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Biological and Economic Assessment of Pacific Ocean Perch (Sebastes alutus) in Waters off Alaska

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by

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ABSTRACT

This paper examines the depleted Pacific ocean perch, *Sebastes alutus*, stocks in waters off Alaska. The biology of the species is reviewed and the exploitation history recounted. Virtual population analysis and stock reduction analysis are used to estimate current status and productivity of the stocks. A predictive model is used to estimate stock rebuilding rates under a range of fishing rates. Finally, long-term yields and profits are examined in an economic analysis and the effects reduced quotas would have on existing fisheries are studied.

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PREFACE

This manuscript on the biology and economics of Pacific ocean perch (POP) analyzes the current status of POP and estimates its current and future productivity in waters off Alaska.

Historical catch data for POP, on which this analysis is based may have included some catches of northern, rougheye, sharpchin, and shortraker rockfish prior to 1979. As much as possible, however, these species were removed from the catch records prior to the analysis. The problems caused by the individual catch of species other than *Sebastes alutus* are believed to be minor. With the exception of the section entitled, "Possible Effects of Reduced Pacific Ocean Perch Quotas on Existing Fisheries," the results in this manuscript apply to S. *alutus* only. The correct application of the results is to identify current biomass of S. *alutus*, determine the case from the manuscript which applies, and find the appropriate exploitation rate.

Since the management plan manages the "POP complex," which includes all five species mentioned above, it would be appropriate to add the available yield from the non-S. *alutus* species to that of S. *alutus* attained from the analysis. It is also appropriate, then, to assure that the total catch is properly distributed among the species.

INTRODUCTION

The decline since the 1960s of Pacific--ocean perch, *Sebastes alutus,* stocks from the eastern Bering Sea to the California coast has been discussed and documented in numerous recent reports. Recognizing this depleted status, the Pacific Fishery Management Council, charged with management of. offshore fisheries from Washington to California, has developed a schedule of reduced fishing rates on Pacific ocean perch. The reduced exploitation is designed to rebuild the stock over a 20-yr period to levels capable of supporting a viable domestic fishery. Similarily, the Canadian Department of Fisheries and Oceans has developed rehabilitation schedules of reduced effort on Pacific ocean perch stocks off the British Columbia coast.

Although the North Pacific Fishery Management Council has restricted recent harvest of Pacific ocean perch in waters off Alaska to levels below estimated equilibrium yield, no information has been available about the effect these restrictions have had on the rebuilding of perch stocks. This paper presents an analysis of rebuilding schedules and the cost of those schedules.

Our analysis is presented in several parts beginning with brief descriptions of Pacific ocean perch biology and the fisheries that have exploited the Alaskan perch stocks. Then, a review of past analyses of abundance and productivity is followed by our most current interpretation of the available data using virtual population analysis and stock reduction analysis.

Our best population parameter estimates are used in a simple predictive model to estimate future stock size under a variety of fishing rates. This is the section of most interest, but it is also the section of most uncertainty. The cornerstone of predictions of future abundance is the prediction of recruitment from the spawning stock. We have not been able to identify a stock-recruitment relationship in the data. Alternatively, we have presented a range of recruitment responses and used the population model to predict future stock size for this range.

We have provided an economic analysis of the simulated populations. cost and revenue functions were added to the predictive model and long-term yield and profits examined.

In some cases the fishing rates, imposed on the simulated populations result in Pacific ocean perch quotas reduced below the present levels of fishing. This report examines the effect such reduced quotas would have on existing fisheries.

BIOLOGY

Description

Pacific ocean perch belongs to the family Scorpaenidae and is one of 54 or more species in the genus Sebastes occurring in the North Pacific Ocean and Bering Sea. Phillips (1957) and Barsukov (1964a, b) provide detailed descriptions of the morphometric, meristic, and other physical characteristics of s. alutus, and these attributes are summarized by Alverson and Westrheim (1961), Major and Shippen (1970), and Hart (1973).

A group of four Sebastes species, with similar color and physical characteristics as S. alutus, may have been misidentified as Pacific ocean perch in commercial catches. This group includes: northern rockfish, S. polyspinis; rougheye rockfish, S. aleutianus; shortraker rockfish, S.

borealis; and sharpchin rockfish, *S. zacentrus*. Unfortunately, relatively little is known about the distribution and biology of these four rockfish species.

Distribution and Migration

Pacific ocean perch are semidemersal and inhabit the temperate waters of the outer continental shelf and upper slope regions throughout their range. Distribution along the North American coast spans from La Jolla, California to the western boundary of the Aleutian Archipelago, and along the continental slope of the eastern Bering Sea. Along the Asiatic coast, small catches have been recorded from Cape Navarin to as far south as the Kuril Islands.

This species is usually associated with gravel, rocky, or boulder type substrate found in and along gullies, canyons, and submarine depressions of the upper continental slope (Alverson and Westrheim 1961). Substrate and bottom topography, however, are not the only factors determining Pacific ocean perch distribution; food supply, water temperature, state of maturity, and such hydrographic factors as oxygen content also influence its occurrence (Lyubimova 1963, 1965; Gunderson 1971). The bathymetric range of *S. alutus* was reported by Clemens and Wilby (1961) as 70 to 640 m, with commercial quantitities generally occurring between 110 and 457 m (Quast 1972).

Pacific ocean perch undergoes a seasonal bathymetric migration throughout its range (Paraketsov 1963; Lyubimova 1963; Gunderson 1971). This movement is primarily associated with spawning behavior, with the time of spawning varying slightly between regions. Typically, this migration is characterized by a movement into deep water spawning areas to release young during the late winter or early spring, then a return to shallower water to feed during the summer.

Diurnal vertical migrations of S. alutus have been documented by a number of investigators. Moiseev and Paraketsov (1961) indicated that Pacific ocean perch in the Bering Sea dwell near the bottom during the day and migrate as much as 40 m off the sea floor during the night. Lestev (1961) observed that during May and June, schools were usually 10 to 15 m off bottom, but occasionally ascended to 50 to 90 m over depths of 140 to 359 m. This same sort of behavior has been described for Pacific ocean perch in the Gulf of Alaska (Lyubimova 1964). These daily vertical shifts are apparently due to changes in light and feeding behavior (Lestev 1961; Skalkin 1964; Pautov 1972).

