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COMMERCIAL FISHERY DATA FROM THREE PROPOSED OTEC SITES

Constance J. Ryan and Anthony T. Jones

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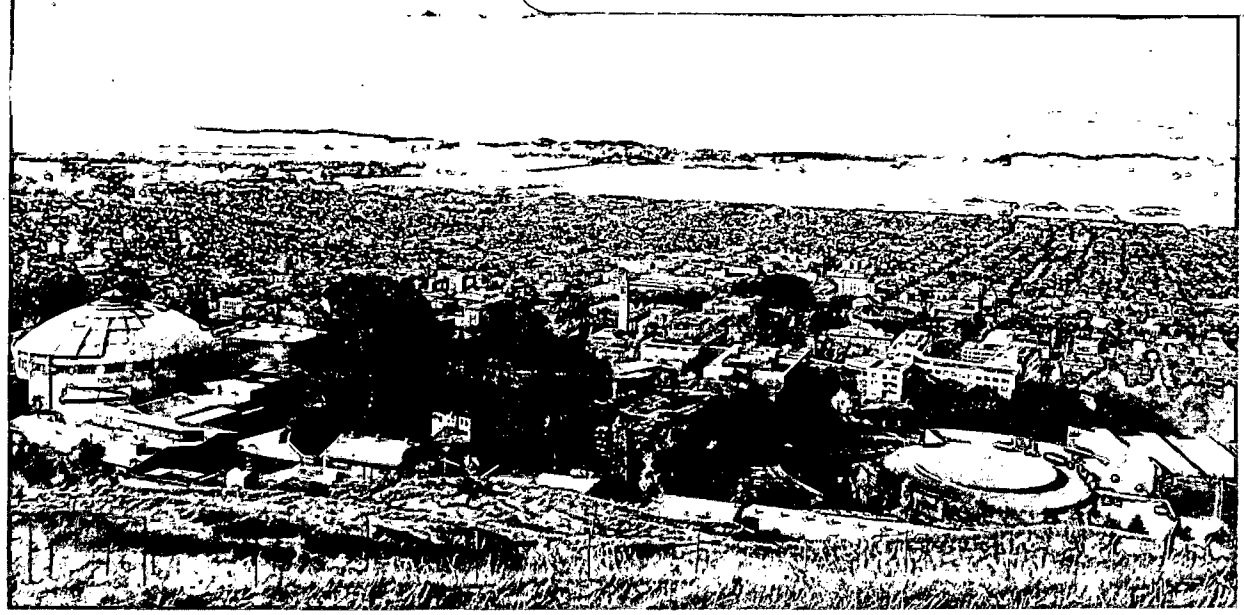

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ABSTRACT

The operation of Ocean Thermal Energy Conversion (OTEC) power plants may affect fish populations in the regions surrounding the plants. As an initial step in estimating the possible impacts of OTEC power plants on local fishery resources at three proposed sites, commercial fishery records were used to identify common commercially-important species and to obtain a general impression of the abundance of those species at the sites. The sites examined are in the waters adjacent to Punta Tuna, Puerto Rico (PROTEC), and in the Islands of Hawaii offshore from Kahe Point, Oahu (O'OTEC) and Keahole Point, Hawaii (HOTEC).

INTRODUCTION

The operation of Ocean Thermal Energy Conversion (OTEC) power plants may alter fish populations in the regions surrounding the OTEC plants. Alterations may be the result of direct impacts on the fish (e.g. entrainment, impingement and biocides) or of impacts on the environment upon which the fish depend (e.g. disturbance of temperature structures, salinity gradients and nutrient levels) (1,2). Identification of the potential effects of OTEC operations on fishery resources requires knowledge of the fish species in the area, their life histories, their ecological roles and their environmental restraints, as well as, knowledge of the distribution, abundance, structure and dynamics of the fish populations. The first step in estimating OTEC's possible impacts on fishery resources is to determine the species composition and the population sizes of fish within the OTEC region.

Information on the species present in an area and their population sizes is often available from scientific collections or from commercial and recreational fishery records. Scientific collections generally provide exhaustive species lists, but rarely provide information on the population sizes. Commercial and sport fishery records may include data on the kinds, numbers, sizes, weights, and selling prices of the fishes landed. Commercial and sport fishery records do not, however, reflect the true species composition of an area; they include only those species which are of commercial value or are prized as food- or game-fish. In this presentation, commercial fishery data are used to identify common commercially-important species, and to obtain a general impression of the abundance of those species at proposed OTEC sites. Three potential sites will be discussed: one site in the waters adjacent to Punta Tuna, Puerto Rico (PROTEC site) and two sites offshore the Hawaiian Islands (HOTEC site and O'OTEC site).

