MFR PAPER 1163

Housing Development Canals in the Coastal Zone of the Gulf of Mexico: Ecological Consequences, Regulations, and Recommendations

WILLIAM N. LINDALL, JR. and LEE TRENT

ABSTRACT—Three types of housing development canals (bayfill, inland, and intertidal) are described, and their effects on estuarine flora, water and sediment quality, and species composition and abundance of fauna are discussed. Varying only in degree, all three types of canal development are similar in adversely affecting the integrity of the estuarine ecosystem.

Existing legislation, designed to minimize adverse alteration in the estuarine zone, is discussed. Presently, full jurisdiction is not exercised over inland canal development. Recent court decisions, however, indicate that jurisdiction will be fully exercised in the near future. To insure continued propagation of estuarine-dependent fish and wildlife resources, guidelines for the location and design of inland canal development are presented.

INTRODUCTION

Population growth in the coastal zone of the United States has intensified the demand for multiple utilization of estuaries, including such activities as petroleum production, shipping, outdoor recreation, commercial and recreational fishing, waste disposal, and the ever-increasing development of residential waterfront real estate. Each user has a legitimate interest in the estuary and the significance of the estuary to each use is well recognized (Sweet, 1971). However, many of the uses are incompatible and inevitable conflicts have evolved among the various interests. Increased environmental awareness in recent years has focused much attention on these conflicts.

William N. Lindall is with the Environmental Assessment Division, Southeast Regional Office, National Marine Fisheries Service, NOAA, 9450 Gandy Boulevard, St. Petersburg, FL 33702. Lee Trent is with the Panama City Laboratory, Gulf Coastal Fisheries Center, National Marine Fisheries Service, NOAA, Panama City, FL 32401.

One of the prominent conflicts is between fishing interests and the developers of waterfront property for residential use. Fishing interests, both commercial and recreational, wish to maintain the estuarine zone in its natural state (except for alterations, such as ports, marinas, and fish processing plants, necessary to pursue their interests) to assure continued propagation of fish and wildlife resources. Conversely, developers are prompted by premium prices home buyers are willing to pay for waterfront housing and are converting prime estuarine habitat to waterfront real estate.

The reason for the conflict is readily apparent. Estuaries provide food and sanctuary for all or part of the life history stages of the majority of commercial and recreational fishes. Of the 26.6 million acres of estuarine area in the United States, only about 29 percent (7.9 million acres) are considered prime habitat for the propagation of fish and wildlife resources (U.S. House of Representatives, 1967). Much of the prime habitat is along the peripheries of estuaries and is easily and relatively inexpensively converted to waterfront residential real estate. Captivated by the prospects of waterfront living, homebuyers are attracted to such communities. Unregulated development, however, can result in deterioration of communities as well as aquatic resources (Barada and Partington, 1972; Marshall, 1974).

The objectives of this report are to: 1) briefly review the effects of housing development canals on the estuarine environment; 2) discuss some of the regulatory legislation enacted to prevent destructive alterations in the estuarine zone; and 3) present recommendations for minimizing damage to coastal resources that is often caused by unregulated development of waterfront property.

TYPES OF DEVELOPMENT

Waterfront housing developments created by excavating canals in the estuarine zone can be categorized as *bayfill*, *inland*, and *intertidal*, depending on their location with respect to tide levels. *Bayfill* developments are those constructed below mean low tide by dredging and filling shallow bay bottoms (Fig. 1). Typically, hydraulic dredges are used to create finger-like projections of land stabilized by vertical bulkheads. About 3 acres of submerged bottom are required to create one acre of fill (Odum, 1970) unless fill material is imported to the area. *Inland* developments are those constructed by excavating areas above mean high tide and connecting the resulting canals to natural channels or to the open bay (Fig. 2). Inland canals are usually excavated by draglines (bucket dredges), but hydraulic dredges may be used where feasible. Typically, an earthen dam (a small unexcavated segment of the canal system) is left in place at the mean high tide line until the interior canal system is completed; the excavated material is exported from the area or used as fill to obtain the required elevations for housing construction on the adjacent lots; and the banks are stabilized by vertical bulkheads. Bayward of the earthen dam, one or more access canals are excavated to provide boat passage to deeper water. The earthen dam is then removed, thereby connecting the canal system to natural channels, man-made channels, or open bay waters. *Intertidal*

Figure 1.—Example of bayfill development. (Photo courtesy of Dillon Aerial Photography, Inc.)

developments, as the name suggests, are those constructed in the area of the shoreline between mean-low and mean-high tides (Fig. 3). In coastal areas where the intertidal area is extensively broad, the entire development may be located in the intertidal zone. In most cases, however, this type of development will include areas below and above the intertidal zone.