Coastwide migrations of 5 alutus have not been well documented, primarily because tagging studies are difficult to conduct on this species. Although coastwide movements of Pacific ocean perch have been suggested for stocks inhabiting the Gulf of Alaska (Lyubimova 1963, 1965) and Bering Sea (Moiseev and Paraketsov 1961), it seems to be the consensus that S alutus do not migrate extensively along the continental slope (Lestev 1961; Fadeev 1968; Chikuni 1975; Robinson 1972; Gunderson 1977; Westrheim 1973). In the present study, it is assumed that migration of juveniles and adults from one region to another is negligible.

Maturity, Fecundity, Reproduction, and Early Life History

Maturation varies with sex, age, and size of the fish. There also appear to be regional differences in the time of, first maturity. Pautov (1972) reported that Pacific ocean perch from the Bering Sea reach sexual maturity at sizes of from 26 to 31 cm in length and that males mature earlier (6 to 7 yr) than females (8 to 9 yr). Perch from the Gulf of Alaska are believed to mature at ages 6-8 yr, corresponding with lengths of 26-28 cm (Lyubimova 1965). Gunderson (1977) indicated that Pacific ocean perch inhabiting the area from Queen Charlotte Sound, British Columbia to Washington reach sexual maturity at 9-11 yr for females and 6-7 yr for males. Maturation of both sexes appears to depend more on the size of the fish than on its age. Chikuni (1975) concluded that Pacific ocean perch in the Bering Sea and Gulf of Alaska begin to mature at age 5, and all individuals finish their sexual maturation by age 9.

Fecundity of S. alutus has been examined by a number of authors (Westrheim 1958; Paraketsov 1963; Lisovenko 1965; Snytko 1971; Alverson and Westrheim 1961; Chikuni 1975; Gunderson 1977). Estimates have ranged from 10,000 to over 300,000 eggs per gravid female. There appear to be significant differences in fecundity between regions. Stocks inhabiting the eastern Pacific region (south of Dixon Entrance) evidently are more fecund thanthose from the Bering Sea, and Pacific ocean perch living in the Bering Sea are reportedly more fecund than fish from the Gulf of Alaska.

Pacific ocean perch are ovoviviparous as are all members of the genus Sebastes (Hart 1973). During the late fall or early winter, the eggs are fertilized internally and are retained in the ovary during incubation. Just prior to parturition, the eggs are hatched within the female and the larvae then extruded. The larvae ascend to the upper layers of the water column and drift with the currents. In the Gulf of Alaska and Bering Sea, parturition occurs during the late winter or early spring at depths ranging from 250 to

450 m. Further details concerning the reproduction of this species are described by Westrheim (1975) and Lisovenko (1970).

The spawning sites are believed to be associated with circular or slow moving currents, so that the pelagic larvae are not carried far from the spawning grounds. Lisovenko (1964) and Lyubimova (1965) indicate that the bulk of the Pacific ocean perch larvae in the Gulf of Alaska are associated with anticyclonic gyrals. These gyrals appear at the boundary between the high velocity Alaskan Stream and the relatively stagnant coastal water, resulting in areas of high productivity. These areas provide ideal conditions for feeding Pacific ocean perch larvae, and the circular currents presumably prevent the larvae from being swept to unfavorable environments. Moiseev and Paraketsov (1961) and Hebard (1959) suggest a similar type of scenario for larvae spawned by demersal species inhabiting the area north of Unimak Island. Pruter (1973) also recognizes the major role that gyres play in creating stable conditions which favor development of fish populations in the Bering Sea.

The length of time the larvae remain planktonic has been a point of contention in the literature. Several authors have speculated that young S. alutus remain pelagic until their second or third year of life (Alverson and Westrheim 1961; Lyubimova 1964, 1965; Paraketsov 1963; Snytko 1971). One author even contends that Pacific ocean perch do not shift their habitat to the bottom of the sea until they reach 3 to 5 yr of age (Chikuni 1975). These authors based their conclusions primarily on back-calculated growth rates and not on confirmed observations of S. alutus larvae and juveniles. Moreover, no one has yet confirmed the existence of juvenile Pacific ocean perch in offshore open water by collecting free-swimming specimens there (Carlson and

Haight 1976). This lack of confirmation, however, may be more apparent than real because adequate samples have not been obtained from the region and criteria have not been developed to distinguish the larval form of the species (A. W. Kendall, NMFS Northwest and Alaska Fisheries Center, Seattle, WA 98112. Pers. commun., September 1984).

Carlson and Haight (1976) reject the hypothesis of an early pelagic existence of greater than 2-3 yr. They show that Pacific ocean perch juveniles become demersal during their first year of life. Their conclusion was based on a comprehensive study of the environment, growth, food habits, and schooling behavior of juveniles from coastal waters of southeastern Alaska. More recent work by Carlson and Straty (1981) support these findings.

The hydrography of the North Pacific is variable and extremely complex. Due to the prevailing ocean currents, there is probably drift of Pacific ocean perch larvae from one region to another. However, it is currently impossible to quantify the magnitude of this drift because of inadequate sampling and the problems associated with identifying rockfish larvae to species. This study assumes that the interchange of Pacific ocean perch larvae among the major regions is minor and that the transformation to the benthic stage occurs inshore near the spawning areas within 1 yr.

Age and Growth

Age determinations from scales and surfaces of otoliths suggest that the longevity of Pacific ocean perch is about 30 yr (Alverson and Westrheim 1961; Chikuni 1975; Westrheim 1973). However, studies employing new aging techniques indicate longevity may be considerably greater than previously thought (Beamish 1979; Chilton and Beamish 1982). By analyzing growth patterns on thin sections of otoliths and from broken and burned otoliths, Chilton and Beamish (1982) concluded that the maximum age of Pacific ocean perch was around 90 yr. Such long life spans were also described for other rockfish species, most notably rougheye. rockfish, 140 yr; shortraker rockfish, 120 yr; and sharpchin rockfish, 45 yr.