PUERTO RICO SITE

1. Puerto Rico's Commercial Fisheries

The primary fishery in Puerto Rican waters is a shallow inshore fishery which uses traditional gear (ie. fish pots, troll lines, handlines) and small fishing craft (less than 20 feet in length). As is common of islands throughout the Caribbean region, no major commercial offshore fishery exists near Puerto Rico (3,4).

Puerto Rico's fish fauna is extremely diverse with some 400 species reported (5). Many of these species are captured by the inshore fishery, and nearly 130 are commercially important (4).

Commercial landings include both demersal and pelagic fishes. Demersal and reef fishes dominate the landings because the type of gear used inherently selects for these fishes. Even if pelagic fishes are seasonally abundant in nearshore waters, they may not be captured in great numbers. The fish pot is the most common type of fishing gear used in Puerto Rico. Fish pots capture demersal or bottom fish such as snappers (Lutjanidae), groupers (Serranidae), grunts (Haemulidae), and goatfish (Mullidae). The average depth fished with fish pots is about 40 meters (21 fathoms) (6). Pelagic species such as mackerels and tunas (Scombridae), barracuda (Sphyraenidae), and dolphin fish (Coryphaenidae) are caught using troll lines, beach seines, or gill nets.

2. Source of the Data

A program to gather statistical information on Puerto Rico's inshore fisheries began in the summer of 1967. The Puerto Rico Department of Agriculture compiles and publishes the landing records. The landing records are published in two forms, monthly or quarterly "Information Bulletins" and annual reports entitled "The Status of Fisheries in Puerto Rico". These publications (4,7-16) provide the data for this section.

Puerto Rico is divided into four regions for the gathering and the reporting of commercial fishery statistics (Figure 1). The PROTEC area off Punta Tuna lies near the border of the South and East Coasts. The East Coast region covers the shelf area from Fajardo in the north to Maunabo in the south and includes Culebra, Vieques and numerous small islands to the east. The South Coast region includes the shelf area from Lajas east to Patillas (8).

3. Fishery Data from the PROTEC Site

For many fish groups, the reported annual landings from 1969 to 1978 exhibit wide fluctuations. Most show a dramatic increase from 1969 to 1970; this probably represents improvements in data collection rather than actual increases in production (8). After 1969, the fluctuations tend to follow a general pattern with the smallest landing reported in 1973, 1974 or 1975, and the largest landing reported in 1970, 1971, 1977 or 1978 (17). The total fish landings reflect this trend, exhibiting a somewhat u-shaped curve (Figure 2). The total landing weight falls from 3.9 million pounds in 1970 to 2.9 million pounds in 1973 then steadily rises for the next 5 years, reaching a high of 5.1 million pounds in 1978. The combined total fish landings on the South and East Coasts also form a u-shaped curve with highs at the beginning and the end of the data period, and lows in the middle (Figure 2).

The composition (by percent weight) of the combined South Coast and East Coast commercial landings between 1970 and 1978 is shown in Figure 3. Grunt (Pomadasyidae), grouper (Serranidae), goatfish (Mullidae), mackerel (Scombridae), and snapper (Lutjanidae) were the most commonly landed groups. The nine most common groups annually comprise more than 80% of the landings.

Despite considerable flux in the annual landing weights of most fish groups, the composition of the landings in the South and East Coasts remained fairly consistent. No group's relative contribution to the total landing weight varied more than 10 percent. If the relative fishing effort for each group was constant during this period, the consistency of the landing compositions may indicate that the relative abundance of the fish groups was constant.

HAWAII SITES

1. Hawaii's Commercial Fisheries

Most commercial fishing in Hawaii occurs within 20 miles of the main islands. This is the result of both natural and human factors: the steepness with which the bottom drops off allows fishermen ready access to wide-ranging pelagic fishes such as tunas and billfishes, the modest size of the fishing boats, the attachment of the aku fleet to a few sources of baitfish which are not durable, and consumer insistence on truely fresh fish (18,19).

Hawaii's fisheries are of modest scale when compared with those of other coastal states, but they are more developed than most of the other Pacific island groups. The commercial fish landings have not substantially increased in the past 30 years. The fishing industry currently accounts for only a small percentage of the state's economy (18,19).