EFFECTS ON THE ESTUARINE ENVIRONMENT

Regardless of their location with respect to tidal level, all three categories of canals may seriously degrade coastal resources. Environmental damage is caused mainly by poor excavation practices and inadequate provisions for good water circulation. As a result, canal construction often causes destruction of wetland vegetation, undesirable changes in water quality and sediment type, and qualitative and quantitative faunal changes. These three major effects are discussed below.

Destruction of Wetland Vegetation

Bayfill and intertidal development often cause alteration and eradication of large areas of shallow bay bottom, submerged vegetation, and emergent vegetation in the intertidal zone—usually the most productive part of the estuarine ecosystem. The area covered by the fill is permanently removed from production, and the canals are usually excavated to depths below the limits of sunlight penetration (below the euphotic zone) which precludes the reestablishment of rooted vegetation. Inland developments alter only relatively small areas of intertidal and subtidal vegetation (as a result of access canals), but often alter large areas of marshland above mean high tide. Marsh vegetation plays an important role in filtering run-off from uplands and providing detrital material, a basic energy source, to the estuarine system. The inland canals and associated fill permanently destroy marsh vegetation, and the fill serves as a barrier to marsh drainage and flushing.

Changes in Water Quality and Sediment Type

Water and sediment quality are usually lowered in the canals, because the canal system is typically labyrinthine, contains dead ends, and is excessively deep. This degradation stems primarily from a lack of adequate water exchange with the parent body (natural stream, bayou, or bay) of water. For example, along the U.S. Gulf coast, where most studies of canal systems have been conducted, the canals are usually excavated to depths of 2-3 m (some as much as 6 m) in areas of the estuary where natural depths are 1 m or less. Average tidal range is less than 1 m in most areas of the Gulf of Mexico. If a uniform 3-m deep canal system (mean high tide) were dug in an estuarine area where the natural depth was 1 m and the average tidal range was