At this time, there is no direct evidence to conclusively validate the ages determined from Pacific ocean perch scales or otoliths. Zones identified as annuli cannot be verified as formin once a year since no method exists to successfully tag and release live Pacific ocean perch. Age estimates that are produced without validation should be used with caution.

Growth analyses of Pacific ocean perch are complicated by age determination difficulties, and by bathymetric and geographic variations in the age-length relationships (Westrheim 1973). Rapid changes in the population structure and abundance, due to heavy exploitation, have undoubtedly confounded the analyses of growth. Nevertheless, some general conclusions can be reached concerning the growth of this species.

Pacific ocean perch are long-lived and slow-growing. Westrheim (1973) working in the Gulf of Alaska and Pautov (1972) in the Bering Sea suggested that differential growth occurs between sexes, with females supposedly growing to a slightly larger size than males. On the other hand, Gritsenko (19631, Lyubimova (1965), and Chikuni (1975) found no differences in growth patterns between males and females within the Gulf of Alaska or Bering Sea. The present study assumes that differences in growth between sexes are negligible.

Geographic differences in the growth of Pacific ocean perch have been described by several workers. Westrheim (1973) noted that mean length per age generally declined northward and westward in the northeast Pacific.

Similarly, Westrheim and Snytko (1974) concluded that weight per given length increased eastward and southward from the Aleutian Islands area to the Washington-Oregon area. He also mentioned that Bering Sea S. alutus generally weigh more per given length than those. in adjacent areas of the Aleutian Islands and Unimak Island. Chikuni (1975) also described regional differences in the age-length, age-weight, and weight-length relationships for Pacific ocean perch from the North Pacific.

DESCRIPTION OF THE FISHERY

Vessels and Gear

Japan and the Soviet Unon have been the principal nations exploiting the Bering Sea and Gulf of Alaska Pacific ocean perch stocks. Both nations employ distant-water trawlers of varying sizes and designs as their primary method of harvest, Many of the smaller vessels function as catcher boats for the large motherships (factory ships), whereas the larger trawlers generally operate independently by processing and freezing their own catch. Use of support vessels, which permit the fishing fleets to operate at sea for extended periods of time, is common.

Most of the Pacific ocean perch catch is headed, eviscerated, and quick-frozen. It is used primarily for direct human consumption. Catch statistics are shown in Table 1.

Japan

The Japanese fishery for Pacific ocean perch can be organized into three major categories: the land-based fleet, the mothership fleet, and the North Pacific trawl fleet. The land-based trawl fishery is conducted by independent trawlers of 100-350 gross registered tons (GRT). Vessels in this fleet are restricted to waters north of lat. 48°N and west of long. 170°W. Much of the fleet operates along the continental slope from north of the Kuril Islands to Cape Navarin. Fishing also occurs along the continental slope of the eastern Bering Sea and throughout the Aleutian Archipelago. During the earlier years, the principal gear type was the Danish seine; stern trawlers are now the mainstay of this fleet.

The mothership fishery employs large factory ships to receive and process catches supplied by a fleet of catcher vessels. Catcher vessels in this fleet have operated a number of gear types, including longlines, gill nets, stern trawls, pair trawls, side trawls, and Danish seines. Fishing mainly occurs along, the continental slope of the eastern Bering Sea and along both sides of the Aleutian Islands. Most of the trawl effort during the early 1960s was directed towards yellowfin sole, Limanda aspera, and Pacific ocean perch. With the development of techniques for processing minced fish (surimi) on board motherships in 1964, and the subsequent decline of perch stocks, considerable effort shifted to walleye pollock, Theragra chalcogramma.

The Japanese North Pacific trawl fishery generally consists of large factory stern trawlers that operate independently of motherships. These vessels range in size from 349 to 5,700 GRT and customarily fish and process their own catch. Much of the effort throughout the 1960s and early 1970s was directed toward Pacific ocean perch and other rockfishes in the Gulf of Alaska and Aleutian Islands, and toward walleye pollock in the eastern Bering Sea.

Soviet Union

The Soviet Union utilized the flotilla concept in its fishing operations. This involves the deployment of several kinds of vessels in support of its catcher fleet. Support vessels typically include factory ships for receiving and processing catches, refrigerator transports (to replenish stores aboard catcher vessels and to receive, freeze, and transport catches to the homeland), oil tankers, personnel transports, tugs, patrol vessels, and hospital ships (Pruter 1976). These vessels, particularly the large refrigerator transports, have enabled the Soviet fleet to locate and fish productive Pacific ocean perch grounds year round and process tremendous quantitites of catch.

The Soviets have employed two basic types of vessels in their fishing operations, side trawlers and stern trawlers. Side trawlers were the prevalent fishing vessel during the early years of this nationl's Pacific ocean perch fishery. These relatively small vessels lacked processing and refrigerating capabilities making them highly dependent on factory ships. Side trawlers were then phased out in favor of the more efficient factory stern trawlers. Because of their larger size and more efficient layout for handling the trawl over the stern, this type of vessel exhibited greater versatility and was better able to fish under bad weather conditions (Pruter 1976). Factory stern trawlers have tremendous processing capabilities and freezing capacity which have enabled them to operate for long periods as independent units.

Other Nations

Minor catches of Pacific ocean perch from the Bering Sea and Gulf of Alaska have been taken by Poland, Republic of Korea, Taiwan, Canada, and the

United States. These catches were taken primarily by stern trawlers. Stern trawlers in the Polish fleet are similar in size and configuration to their Soviet counterparts, ranging in length from 70 to 90 m and weighing 2,300-2,500 GRT (Wall et al. 1981). In 1977 and 1978, trawlers of the Korean fleet were comparable in size and design to the large Japanese freezer trawlers; Taiwanese trawlers ranged in size from 900 to 1,900 GRT (Nelson et al. 1981). Canadian and U.S. trawlers are considerbly smaller than trawlers employed by the Asian and European nations.

Fishing Grounds, Seasons, and Depth of Fishing

The Japanese and Soviets have generally conducted trawling operations for Pacific ocean perch in the same areas. Productive areas in the Gulf of Alaska include the Shumagin Island grounds, the Albatross Bank off Kodiak, the Portlock Bank south of the Kenai Peninsula, and the trawlable areas off Yakutat and southeastern Alaska. In the Bering Sea, catches are taken along the entire length of the eastern continental slope, also known as the "eastern slope region." Large catches are also taken from both sides of the Aleutian Islands.