Hawaii's fauna is unique and extremely diverse with over 580 fish species reported (20,21). However, the majority of the fish species in this rich fauna are not of direct commercial value. Though

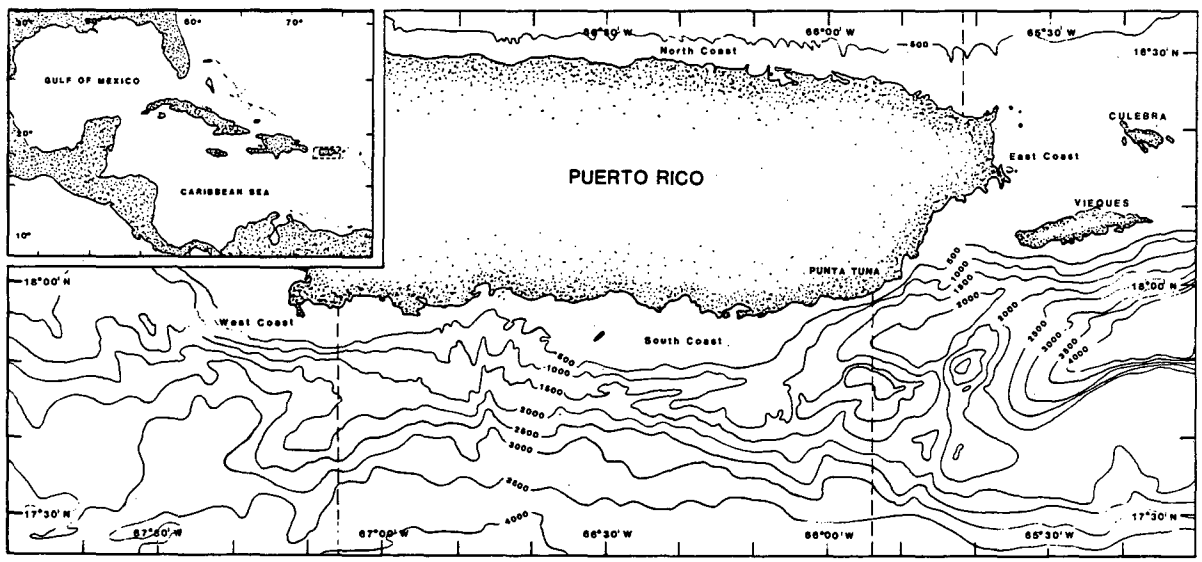

Figure 1. Map of Puerto Rico and fishing areas.

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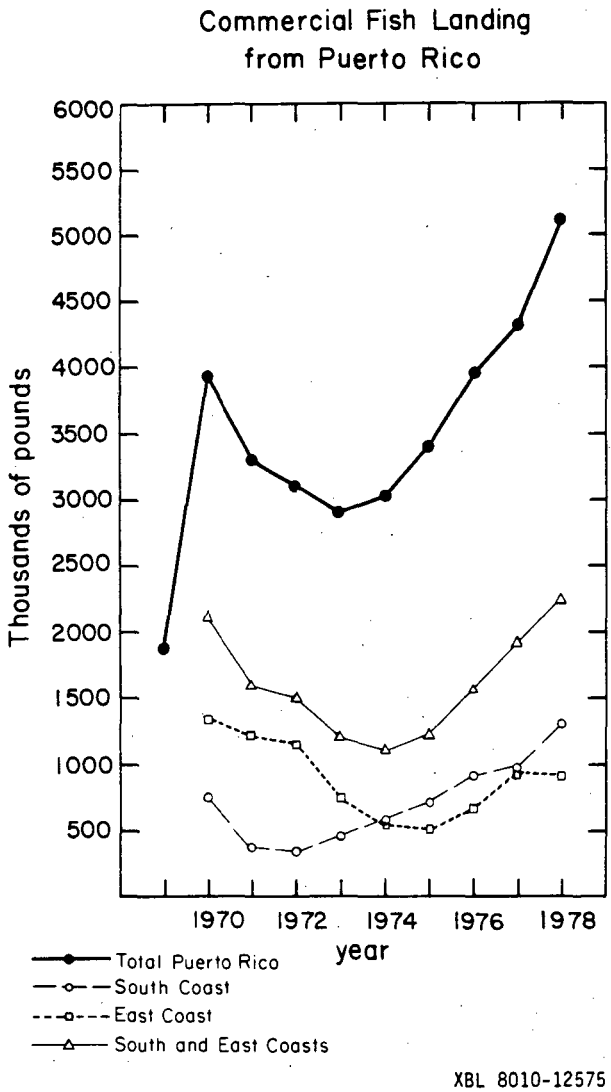

Figure 2. Commercial fishlandings from Puerto Rico, 1969-1978.