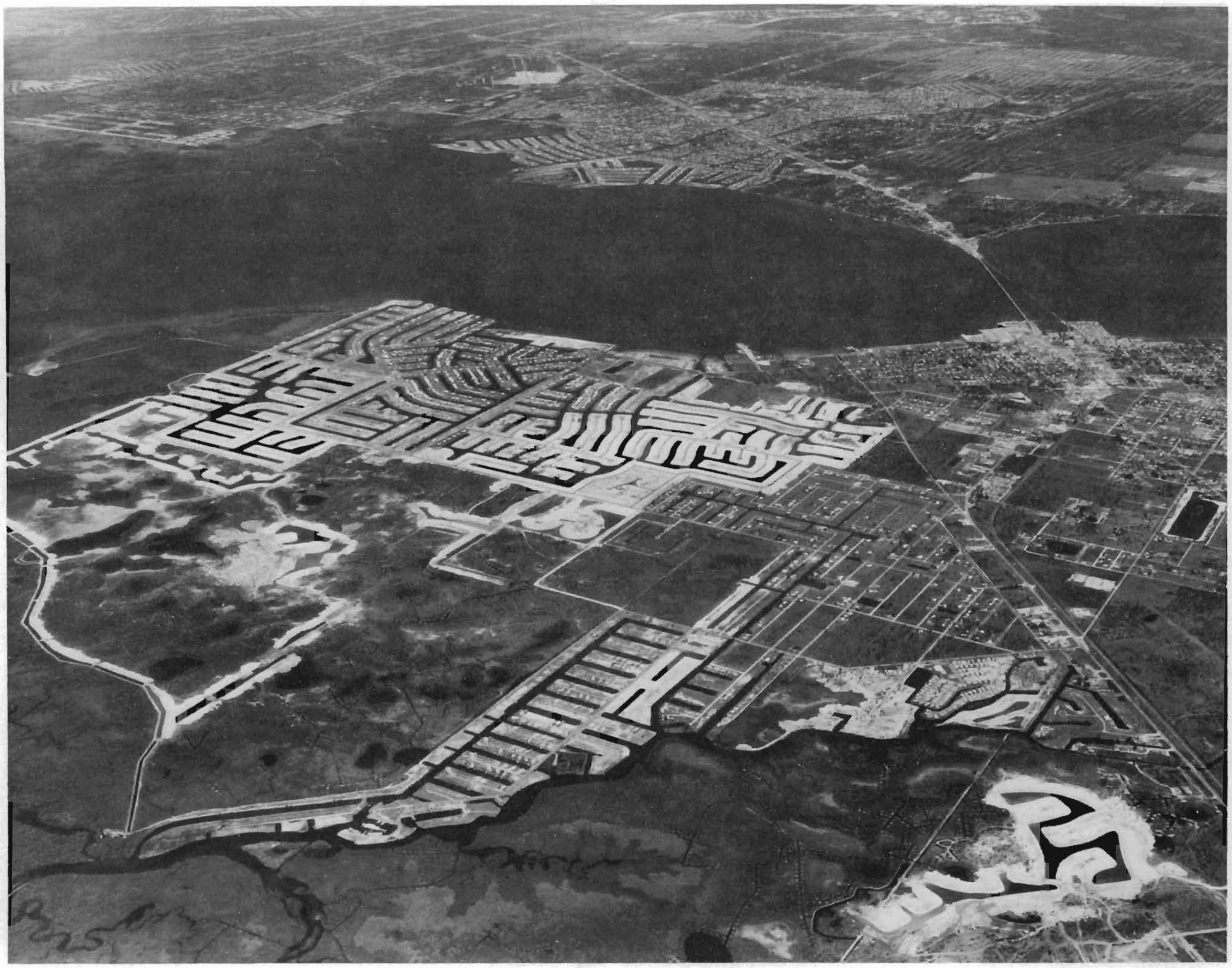

Figure 2.—Example of inland canal development. (Photo courtesy of Dillon Aerial Photography, Inc.)

0.5 m, the theoretical amount of water mass exchanged with each tidal cycle would be 50 percent in the natural area, but only about 17 percent in the canals. Water currents, especially near the bottom, would be much slower in the deep canals than in the shallow, subtidal areas. Owing to low current speeds, the canal bottoms serve as settling basins that readily accumulate large quantities of fine silts and biogenic materials, the results of which are discussed below in the section on faunal changes.

Increased water depth and the resulting low water exchange rates in the area following alteration affect water quality, particularly oxygen concentration. Usually, increased water depth creates a water mass with lower inorganic turbidities and a greater capacity for producing phytoplankton (deeper zone for sunlight penetration) than in the area prior to alteration (Taylor and Saloman, 1968; Corliss and Trent, 1971). The zone below sunlight penetration, however, becomes an oxygen-demanding rather than an oxygen-producing zone, and this demand is increased in relation to the amount of biogenic material on the bottom. The canals not only have a great potential for phytoplankton production but for overproduction as well. Overproduction results in a water mass deficient in dissolved oxygen. Although the increased concentration of phytoplankton produces large amounts of oxygen (part of which is retained in the water) during the day through photosynthesis, most or all of this oxygen is removed at night as a result of respiration by phytoplankton and other organisms. Also, the phytoplankters die because of low oxygen, settle below the euphotic zone, and create even heavier demands on dissolved oxygen as they decompose. Such oxygen deficiency is more likely to occur and slower to correct itself in a canal than in a shallow, more open area, because of the canal's slower rates of water exchange. This situation has been documented by the above authors and several others (Reish, 1961; Trent, Pullen, and Moore 1972; Lindall, Hall, and Saloman, 1973).

Other factors that cause reductions in oxygen concentrations in canals of completed developments include reduced aeration of the water (caused by narrowness of the canals and the houses blocking and diverting prevailing winds) and increased concentrations

Figure 3.—Example of intertidal canal development.

of organic material caused by increases in nutrients and biogenic materials from storm runoff (Moor and Trent, 1971).