Pacific ocean perch are caught year round in the Gulf of Alaska and during most of the year in the eastern slope region. Pacific ocean perch catches from both regions are taken by a directed fishery as well as appearing incidentally in other directed fisheries, such as those for walleye pollock, flounder, and Pacific cod, Gadus macrocephalus. In the Aleutian Islands region most of the 1964 to 1979 Japanese Pacific ocean perch catch was caught during a 6-month period from April to October.

Depth of fishing varies by season. This is apparently in response to the bathymetric migration of S. alutus. Lyubimova (1964) indicated that the most suitable depths for Pacific ocean perch fishing in the Gulf of Alaska were between 180 and 350 m in summer and between 250 and 420 m in winter. Alverson and Westrheim (1961) reported a similar distribution in the waters off Washington and Oregon. Paraketsov (1963) noted that S. alutus. in the Bering Sea were common at depths of 140-360 m during the winter and spring. Chikuni (1975) showed that the bulk of the Japanese Pacific ocean perch catch from the Gulf of Alaska in 1965 was taken at depths between 200 to 300 m.

Lyubimova (1964) indicated differences in the size of S. alutus caught by depth. The larger adult fish were usually found at deeper depths than were the smaller juveniles. Examination of the size composition data from the Japanese groundfish fishery in 1965 (Fig. 1) corroborates the findings of Lyubimova (1964).

Catch Trends

The foreign fishery for Pacific ocean perch did not begin in earnest until about 1960. During the first year the foreign fleets removed about 6,100 t of Pacific ocean perch from the eastern slope region. By 1962 the fishery had expanded into the Gulf of Alaska and Aleutian Islands regions. Growth of this new fishery was rapid. Within just 6 yr of its inception, total removals (all regions combined) peaked with a harvest of 474,100 t (Fig. 2). Soon after, total removals declined almost as rapidly as they had increased. In 1982 total catches amounted to only 1.6% of the 1965 peak catch.

Pacific ocean perch harvests from the Gulf of Alaska have generally been greater than those taken from the Aleutian Islands and eastern slope regions. These catch trends indicate the relative stock size in each of the three regions. It appears that the Gulf of Alaska contains the largest stock; the Aleutian Islands region the next largest. Pacific ocean perch in the eastern slope region apparently is the smallest stock.

Maximum sustainable yield (MSY) has been estimated at 150,000 t for the Gulf of Alaska stock; 75,000 t for the Aleutian Islands stock; and 32,000 t for the eastern slope stock (Chikuni 1975). Clearly, sustained exploitation of the magnitude characterizing the early years of the fishery was not possible. Low (1974) estimated MSY for the eastern slope and Aleutian Islands stocks combined at 12,000-37,000 t.

The percent composition of Pacific ocean perch in the Japanese groundfish catch has declined through the years (Fig. 3). In the Aleutian Islands and Gulf of Alaska regions, this decline was probably due to a combination of decreasing stock abundance and a shift to different target species. After 1972, Pacific ocean perch never comprised more than 50% of the total groundfish catch from any region. Pacific ocean perch in the eastern slope region is apparently not a primary target species in the Japanese groundfish fishery; Pacific ocean perch from this region has never exceeded 9% of the total annual groundfish catch.

PREVIOUS STOCK ASSESSMENTS

Previous assessments of Pacific ocean perch have been based primarily on changes in catch per unit of effort (CPUE) in the commercial trawl fisheries. These CPUE data, however, have become increasingly difficult to interpret as an index of stock abundance. Quota restrictions, effort shifts to different target species, and rapid improvements in fishing technology and fishing skill have confounded the analyses of CPUE data. Only recently have reasonable estimates of absolute abundance become available from survey data. The following sections briefly describe results from previous stock assessments.

CPUE Analysis

Commercial catch and effort statistics supplied by Japan have been the primary data source for most CPUE-type analyses. These statistics are detailed and complete, in temporal and areal sequence, and are perhaps among the best on demersal fisheries anywhere in the world. Several researchers have used these data as a means of monitoring changes in Pacific ocean perch stock abundance.

Ito (1982) calculated the catch in tons of Pacific ocean perch per stern trawl hour (Fig. 4). This index was based on the nominal effort of all stern trawlers combined from the Japanese mothership and North Pacific trawl fisheries. He also calculated CPUE by stern trawler size categories (Tables 2-4). The results of Ito's CPUE analysis indicated that Pacific ocean perch stocks underwent sizable reductions in biomass throughout much of the 1960s and 1970s.

The CPUE analyses presented by Ito (1982) were simplistic. No attempts were made to adjust for differences in effective fishing effort. Effort was treated as if all stern trawl hours were directed toward catching Pacific ocean perch, when such was not the case. Vessels operating in the Pacific ocean perch fishery do not depend solely on this species to fill their fish holds. Furthermore, with recent quota restrictions on the harvest of Pacific ocean perch, much of the Japanese trawl effort shifted to other target species. Recent changes in CPUE, therefore, may not be indicative of actual changes in stock abundance.

Chikuni (1975) derived a relative abundance index to account for effort directed only toward S. alutus. For each stock and year, CPUE of vessel class-8 stern trawlers (2,501-3,500 t) were regressed against the percent composition of Pacific ocean perch in the total groundfish catch. The density index was then estimated from this regression equation, by assuming the S. alutus catch was a fixed percentage of the total groundfish catch in each year (95% for the Bering Sea stocks and 85% for the Gulf of Alaska stock). The resulting quantitites are assumed to represent what the true CPUE would be if all the effort were directed solely toward harvesting Pacific ocean perch. For comparative purposes, these indices were plotted with the absolute abundance estimates from Ito's (1982) cohort analysis (Fig. 5).

