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Fish Health and Environmental Health

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Surveys conducted to evaluate the health of marine-bottom fishes have been conducted in the eastern and western North Atlantic for the past 15 years, usually in conjunction with fish stock assessment cruises. The health of the fish sampled was evaluated using certain integumental and skeletal lesions and anomalies as markers to signify compromised health status. The results of these surveys indicate that fish health is poorer in coastal waters that have been anthropogenically degraded. Monitoring programs to determine the status and trends in levels of inorganic and organic contaminants in fish tissue and sediments have disclosed high levels of chemical contaminants in several coastal areas of the northeastern United States. Histopathological examinations of liver tissues of winter flounder, *Pseudopleuronectes americanus*, from Boston Harbor, one of the more chemically contaminated sites, has revealed a high prevalence of hepatocarcinoma.

One of the research activities of the Northeast Fisheries Center, National Marine Fisheries Service, is the conduct of stock assessment surveys in depth-defined strata of the northeastern continental shelf between Cape Hatteras and Nova Scotia, Canada. On these surveys bottom fishes are collected by otter trawl to acquire information on age, abundance, distribution, growth, fecundity, maturity, food habits, and disease. All of these data are needed to determine stock condition and size for effectively managing the fishery resources.

For approximately 15 years the evaluation of marine fish health has been attempted by a number of fishing nations, especially those that are members of the International Council for the Exploration of the Sea (ICES). Cruises conducted by ICES countries in the southern North Sea and eastern North Atlantic (coastal and offshore waters of the United Kingdom, Denmark, Holland, Belgium, Germany, France, and Spain) have provided opportunities to enumerate integumental lesions such as ulcers of the fins (fin rot) and trunk, lymphocystis (a cytokinetic viral disease), and epidermal papilloma. Although the results of individual studies have not been evaluated with equal statistical rigor, the emerging pattern supports the hypothesis that higher prevalences of these lesions are found in bottom fishes inhabiting anthropogenically degraded aquatic habitats (*1–8*). The ulcerative lesions, in particular, are more numerous in flatfishes from coastal waters adjacent to large urban populations.

Surveys of marine fish diseases in United States coastal waters also disclose higher disease prevalences in presumed degraded environments (*9–18*). Beginning in 1979 and continuing until 1983, ten commercially important fish species (winter, yellowtail, summer, and witch flounder; American plaice; cod; red, silver, and white hake; haddock) collected on stock assessment cruises in the western North Atlantic were examined for the presence of five integumental lesions and pigmentation and skeletal anomalies (fin rot, lymphocystis, trunk ulcers, ambiocoloration, bent fin rays, and axial skeletal deformities). Examinations for fish diseases could be neither skill-intensive nor time-intensive, since they were done in addition to other staff responsibilities. However, enumeration of integumental lesions provided a reasonable and practical first assessment of fish health in a broad geographic area. Fishery biologists were trained to recognize particular lesions and anomalies and were given descriptive aids for use at sea (*19*).

During the 5-year period, 84,700 fishes were examined (*20*). The prevalence and distribution of the lesions encountered was collated for eight discrete areas: five inshore (less than 90 ft in depth) and three offshore (more than 90 ft in depth). Two of the inshore areas were adjacent to large cities, New York and Boston. The results of statistical evaluations to determine differences in disease prevalences between areas and between fish species provided several interesting conclusions. First, fin rot appears to be the best lesion for comparative studies of disease prevalence between the discrete geographic areas surveyed. Second, whenever fish species were sampled adequately inshore and offshore, the prevalence of fin rot was higher inshore, regardless of whether more fish were caught offshore. Third, diseases were not randomly distributed by fish species or by geographic area. Flatfish had more diseases, and inshore areas had more fish with diseases. Fourth, disease maxima cluster in coastal waters adjacent to large population centers; 11 or 18 (60%) of the disease maxima

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are in the inner New York Bight, Massachusetts Bay, and Stellwagen Bank. These areas constitute only 5% of the area surveyed. Fifth, only 20% of the total catch of 84,700 fishes was from inshore, and the inshore area comprised only 20% of the total geographic area surveyed.