Qualitative and Quantitative Faunal Changes

Published biological studies of housing development canals in the estuarine zone indicate, with the possible exception of phytoplankton, that species composition, abundance, growth, or reproduction of organisms can be expected to be detrimentally affected by reduced water and sediment quality that usually occurs in the canals.

As a direct or indirect result of low dissolved oxygen, which occurs principally in the summer months, researchers working in canals in the estuaries of the Gulf of Mexico have documented that: 1) abundance and species composition of benthic organisms were reduced in Texas (Gilmore and Trent, 1974) and Florida (Hall and Lindall, 1974); 2) oysters reproduced less, and suffered higher mortalities in Texas (Moore and Trent, 1971); and 3) the abundance of fishes and crustaceans was reduced in Texas (Trent, et al., 1972) and in Florida (Lindall, Fable, and Collins, 1975). Low dissolved oxygen also was suspected of causing a reduction in the abundance and species composition of benthic organisms in boat-basin canals in California (Reish, 1961).

Comparisons of the relative abundance of benthic organisms in dredged canals and undredged areas in Boca Ciega Bay, Fla., indicate the adverse effects of large-scale accumulation of fine sediments in the canals. Taylor and Saloman (1968) found that sediments in the dredged canals averaged 92 percent silt and clay, whereas those in undredged areas averaged 94 percent sand and shell. Although they had been in existence for 10 years, the deeply dredged canals contained less than 1 percent of the number of benthic organisms recorded from both areas. A detailed examination of mollusks from these same canals was made by Sykes and Hall (1970) who showed that samples from undredged areas contained an average of 60.5 individuals and 3.8 species, whereas those from the dredged canals contained an average of 1.1 individuals and 0.6 species.

REGULATORY MECHANISMS IN MANAGEMENT

Historically, the controversy between fishing interests and real estate interests focused primarily on bayfill developments in Florida (Sykes, 1967). Because of their damaging effects on the estuarine environment, Federal legislation was enacted which established the means for abolishing indiscriminate dredging and filling below the level of mean high water (McNulty, Lindall, and Sykes, 1972). The Fish and Wildlife Coordination Act of 1958 (P.L. 85-624) requires that living aquatic resources be equally considered with other project features in the issuance of Federal permits for construction in navigable waters, and the National Environmental Policy Act of 1969 (P.L. 91-190) requires that Federal agencies consider environmental matters in the administration of public laws.

The former legislative act was applied by the U.S. Army Corps of Engineers in its unprecedented denial of a dredge-fill permit in Boca Ciega Bay, Fla., on the grounds that the work was not in the general public interest because of damages to fish and wildlife resources. The constitutionality of this denial was confirmed in the *Zabel* v. *Tabb* decision by the U.S. Court of Appeals in July 1970 (U.S. House of Representatives, 1974). Since then, most bayfill proposals have been largely curtailed or modified to insure protection of estuarine resources.

In response to statutory restraints on bayfill development, waterfront real estate developers have turned to canal excavation in areas above mean high tide, and the conflict now centers around these inland canals. Because inland canal development takes place above mean high water, the development is usually unregulated by Federal authority except for the requirement of a permit to construct one or more access canals from the development to navigable waters and to remove the earthen dam. Ironically, Federal legislation exists that provides the potential for regulating dredging and filling inland areas, but the design and construction of inland housing developments in estuarine areas are essentially uncontrolled at the present time. The explanation for this incongruity is discussed in a recent report by the Committee on Government Operations (U.S. House of Representatives, 1974), the Corps Section 404 of the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 authorizes the Corps of Engineers to issue permits for the discharge of dredge or fill material into "navigable waters" at specified sites. The Environmental Protection Agency (EPA), which is primarily responsible for administering the FWPCA amendments, interprets the phrase "navigable waters" to include wetlands above the line of mean high water. However, the Corps' interpretation of the Act is that its jurisdiction is limited to all lands and waters below the ordinary high water mark. These interpretations were tested in the 1974 case of *United States* v. *Holland* held in the U.S. District Court for the Middle District of Florida. The Court agreed with EPA's interpretation and concluded that under the FWPCA Amendments of 1972 the Corps has authority to regulate and protect against deposits of dredge or fill material in wetlands above the mean high water line.

According to the Committee on Government Operations (U.S. House of Representatives, 1974), the Corps declined to acquiesce in the Holland decision and refused to exercise its jurisdiction over inland canals, except to require a permit to connect them with navigable waters. Thus, wetlands above mean high tide, although vital to the total function of the estuarine ecosystem, are essentially unprotected from indiscriminate dredging and filling. By the time permit application is made to connect the canal system with open water, the wetlands above mean high water usually have suffered irrevocable damage by the development. In most cases, relevant fish and wildlife agencies, whose statutory responsibility is to assess these permit applications, have no recourse but to recommend denial, because the traditional design and location of the development would be a liability to water quality and estuarine-dependent resources. Not only does the present process allow the extensive alteration of wetlands, it precludes fish and wildlife agencies from accomplishing their mandate and is confusing to the developer and the public.

A more recent court decision, however, is encouraging. On 27 March 1975, the U.S. District Court in Washington, D.C. ordered the Corps of Engineers to promulgate new regulations expanding their definition of "navigable waters" to include areas above the line of mean high water. The ruling came in a suit brought by the Natural Resources Defense Council and the National Wildlife Federation and should expand the Corps' jurisdiction to include inland canal development.

CONCLUSIONS AND RECOMMENDATIONS

State and Federal jurisdiction is being exercised to control development in estuarine areas below mean high tide. However, with respect to maintaining productive estuarine areas, mean high tide is an arbitrary demarcation point. To insure continued propagation of estuarine-dependent fish and wildlife resources, development of wetland areas above mean high tide must also be regulated, especially those that will contain "navigable waters" after canals are constructed.

Based on recent court decisions, the Corps of Engineers apparently will begin exercising full jurisdiction over inland housing development canals in the near future. Therefore, real estate developers contemplating inland canal development should request a Corps' permit prior to beginning excavation. Meanwhile, guidelines for the location and design of inland canals must be developed that are compatible with continued high production of fish and wildlife resources. As an initial effort toward achieving this, we recommend the following:

I. Avoid disruption of wetland and subtidal habitats to the greatest extent possible.
   1. Restrict residential lots and their adjacent canals to non-wetland areas, i.e., on high and dry land.
   2. Route access canals from the housing development to the parent body of water by the shortest and least environmentally damaging route possible, i.e., avoid intertidal marsh, submerged grass beds, and oyster reefs. Alignment should take advantage of existing natural or manmade channels.
   3. Control turbidity and sediment dispersion as much as possible.
      a. Complete all construction of housing development canals before connecting them with the access canals.
      b. Excavate access canals using the best dredging techniques available, i.e., use turbidity control screens and dispose the excess spoil in diked non-wetland areas.
      c. Reserve adequate spoil disposal sites and easements in non-wetland areas for future maintenance dredging.

II. Design the canal system so that State and Federal water quality standards, especially for dissolved oxygen, will be maintained at all times. This can be accomplished if the entire canal complex is designed as a flow-through system that provides adequate water exchange with the parent body of water, and if nutrient input is maintained at low levels. Water exchange rates should be determined for each area considered for development, and for each plan of canal layout, by an environmental engineer who has expertise in hydraulics and coastal circulation. In addition to the design criteria in I above, the engineer should consider the following:

1. Dead-end canals should not be permitted. Culverts and bridges should be used as methods of alleviating the need for dead-end canals.
2. Pumps should be used to increase circulation, and reaeration techniques should be used to increase dissolved oxygen.
3. Canal (interior and access) depths should not exceed that of the euphotic zone. In most areas of the Gulf of Mexico this would be 1.8-2.0 m at mean low water and is ample for navigation of small pleasure craft. Exceptions may be acceptable in areas where ambient turbidity normally results in an extremely shallow euphotic zone. However, canal depths should never exceed those of the parent body of water where the access canal terminates.
4. The entire canal system, including access canals, should be of uniform depth, or become gradually shallower, proceeding from the parent body of water to the inlandmost portion of the development. This would prevent the formation of "pockets" of stagnant water.
5. Interior canals should be as wide as possible and, where feasible, aligned with prevailing summer winds to increase aeration.
6. Canals should not be cut into an aquifer.
7. Septic tanks or effluent discharge from sewage treatment plants should not be allowed within the development.
8. Storm-water runoff into the canals should be minimized and controlled as much as possible. Adequate storm drains should be installed throughout the development and designed to direct runoff from streets and lawns away from the canals.

These guidelines are not intended to be all-encompassing, nor is strict adherence to them expected. Rather, they should be considered on the merits of each proposed project in its own particular ecological setting.

LITERATURE CITED

Barada, W., and W. M. Partington. 1972. Report of investigation of the environmental effects of private waterfront canals. Environ. Inf. Cent. Fla. Conserv. Found., Winter Park, Fla., 63 p.

Corliss, J., and L. Trent. 1971. Comparison of phytoplankton production between natural and altered areas in West Bay, Texas. Fish. Bull., U.S. 69:829-832.

Gilmore, G., and L. Trent. 1974. Abundance of benthic macroinvertebrates in natural and altered estuarine areas. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-677, 13 p.

Hall, J. R., and W. N. Lindall, Jr. 1974. Benthic macroinvertebrates and sediments from upland canals in Tampa Bay, Florida. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Data Rep. 94, 221 p. on 4 microfiche.

Lindall, W. N., Jr., W. A. Fable, Jr., and L. A. Collins. 1975. Additional studies of the fishes, macroinvertebrates, and hydrological conditions of upland canals in Tampa Bay, Florida. Fish. Bull., U.S. 73:81-85.

Lindall, W. N., Jr., J. R. Hall, and C. H. Saloman. 1973. Fishes, macroinvertebrates, and hydrological conditions of upland canals in Tampa Bay, Florida. Fish. Bull., U.S. 71:155-163.

Marshall, A. R. 1974. The limitless city: An idea whose time has gone. *In* Business and economic dimensions, p. 1-7. Bur. Econ. Bus. Res., Coll. Bus. Admin., Univ. Fla.

McNulty, J. K., W. N. Lindall, Jr., and J. E. Sykes. 1972. Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase I, area description. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-368, 126 p.

Moore, D., and L. Trent. 1971. Setting, growth and mortality of *Crassostrea virginica* in a natural marsh and a marsh altered by a housing development. Proc. Natl. Shellfish. Assoc. 61:51-58.

Odum, W. E. 1970. Insidious alteration of the estuarine environment. Trans. Am. Fish. Soc. 99:836-847.

Reish, D. J. 1961. A study of benthic fauna in a recently constructed boat harbor in southern California. Ecology 42:84-91.

Sweet, D. C. 1971. The economic and social importance of estuaries. U.S. Environ. Prot. Agency, Estuarine Pollut. Study Ser. 2, 61 p.

Sykes, J. E. 1967. The role of research in the preservation of estuaries. Trans. N. Am. Wildl. Nat. Resour. Conf. 23:151-160.

Sykes, J. E. and J. R. Hall. 1970. Comparative distribution of mollusks in dredged and undredged portions of an estuary, with a systematic list of species. Fish. Bull., U.S. 68:299-306.

Taylor, J. L., and C. H. Saloman. 1968. Some effects of hydraulic dredging and coastal development in Boca Ciega Bay, Florida. U.S. Fish Wildl. Serv., Fish. Bull. 67:213-241.

Trent, W. L., E. J. Pullen, and D. Moore. 1972. Waterfront housing developments: Their effect on the ecology of a Texas estuarine area. *In* M. Ruivo (editor), Marine pollution and sea life, p. 411-417. Fishing News (Books) Ltd., West Byfleet, Surrey.

U.S. House of Representatives. 1967. Estuarine areas. Hearings before the Subcommittee on Fisheries and Wildlife Conservation of the Committee on Merchant Marine and Fisheries, House of Representatives. 90th Congress, 1st Sess., Serial No. 90-3, 486 p.

———. 1974. Our threatened environment: Florida and the Gulf of Mexico. Nineteenth Report by the Committee on Government Operations together with Additional Views. 93rd Congress, 2nd Sess., House report No. 93-1396, 100 p.

MFR Paper 1163. From Marine Fisheries Review, *Vol. 37, No. 10, October 1975. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235. Copies of* Marine Fisheries Review *are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 for $1.10 each.*