The Chikuni density index assumes that the percentage of Pacific ocean perch in the total groundfish catch represents the fraction of the total effort directed toward catching S. alutus. However, if all the effort was directed toward harvesting Pacific ocean perch and this species represented only 20% of the total groundfish catch, no adjustment to the CPUE figure should be required. Chikuni's density index, nevertheless, would still make the correction to CPUE as if only 20% of the total effort were directed toward Pacific ocean perch. The density index in this case would be biased toward the high side. Furthermore, this method involves such hazards as arbitrarily fixing the standard catch proportion at 95% for the Bering Sea stocks and 85% for the Gulf of Alaska stock.

Commercial fishery statistics are not the only data available for assessing the status of Pacific ocean perch stocks; data collected from scientific surveys provide valuable information as well. In 1961-62, the first large-scale, systematic assessment of the groundfish resources in the Gulf of Alaska was a trawl survey carried out by the International Pacific Halibut Commission, with the cooperation of the U.S. Bureau of Commercial Fisheries (BCF). This survey occurred prior to the intense exploitation of the Pacific ocean perch stocks by foreign fleets during the mid-1960s. A similar survey was later conducted in the same region from 1973 to 1976 by the National Marine Fisheries Service (NMFS), successor to the BCF. The CPUE statistics from these surveys suggested a substantial decrease in abundance from 1961 to the mid-1970s (Table 5).

CPUE estimates from surveys conducted in the Gulf of Alaska in 1979 and 1981 indicate considerable increases in abundance over levels present in 1978 (Table 6). The size of this increase, however, does not seem reasonable.

Absolute Abundance Analyses

Data from 1979, 1981, and 1982 cooperative U.S.-Japan trawl surveys provide biomass estimates of Pacific ocean perch in the eastern Bering Sea. The survey results indicate that biomass increased from 4,459 t in 1979 to 9,821 t in 1981 and then decreased to 5,505 t in 1982 (Table 7). These estimates, however, were characterized by relatively wide variances. The 95% confidence intervals overlapped extensively indicating that the point estimates for each year may not be significantly different.

The surveys conducted in 1979, 1981, and 1982 did not sample the Aleutian Islands portion of the eastern Bering Sea region (long. 165° to 170°W). This section, however, was surveyed during the 1980 U.S.-Japan trawl survey of the Aleutian Islands; biomass from this section amounted to about 7,000 t. A reasonable biomass estimate for the entire eastern Bering Sea region was calculated as an average of the 1979-82 estimates plus the 1980 point estimate from the Aleutian Islands segment. This estimate amounted to about 13,600 t (Table 7).

A Japanese groundfish survey conducted in 1969 along the eastern Bering Sea slope provided sufficient information to estimate Pacific ocean perch biomass within the 189-366 m depth strata. Biomass estimates were also recalculated for the 189-366 m depth strata from the 1979-82 survey data. Although the sampling design and trawl gear employed during the 1969 and 1979-82 surveys were different, the data should still provide an approximation of changes in abundance between the two periods. These data indicate that Pacific ocean perch biomass fell approximately 86% during the 10-yr period from 1969-79 (Table 7). Recently, biomass in the 189-366 m depth strata appears to have stabilized at a low level, averaging about 5,700 t during the 1979-82 survey period.

During the summer-fall of 1980, the NMFS Northwest and Alaska Fisheries Center, in cooperation with the Japan Fishery Agency, conducted a groundfish survey of the Aleutian Islands from Unimak Pass to Attu Island. This was the first NMFS resource assessment of groundfish in the Aleutian Islands region. Therefore, no previous survey data bases were available to measure changes in the status of Pacific ocean perch stocks in the survey area. As previously mentioned, this survey also covered that portion of the International North Pacific Fisheries Commission's (INPFC) Bering Sea statistical area 1 not surveyed in the 1979-82 Bering Sea assessments.

The exploitable biomass of Pacific ocean perch in the Aleutian Islands region (long. 170°E - 170°w) was estimated at 107,800 t. The biomass estimate from the Aleutian Islands portion of INPFC Bering Sea statistical area 1 was about 7,000 t. The bulk of the biomass (86.2%) occurred in the depth range from 100 to 300 m.

Although many trawl surveys have been conducted in the Gulf of Alaska, currently no reasonable biomass estimates exist for Pacific ocean perch in the region. The 1984 comprehensive resource assessment survey in the Gulf of Alaska should provide these data.

The biomass estimates from the above-mentioned trawl surveys probably underestimate the true population size of Pacific ocean perch. As discussed by Bakkala et al. (1982), this species is known to occupy the water column above that sampled by the bottom trawls. Pacific ocean perch are also known to inhabit areas of rough bottom which were avoided during the surveys to prevent damage to the trawls. Unfortunately, that portion of the population unavailable to the trawl gear cannot be determined at this time.

Cohort ana sis (Pope 1972) gives an alternative to commercial CPUE and, trawl survey stock assessment methods of estimating abundance. This method circumvents the need for effort statistics and estimates stock abundance in actual numbers. However, cohort analysis requires historical catch-at-age, data, an estimate of natural mortality, and an estimate of terminal fishing mortality for each year class.

Ito (1982) applied cohort analysis to catch-at-age data from all three stocks. For each stock, catch and age data (1963-79) were derived from Chikuni (1975), foreign reported catches, and the U.S. observer data bases (Appendix A). Natural (M) and terminal fishing mortalities (F(t)) were taken from the literature. The cohort analysis was initially run with M = 0.15 and F(t) = 0.35 (first approximations). The abundance estimates from cohort analysis did not correlate well with the trend of Chikuni's (1975) density index (Fig. 5).

When employing CPUE as an index of stock abundance, a major source of bias stems from the measurement of effective fishing effort. Effective effort is difficult to quantify, particularly in multispecies fisheries. Chikuni (1975) attempted to estimate effective fishing effort but, as noted above, there were drawbacks to his method. Furthermore, none of the CPUE data used in his analysis were adjusted for learning and skill factors. Rapid developments in technology and fishing skill undoubtedly occurred throughout the history of the Pacific ocean perch fishery, and unless these factors are considered, CPUE may be seriously biased as an index of stock abundance.

The abundance results from cohort analysis do not depend on fishing effort; moreover, stock size is measured in terms of absolute numbers of fish, rather than as an index. Although cohort analysis is free from errors associated with the estimation of fishing effort, this, type of analysis is subject to its own errors such as the incorrect estimation of M, F(t), and catch at age.

Because of the uncertainty regarding the true values for the input parameters (M and F(t)), Ito (1982) examined their effect on the abundance estimates from cohort analysis. Natural mortality was varied using values of 0.05, 0.10, 0.15, 0.20, and 0.30. The values of F(t) emloyed were 0.175, 0.350, 0.525, 0.700, and 1.050. Based on the literature,, these values appeared to encompass the conceivable range for the model parameters. Regardless of which parameter combination was used, the results always indicated a decreasing trend in biomass.

CURRENT STOCK ASSESSMENTS

Methods

Stock assessments presented in this report are based on Virtual Population Analysis (VPA) and Stock Reduction Analysis (SRA). The standard form of VPA was used (called "Gulland's VPA" by Pope 1972), which can be described by the exponential model of survival. Stock Reduction Analysis (Kimura and Tagart 1982; Kimura et al. 1984) is a new, biomass-based method of stock assessment using Deriso's (1980) delay-difference equation. The assumptions of VPA and SRA differ significantly, so that the two models are capable of providing relatively independent assessments.

The controversy on methods of deriving age data from otoliths (whether the method that uses otoliths which have been broken and burned and then sectioned is better than the method that uses whole otoliths) is especially relevant to the assessment of Pacific ocean perch. Beamish (1979) showed that perch age data derived from the former method were significantly higher than data derived from the latter method, and these higher ages have been validated in some Sebastes species (Bennett et al. 1982). Pacific ocean perch is the prime example used by Canadian scientists (Archibald et al. 1983; Beamish and McFarlane 1983) to describe how mis-aging has lead to incorrect stock assessments. The consensus among rockfish biologists now appears to be that data derived from the sectioned, or break-burn method, provide the more correct ages.

Mis-aging affects stock assessments in three main ways: most importantly, in our estimates of the natural mortality rate M; in our estimates of the age distribution of catch; and probably less cirtically in our estimates of growth. For Pacific ocean perch, the effect age determination methodology has on natural mortality estimates is critical, with M = 0.05 for ages derived from the sectioned method (Archibald et al. 1981) and M = 0.15 for ages derived from the use of whole otoliths (Ito 1982).

What estimates of natural mortality should we use in our stock assessments? Based on the literature, M = 0.05 is our preferred estimate of natural mortality, but the appropriate natural mortality rate for a stock assessment must also take into account the data to be analyzed. Because the catch-at-age compositions to be analyzed using VPA are based on surface ages, using the natural mortality rate of M = 0.05 would overestimate F and result in biomass estimates that are seriously biased in the low direction. Therefore, we feel that M = 0.15 is the correct natural mortality rate to use in analyzing surface-aged data using VPA.

Because SRA analyses annual catch in weight rather than annual catch in numbers at age, we can use M = 0.05 in SRA without being concerned with age distribution of the catch.

When comparing VPA and SRA assessments, we must realize that not only are they based on different natural mortality rates, but may also define the population biomasss differently. In this study, the population biomass for VPA was estimated using ages 5+ and 9+; for SRA, the population biomasss was considered to be the fishable biomass (ages 9+).

Virtual Population Analysis

The equations for the standard formulation of VPA are underdetermined. This means that a preliminary estimate of F is required for every cohort being analyzed. We did this by setting a single F value in a single cohort to some constant and then linking the other cohorts by assuming different ages in the same year were fished at the same rate. This method of linking cohorts was apparently developed by W. H. Lenarz, NMFS Southwest Fisheries Center, Tiburon, California, and is described by Tagart (1982).

Because the initial F values influence the results, it is important to run VPAs using a variety of initial F values. Due to the convergence properties of VPA (Pope 1972), biomass estimates for earlier years are often similar for a range of initial F values. This is especially true with an F estimated through linked cohorts, since this technique fully utilizes the convergence properties of VPA.

Stock Reduction Analysis

A major problem in our assessment of Pacific ocean perch is that our age data, which were derived from the layers observed on the surface of unbroken otoliths, are now thought to be incorrect. The SRA allows an assessment of perch that is independent of detailed age composition data. The SRA methods used in this report were described briefly in Appendix B and in a paper by Kimura et al. (1984).

Although SRA does not require detailed age composition data, estimates of the age at recruitment (k), the natural mortality rate, and the, Brody growth coefficient are required. The age at recruitment was calculated to be k = 9 yr from the average modal surface age in catches from the Gulf of Alaska (data from Ito 1982). Because we wished our assessment to be consistent with the older ages derived from sectioned otoliths that have been broken and burned, we used available biological data from Pacific ocean perch in Queen Charlotte Sound. The natural mortality rate M = 0.05 was estimated by

Archibald et al. (1981), and growth data found in Archibald et al. (1983) was used to estimate the Brody weight coefficient p = 0.38.

Rebuilding Schedules

One of our principal goals in this study was to predict possible rebuilding scenarios given current stock conditions. We did this using the modeling results from SRA, and then projected these results into the future using the Deriso (1980) delay-difference equation. Details of how this was done can be found in Appendix B. Kimura (1984) describes how variability in recruitment can be added to this projection.

Using the SRA modeling results to project future stock biomass has several advantages over using results from the VPA analysis. Most importantly, since M = 0.05 was used in SRA and M = 0.15 was used in VPA, recruitment according to the VPA can be expected to be overestimated. A graph of the expected recruitment lines (Fig. 9, Appendix B) indicates recruitment using M = 0.15 may be overestimated by a factor of 2. Second, because recruitment is a component in the SRA model, future stock biomass can be estimated in a straightforward way. Finally, assumptions concerning current stock condition and stock-recruitment relationships can be easily modified in the SRA model.

Results of Current Assessments

Virtual Population Analysis

A range of F values was used to initiate the VPA computations because precise estimates of F were not known for recent years. The values employed for the eastern Bering Sea and Aleutian Islands stocks ranged from 0.05 to

1.00; for the Gulf of Alaska stock,. the range spanned from 0.01 to 0.50. Although these values were chosen somewhat arbitrarily, they were believed to encompass the range of conceivable F values for each stock.

The VPA results indicated a long-term, decreasing trend in biomass for all three Pacific ocean perch stocks. Depending on the initial F value chosen, the eastern Bering Sea stock decreased 60.4-98.8% during the 16 yr period from 1963 to 1979 (Fig. 6). The results further suggested that biomass in the Aleutian Islands stock may have decline 76.7%-98.2% from 1964 to 1979 (Fig. 7). The Gulf of Alaska stock apparently underwent large reductions in biomass as well. The 1979 biomass estimates for this stock represented a reduction of 69.1-99.5% from levels present in 1963 (Fig. 8).

Regardless of the F value used, however, the resulting biomass trends converged toward similar estimates of virgin biomass. Assuming M = 0.15, reasonable estimates of total virgin biomass (Table 8) are 188,000 t, 535,000 t, and 1,910,000 t for the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska stocks, respectively.

All biomass estimates presented thus far included 5 to 20 yr-olds. However, if we assume knife-edge recruitment at some age greater than 5 yr, the above estimates would not reflect "exploitable" biomass--the exploitable biomass would of course be less. In the present study, knife-edge recruitment is assumed to occur at age 9 yr for all three stocks.

Given an estimate of the virgin stock biomass, maximum sustainable yield (MSY) can be estimated as:

$$MSY = 0.5\ M\ B_1, \qquad (1)$$

where M = natural morality rate and B_1 = the virgin (unexploited) biomass of, the exploitable stock (Gulland 1970, Francis 1974). The B_1 estimate for each stock was calculated by summing the age-specific biomass estimates from ages 9 to 20 yr from the VPA results for the earliest year in the data series. Because the VPA analysis was executed with a range of F values, the above summing procedure was done to obtain the corresponding range of exploitable virgin biomasses for each stock.

Estimates of MSY were calculated using equation (1) and were based on M = 0.15 and the B_1 estimates (ages 9+) from Table 8. The MSY estimates for each stock. are shown below:

Region		Estimates of MSY
Eastern Bering Sea		10,050 t
Aleutian Islands		28,950 t
Gulf of Alaska		93,525 t
	Total	132,525 t

These MSY estimates are considerably lower than those estimated by Chikuni (1975): eastern Bering Sea, 32,000 t; Aleutian Islands, 75,000 t; and Gulf of Alaska, 150,000 t.

Stock Reduction Analysis

Treating each stock separately, Stock Reduction Analysis (SRA) was used to analyze Pacific ocean perch in the Gulf of Alaska, the Aleutian Islands region, and the eastern Bering Sea. The most recent survey estimates of Pacific ocean perch biomass were 13,600 t in the eastern Bering Sea (Table 7) and 107,800 t in the Aleutian Islands region. Recent trawl surveys in the Gulf of Alaska have not lent themselves to estimates of biomass, but relative levels can be inferred from CPUE. Considering the catch history of Pacific ocean perch, these levels would indicate that stocks are now low. To be consistent with the survey results, SRA estimates of P ($P = B_{n+1}/B_1$ is virgin biomass and B_{n+1} is final 1983 biomass) must average less than 0.3.

SRA estimates of virgin biomass--We begin our assessment by presenting tables of P (Tables 9-11), assuming different values for B_1 and r ($0.0 < r < 1.0$ indicates the dependence of recruitment on stock size, see Appendix B). Virgin biomass can be estimated assuming $P \approx 0.2$ with $r = 0.5$, and a confidence interval inferred from the range of B_1 constrained by $P \approx 0.2$ with $0.0 < r < 1.0$. This interval is not a statistical confidence interval, but an interval consistent with $P \approx 0.2$ and strong or weak recruitment. These estimates are shown below.

Region	Estimates of virgin biomass assuming $P \approx 0.2$, $r = 0.5$ (thousand t)	Interval consistent with SRA, $P \approx 0.2$
Eastern Bering Sea	240	+ 30
Aleutian Islands	560	+ 60
Gulf of Alaska	1,450	+ 150
Total	2,250	

SRA estimates of maximum sustainable yield--Estimates of Maximum Sustainable Yield (MSY) were calculated using the formulas described in Appendix B. High estimates of MSY were calculated assuming a nominal $P \approx 0.25$ with $r = 0.0$ (assuming $F = M$), and middle estimates were calculated assuming $P \approx 0.2$ with $r = 0.5$. The constraint $F = M$ was used because it is unrealistic to assume expected recruitment would remain constant at low biomass levels and because of the precedence of this relationship in the groundfish stock assessment literature (Gulland 1970; Francis 1974). When $r = 0.0$, SRA solutions for $P \ll 0.25$ were not possible because predicted catch would exceed biomass at some point in time. One property of SRA which is relevant here, is that if r = 1.0, no sustainable yield is possible regardless of the value of P. (See Appendix B, Equation 6). The SRA estimates of MSY are shown below.

Estimates of MSY in t

Region	$P \approx 0.25$, $r = 0.0$ (F = M)	$P \approx 0.2$, $r = 0.5$	$r = 1.0$
Eastern Bering Sea	4,984	2,840	0
Aleutian Island	11,865	6,627	0
Gulf of Alaska	30,849	17,160	0
Total	47,698	26,627	0

Rebuilding Schedules

As noted before, our current survey estimates of stock biomass (13,600 t in the eastern Bering Sea, 107,800 t in the Aleutian Islands region) indicate $P < 0.3$. With this in mind, SRA models were fit assuming $P \approx$ 0.1,0.2, and 0.3, with r = 0.5, and $P \approx 0.25$ with r = 0.0. Recall that when r equals 0.0, SRA fits with $P << 0.25$ were not possible with our data sets. The estimated historic stock biomass trends were plotted for these four scenarios in Figures 10-12, along with plots of equilibrium sustainable yield (Figs. 13-15).

Current stock conditions estimated from these fits (i.e., the estimated stock biomass at the beginning of 1983) and predicted future biomasses were calculated for each study, region, assuming constant future instantaneous fishing mortality rates of F = 0.0, 0.02, and 0.05 (Tables 12-14).

Discussion of Current Assessments

Current Stock Conditions

Unless additional information is available, VPA and SRA tell us nothing about current stock conditions. However, if current stock biomasses are known, a unique VPA solution can be determined, as well as an SRA solution up to the recruitment exponent r. Therefore, for both VPA and SRA, a complete assessment rests on survey estimates of current biomass. However, being cognizant of the potential errors present in survey biomass estimates, we use survey results mainly to establish the maximum SRA P value to be less than or equal to 0.3.

Virgin Biomass

The most robust parameter estimated in both VPA and SRA is virgin biomass. The SRA and VPA estimates of fishable biomass (ages 9+) are shown below.

Virgin Biomass Estimates in 1,000 t

Region		VPA	SRA ($P \approx 0.2$, $r = 0.5$)
Eastern Bering Sea		134	240
Aleutian Islands		386	560
Gulf of Alaska		1,247	1,450
	Total	1,767	2,250

The difference in these estimates may possibly be explained by the difference in natural mortality rates (M = 0.15 for VPA and M = 0.05 for SRA) used in the assessments, or in the SRA P, p, or r parameters being used. It is clear that the estimated total virgin biomass of 1,767,000 to 2,250,000 t for the three study regions is substantial.

Maximum Sustainable Yield

Roughly speaking, MSY is determined by the natural mortality rate and stock-recruitment relationships in a population. Estimates of MSY estimated from VPA are completely different from those obtained through SRA.

Region	VPA estimate of MSY (M = 0.15)	SPA estimate of MSY (M = 0.05) (assuming F = M): P ≈ 0.25 r = 0.0	SPA estimate of MSY (M = 0.05) (assuming F = M): P ≈ 0.2 r = 0.5
Eastern Bering Sea	10,050	4,984	2,840
Aleutian Islands	28,950	11,865	6,627
Gulf of Alaska	93,525	30,849	17,160
Total	132,525	47,698	26,627

These differences reflect differences in assumed natural mortality rates, and for SRA with r = 0.5, differences in the assumed stock-recruitment relationship. There are also biases in the models and data that are very difficult to evalute.

The VPA estimates of MSY though much higher than the SRA estimates are still considerably lower than the estimates made by Chikuni (1975). It is now apparent from the catch records (Table 1) and current stock conditions that catches of this magnitude were not sustainable.

The SRA probably used the more correct estimate of natural mortality (M = 0.05), but estimates of MSY are complicated by the recruitment exponent r, which greatly affects the. estimates. Low's (1975) combined estimate (based on production modeling) of 12,000-17,000 t for the combined eastern Bering Sea and Aleutian Islands regions compares well with the combined SRA estimates of 9,467 t (P≈ 0.2, r = 0.5) to 16,849 t (P≈ 0.25, r = 0.0). If the productivity of the stocks is measured by MSY ÷ (virgin biomass), our high MSY estimates give a productivity index of 2.1% compared with 2.2% estimated by Archibald et al. (1983) for Pacific ocean perch in the Queen Charlotte Sound region. While we have some hope that the larger MSYs calculated from SRA may be attainable, it appears equally likely that the existence of a stock-recruitment relationship will curtail MSY to the middle estimate of 26,627 t ([illegible] 0.2, $r = 0.5$) for the three study regions..

Rebuilding Schedules

The rapidity of the stock rebuilding process (Tables 12-14) is largely dependent on the recruitment exponent r. If $r = 0.0$, recruitment is constant and rebuilding is rapid even from low stock levels. With a moderate stock-recruitment, relationship of $r = 0.5$, rebuilding is relatively slow even when there is no fishing. If recruitment is proportional to stock biomass ($r = 1.0$) no rebuilding can occur.

To properly understand Tables 12-14, it is important to realize that for $F > 0.0$, the Equilibrium Biomass (EB) is significantly smaller than virgin biomass (B_1). The EB is the asymptotic biomass level towards which the stock is moving. For $r = 0.5$ and $F = 0.02$, $EB/B_1 = 0.51$; for $r = 0.5$ and $F = 0.05$, $EB/B_1 = 0.25$; for $r = 0.0$ and $F = 0.02$, $EB/B_1 = 0.71$, and for $r = 0.0$ and $F = 0.05$, $EB/B_1 = 0.50$.

At this time, we do not know which value of r is correct; in fact, as far as modeling rebuilding goes, different values of r may be appropriate at different stock biomass levels. As a stock rebuilds, strong recruitment (i.e., small values of r) becomes more likely.

An important fact is that for $r = 0.5$ and $F = 0.05$, there is virtually no rebuilding, and $EB = 0.25B_1$. However., for $r = 0.5$ and $F = 0.02$, $EB = 0.51B_1$, and asymptotic yield is nearly the same as for $F = 0.05$. Therefore, to our knowledge, an F of 0.02 appears to be the maximum allowable value consistent with concern for these stocks. Even smaller values of F are desirable, allowing for more rapid rebuilding, and providing a cushion for modeling and survey bias. These arguments are based on equilibrium conditions and do not consider costs involved in reaching these equilibria.

Using the most recent survey results, we estimate $P < 0.3$ for the eastern Bering Sea, the Aleutian Islands region, and the Gulf of Alaska. However, Gulf of Alaska surveys have been fragmentary and cannot provide biomass estimates. More accurate and more recent surveys could strengthen our conclusions. Future surveys will allow us to measure the actual rate of rebuilding, and develop firmer estimates of the sustainable yield from these stocks.

ECONOMIC ANALYSIS

The SRA simulation models for the three areas and four cases described below were run for a range of Fs.

Region	Case 1	Case 2	Case 3	Case 4
Gulf of Alaska				
Value r	0.5	0.5	0.5	0.0
Value P	0.112	0.194	0.308	0.266
Aleutian Islands				
Value r	0.5	0.5	0.5	0.0
Value P	0.111	0.198	0.303	0.240
Eastern Bering Sea				
Value r	0.5	0.5	0.5	0.0
Value P	0.101	0.198	0.301	0.261

The ratio of 1983 biomass to virgin stock biomass, P, differs among cases 1, 2, and 3, as the estimates of the 1983 biomasses become successively higher. Case 4 differs from the other three cases in terms #f both the values of P and r. The latter difference, the assumed recruitment parameter, is more significant. For cases 1 through 3, recruitment is a function of biomass; for case 4 it is constant and relatively high. