup>
	<u>a/</u>	3 687			500
North Atlantic	386+	22	429	1 437	500
Totals	386+	16 473	13 876	8 847	1 549
					41 131

This table does not take into account unemployment due to lack of resource caused by pollution  
un - undeterminable

a/ No present oil and gas offshore production,  
for potential see text

b/ Kepone related

c/ New York Bight Anoxia, 1976

d/ Annual average 1973-1975



## 6.2 Recommendations

Based upon the preparation of this report and the recognized necessity of further refinement of analysis of the impact of pollution on fisheries, the following recommendations are made. There is no inference as to priority.

- (1) Increase the utilization and presentation of data from related disciplines:

Data exist in related disciplines that are underutilized and could affect analysis of pollution-related impacts on fisheries. Land use of the coastal zone, employment profiles, competition for onshore marine facilities and energy demands are examples of but a few of these related inputs. Consideration of data input from such sources would increase the level of substantiation.

- (2) Closer coordination among the pollution control agencies themselves as well as with fishery managers:

Cooperation from local, state and federal pollution control agencies has been excellent and their input to this report is appreciated. Clarification of several situations would have been of benefit. The occurrence and/or levels of resource mortalities was not always cross-referenced and could be missing from agency records. Various types of data, important to fisheries analysis were not reported because the need had not been properly demonstrated by fishery managers. Inclusion of such information along with automatic data processing procedures would increase documentations with relatively little cost increase.

- (3) Determination of unit values for pollution-affected fisheries correlated with an economic marketing model:

Certain species resources will have a fluctuating unit value rather than a mean monetary value. A monetary unit value exists for freshwater species of the United States but it is based on unit replacement cost, i.e. restocking, and none exists for North American marine species. It must be recognized that the reduction or elimination of a resource may not necessarily reflect a linear relationship with a monetary fluctuation in the value of a fishery. An economic marketing model reflecting supply (reduced landings) locale, time of year and demand (reflected in ex-vessel values) developed for vulnerable species would enhance the precision of an impact analysis.

- (4) Define and determine realistic non-market values of resources affected by the impact of pollution:

Recreational usage of coastal areas impacted by alteration of estuaries and degradation of water quality has been defined for a number of localities but methods of evaluation have varied. Although there may be local extenuating circumstances compiling and comparing areas for trend analysis is difficult or not possible when basic methodology is not standard.

- (5) Revise and update the estimates on the impact of pollution at regular intervals:

The burgeoning volume of reports dealing with environmental matters (at varying levels of precision and applicability) necessitates re-analysis for detection of trends on the impact of pollution. Increased urban and industrial development, sociological changes and energy usage in the coastal zone of the United States will in all probability exercise a growing impact on the living marine coastal resources. Annual updating may be too frequent for trend analyses but at least a biennial re-evaluation is in order.



- (6) Establishment of national, regional and/or subregional standardized evaluation regimes of the impact of pollution on resources.

Although there presently exist several waste product management schemes, it is the activation and enforcement of these regimes that lacks standardization. The institution of a pollution evaluation program such as the regional seas concept developed in the Mediterranean Sea could serve as a useful guide.

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