In 1984, the National Oceanic and Atmospheric Administration initiated a monitoring program (National Status and Trends Program for Marine Environmental Quality) in the near coastal waters of the United States to determine the status and trends in levels of sediment and fish tissue (liver) and inorganic and organic chemical contaminants. Sediments and tissues are collected annually from approximately 50 sampling sites. Analyses for metals are made using atomic absorption spectrophotometry (AA) and using gas chromatography and mass spectrometry (GC/MS) for organics. The program incorporates rigorous quality assurance and control by using internal standards, unknowns, and standardized analytical procedures. Altogether, 17 metal species, 18 aromatic hydrocarbons, and 15 chlorinated pesticides are quantified (analyses for aromatic hydrocarbons are not made in fish liver).

Presently, data are available only for liver samples obtained in 1984 and 1985 (*21*). In the northeastern United States, Boston Harbor is the most contaminated site and contains fish (winter flounder) with substantially elevated levels of organic chemical contaminants (total chlorinated hydrocarbons = 1078 ppb; DDT = 827 ppb; PCB = 17,487 ppb). Sediment organic contaminant levels (1984) in this harbor also are elevated (DDT = 210 ppb; PAH = 26,437 ppb; PCB = 17,105 ppb). Other northeastern sites (Salem Harbor and Buzzards Bay, MA; Long Island Sound, CT; Hudson/Raritan Estuary, NY; New York Bight) also contained winter flounder with elevated organic contaminant levels, but none as high as in those samples measured in Boston.

Since the 5-year fish disease survey disclosed that winter flounder that were obtained from inshore areas adjacent to centers of large population had higher prevalences of certain diseases than flounder obtained from offshore areas, in 1984 a survey was initiated that sampled winter flounder from selected inshore areas in Long Island Sound, Narragansett Bay, and Massachusetts Bay. The specific areas sampled were New Haven Harbor, upper Narragansett Bay, and Boston Harbor; all areas receive substantial amounts of inorganic and organic chemical contaminants from domestic and industrial sources. Winter flounder obtained from these sites were necropsied and the presence of gross visceral pathology noted. Additionally, a median slice of liver was excised and processed for histopathological examination.

No gross lesions were seen in fish from Long Island Sound or Narragansett Bay; however, examinations of Boston Harbor winter flounder revealed that hepatic tumors were common (*22*). Microscopic examination of liver tissues showed that hepatotoxic and neoplastic lesions were present in approximately 70% and 25% of the 325 flounder respectively. Most of the fish examined were larger than 36 cm in total length; neoplasm prevalence was strongly correlated with length, i.e., larger fish had more neoplasms. The hepatotoxic lesions consisted of a modified form of apoptosis in which hepatocytes had large vacuoles consisting of dilated endoplasmic reticulum. Apoptotic cell areas were acinar in configuration reflecting the tubulosinusoidal morphology of fish liver. Putative preneoplastic liver lesions consisted of foci of cellular alteration. These small areas contained hepatocytes with minimal atypical morphology and pronounced basophilia. Frank neoplasms included hepatocellular adenoma and carcinoma. The carcinomas were morphologically diverse. Hepatocarcinomas usually were solid or trabecular with constituent cells that were either spindle-shaped or polygonal; cholangiocarcinomas were ductular and composed of essentially cuboidal epithelial cells. Other more pleomorphic tumors could be best designated as anaplastic adenocarcinomas. These lesions contained many large cells with large nuclei that frequently were polyploid.

Organic chemical contaminants in Boston Harbor sediments may be responsible for the hepatotoxic and neoplastic lesions described; however, this correlation has not been substantiated yet. Although levels of certain organic chemical contaminants have been determined in liver tissues, it is unlikely that it ever will be possible to determine the identity and quantity of all of the innumerable chemical contaminants that, likely, are present in harbor sediments and waters and that may accumulate in fish tissues.

Despite the high prevalence of neoplastic liver disease, few studies have been made of organic chemical contaminants in tissues other than liver, e.g., muscle. Since winter flounder is an important food fish, analytical, experimental, and epidemiological studies are warranted to determine if increased risk to cancer results from consumption of edible tissues.

The results of the research and monitoring herein reported substantiate that anthropogenic, chemical contamination of the marine environment has caused increased prevalence of certain fish diseases, which also may be compromising the use of fish as food. Unless introductions of toxic chemicals to estuarine and near coastal waters are substantially curtailed by the twenty-first century, fish and environmental health will continue to deteriorate, and nutritional benefits derived from the consumption of fish protein will be negated by adverse effects of chemical contaminants.

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