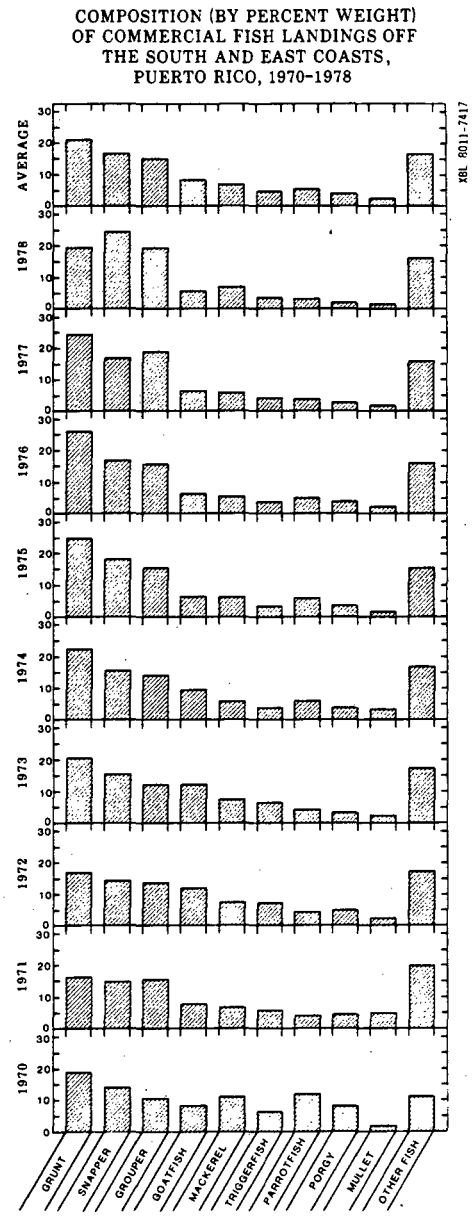

Figure 3. Composition of the combined commercial fish landings on the south and east coasts of Puerto Rico.

over 100 species are sold, it is common for five species to compose over 90% of the total annual landings. In fact, one species, the skipjack tuna or aku, is usually responsible for 40% to 60% of Hawaii's total commercial landings.

Hawaii's principal fisheries are carried on by a variety of techniques including: pole-and-line, midwater longline, trolling, handline, seines, gillnets and traps. Use of the live-bait, pole-and-line method generally results in a catch composed of at least 90% (by weight) skipjack tuna (aku); the remainder of the catch may include such offshore pelagic species as mahimahi (dolphin fish), small yellowfin tuna (ahi), and little tuna (kawakawa). Large yellowfin tuna (about 250 lbs) and large bigeye tuna (about 300 lbs), are the principal catch of the longline or flagline fishery. Flaglines also catch lesser quantities of large albacore tuna (up to 90 lbs), billfishes, ono (wahoo), mahimahi, sharks, and other pelagic species. Trollers catch ahi, (primiarily yellowfin tuna), billfishes, ono, mahimahi and smaller species of tuna. Handlines are used to catch bottomfishes such as, snapper and goatfish. At night,

handlines are used with lights to catch coastal pelagic schooling species such as, akule (bigeyed scad), and opelu (mackerel scad). Seines and gillnets are used in shallow waters for akule, opelu, mullet, reef-fishes and inshore bottom fishes. Traps are used in shallow water to catch reef fishes (18,19).

2. Source of the Data

Since the late 1940's, the State of Hawaii Division of Fish and Game has required all licensed commercial fishermen to submit monthly catch reports. From these reports the Division tabulates data in three basic areas: 1) catch weight and numbers, 2) time and place of capture, and 3) fishing effort. This section of the report uses fisheries data made available by the Hawaii Division of Fish and Game.

For ease in reporting the place of capture the Hawaii Division of Fish and Game has divided the waters around Hawaii into Fishing Areas. A proposed OTEC site off the Island of Hawaii (HOTEC) is located in Area 122 (Figure 4). Area 122 extends from Ke-ahole Point in the south to Malaea Point in the north, and encompasses the area from 2 to 20 miles offshore. A proposed OTEC site off Oahu (O'OTEC) is located in Area 423 (Figure 4), which extends 2 to 20 miles offshore from Kaena Point to Maili Point.

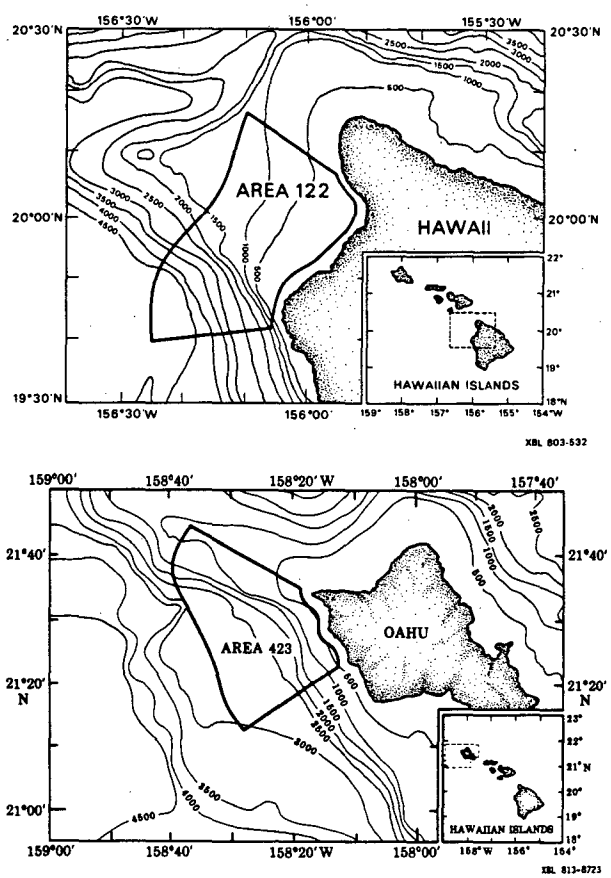

Figure 4. Maps of fishing areas 122 and 423 in Hawaii.

3. Fishery Data from the HOTEC Site

In the 20 years of commercial fish records examined, over 60 species of fish from 31 families were represented in the landings from Area 122 (22). The composition of the landings varied during the period examined, but generally skipjack tuna, yellowfin tuna, blue marlin, and snappers were the most important groups in terms of pounds landed (Figure 5). On the average, skipjack tuna comprised 62% of the landings, yellowfin tuna 10%, blue marlin 9%, and snappers 5%.

COMPOSITION (BY PERCENT WEIGHT) OF
COMMERCIAL FISH LANDINGS IN AREA 122
HAWAII 1959-1978

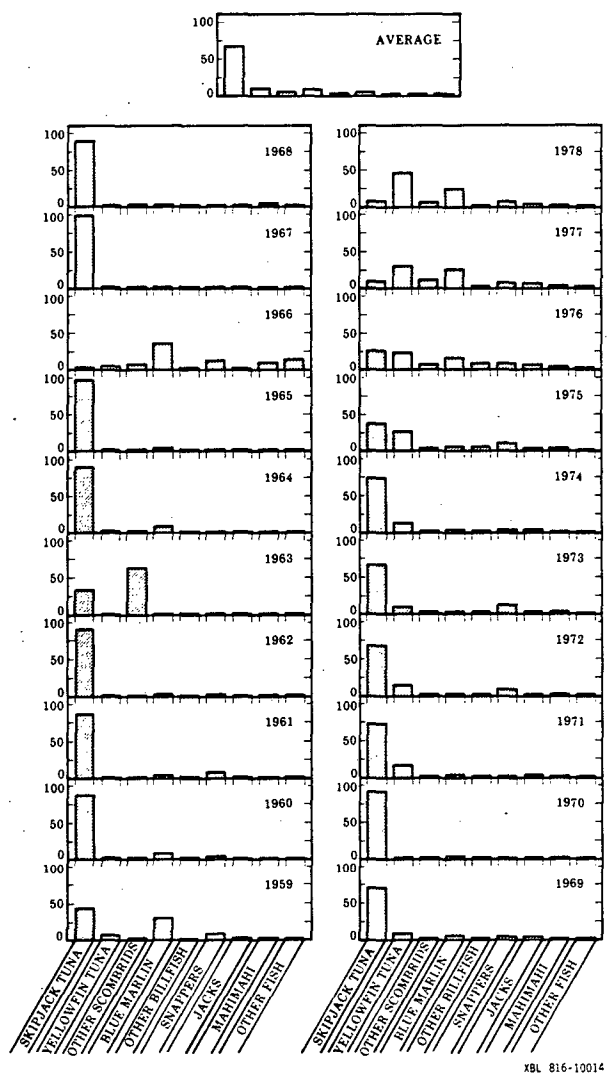

Figure 5. Composition of the commercial fish landings near the HOTEC site.

Figure 6 shows the reported annual landings from Area 122 over the 20 years from 1959 to 1978. The weight of the total landings varied considerably during this time period. The fluctuations are primarily due to fluctuations in tuna landings, especially the amount of skipjack landed. The landings of skipjack tuna range from a low of 123 pounds in 1966 to a high of 407,453 pounds in 1974.

The only catch per unit of effort (CPUE) data made available from Area 122 are for blue marlin catches from 1966 to 1978. The catch of blue marlin per unit of effort varied during this period, indicating that the density of blue marlin in Area 122 varied from year to year (19).

In 1978, the annual landing from the fishing area (Area 122) off Ke-ahole Point was valued at $272,135; the 10-year average was $141,000 (1969-1978).

4. Fishery Data from the O'OTEC Site

From 1973 to 1977 Area 423 off the Waianae Coast was the highest ranking area by poundage in the entire state. Fishermen tend to concentrate their activities in this area because of the comfortable fishing it provides by being in the lee of the island, its closeness to safe harbors, and the likelihood of catching skipjack, ahi (yellowfin or bigeye tuna) or marlin (18,19).

Figure 7 shows the total fish landings from Area 423 from 1959 to 1978. During this 20 year period, there are wide variations in the amount of fish landed. The enormous influence of tuna landings on fluctuations in total landings is evident when looking at the non-tuna landings (Figure 7).

The composition (by percent weight) of the landings is shown in Figure 8. On the average, from 1959 to 1978 the landings were 71% skipjack tuna, 9% yellowfin tuna, 8% bigeye tuna, 6% striped marlin, 2% blue marlin, and 4% miscellaneous species.

CPUE of mahimahi, striped marlin, blue marlin and skipjack tuna in Area 423 varied from 1966 to 1978; indicating that the abundance of these species also varied. Comparison of CPUE with landing data shows that the CPUE of mahimahi and striped marlin generally correspond with changes in landings; possibly, indicating that changes in landings are primarily due to changes in abundance. CPUE and landing of blue marlin and skipjack tuna do not show correspondence; this may indicate that variations in the landings are due both to fluctuations in abundance and fishing effort (19).

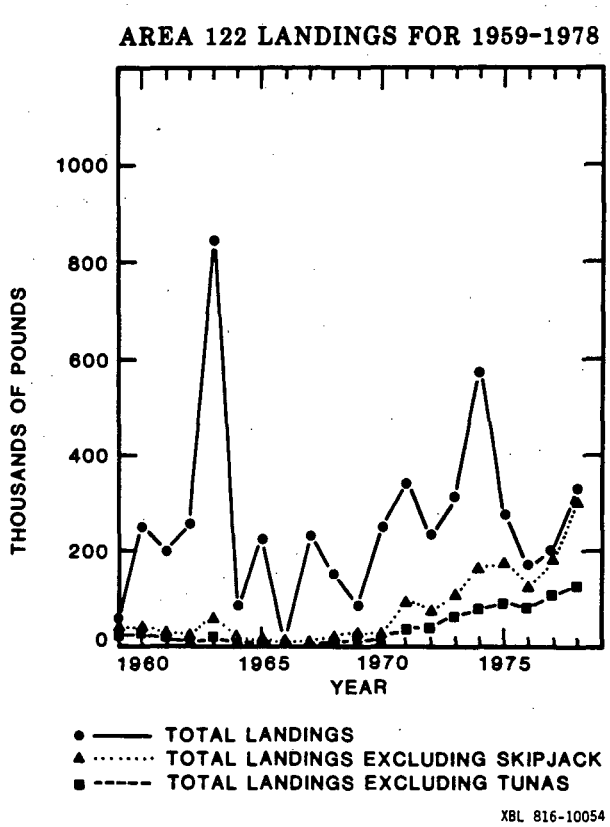

Figure 6. Total commercial landings near the HOTEC site, 1959-1978.

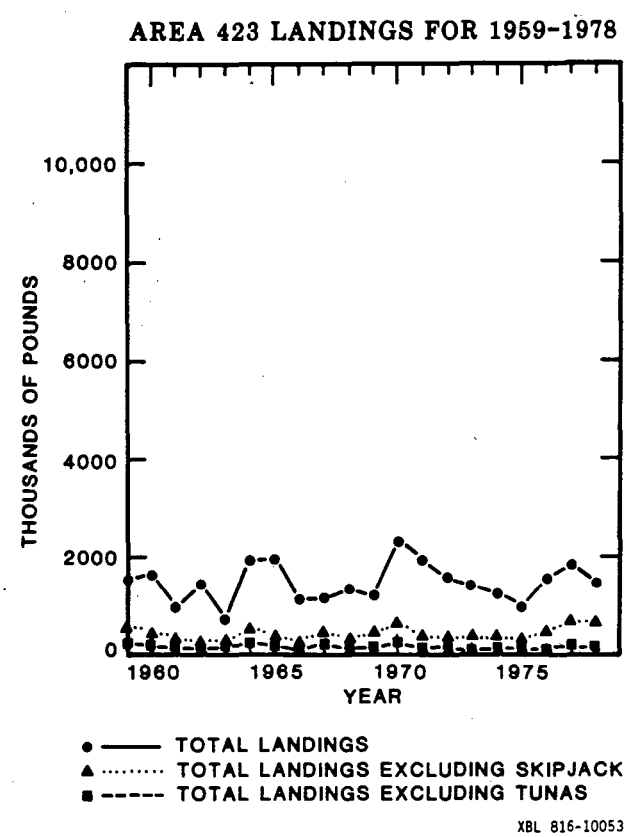

Figure 7. Total commercial landings near the O'OTEC site, 1959-1978.

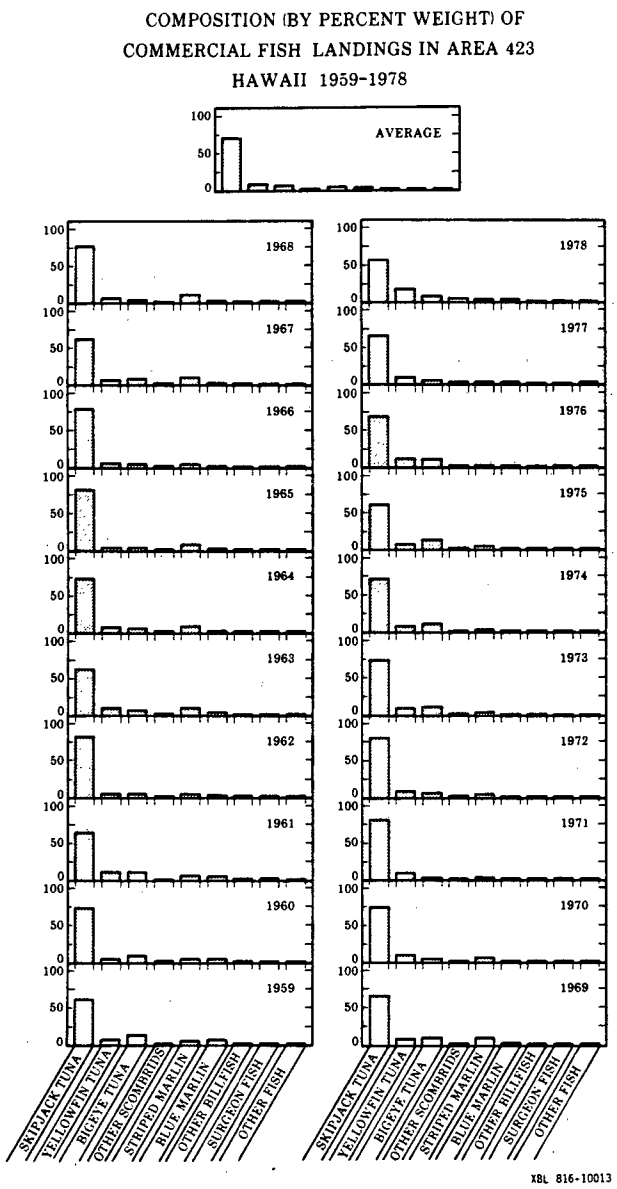

Figure 8. Composition of the commercial fish landings near the HOTEC site.

POTENTIAL IMPACTS OF OTEC OPERATIONS ON FISH POPULATIONS

OTEC plant operations may affect the sizes of local fish populations and the mechanisms which regulate them. Alterations may primarily be the result of changes in mortality rates. People intuitively expect power plant induced mortalities to reduce the size of a fish population, however, this is not always the case, because compensatory processes may offset deaths from power plant operations (23). All density-dependent mechanisms that tend to stabilize population size by decreasing mortality rates and increasing reproduction as population size decreases are considered compensatory. A number of such mechanisms have been described in the literature and include, density-dependent changes in growth, predation, fecundity, cannibalism and territoriality.

The same processes which allow fish populations to maintain their size while undergoing exploitation (i.e. fishing), permit populations to withstand power plant induced mortalities (24,25). Through most fish populations continue to exist when fished, some fisheries have experienced catastrophic failures. Such failures, demonstrate that the ability of compensatory process to offset increased mortalities is limited (24,25). Power plant induced mortalities place additional stress on exploited fish populations. The ability of a population to compensate for this partially depends on the levels of mortality present in the system prior to power plant operation. In general, a fish stock's capacity for compensation is reduced by fishing mortality (23-25).

In some cases, loses may be magnified by depensatory processes. Depensation results from density-dependent mechanisms which increase mortality rates and decrease reproduction as population size decreases.

The four major ways ocean thermal power plants may affect fish population densities are: 1) attraction, 2) entrainment, 3) impingement, and 4) water discharges.

1. Attraction

Pelagic fishes are frequently found in association with floating objects and fixed structures. OTEC power plants may attract and concentrate pelagic fishes such as, tunas, mackerels, and dolphin fish. A survey of fish attracted to Mini-OTEC was conducted during the barge's deployment and operation off Ke-ahole Point, Hawaii (June 1979 to November 1979). The following species were reported from the diver and camera observations: spotted triggerfish, opelu, rainbow runner, mahimahi, pilot fish, white-tipped shark, kahala, akule, filefish, rudderfish, juvenile yellow tang, reef blenny, and damselfish (26). Commercial and charter fishermen reported catching or siting mahimahi, whale shark, white-tipped shark, aku, ahi, and ono (26). The OTEC-1 platform when moored off Ke-ahole Point, acted as an aggregating device. Numerous ahi (yellowfin and bigeye tuna) and aku (skipjack tuna) were caught off the vessel. In addition, commercial, sport and charter fishermen took advantage of the congregation of pelagic species around the vessel. It is not known whether commercial scale OTEC operations will also attract fish; the noise, lights, chemical releases and the physical design of the structure may affect the plant's aggregating abilities.

Mini-OTEC and OTEC-1 did not increase fish production, instead they made exploitation of the fish in the general area easier. Unlike Mini-OTEC and OTEC-1, commercial OTEC plants would remain in the water for extended periods permitting the development of fouling communities with encrusting organisms and associated motile invertebrates.

With the successional development of the fouling community, an OTEC plant would act as an artificial reef. Some studies report that artificial reefs increase production in the areas where they are located.

If OTEC power plants act as aggregating devices or as artificial reefs, they may increase mortalities due to fishing. If OTEC plants attract fish, the impact of plant operations on fish will be increased (27). If they act as artificial reefs, production and natural mortality rates of local fish populations may be altered.

2. Entrainment

Water passing through the plant will contain entrained organisms. Organisms susceptible to entrainment include, phytoplankton, zooplankton, fish eggs, fish larvae and small fish. Entrained organisms will be subjected to mechanical abrasion, temperature and pressure changes and biocides (1). These stresses will result in mass mortalities. Ichthyoplankton is highly susceptible and mortalities in fossil-fuel and nuclear power plants generally range from 60 to 100% (28).

3. Impingement

Fish with low avoidance capabilities, such as small epipelagic fish and mesopelagic fish will be impinged on plant screens. Impingement may increase the mortality rates of those species affected. If the population sizes of impinged species are altered the natural mortality rates of other species may be changed through food-chain interactions (27).

4. Water Discharges

The displacement of large quantities of water may locally alter temperature structures, salinity gradients, and turbidity levels (1,2). Such habitat alterations may affect fishes' use of the waters around the plant, and the mortality rates of eggs and larvae. Larval survival rates may be affected if water discharges alter food availability. Biocide releases may have lethal and sublethal affects on adult, juvenile and larval fish.

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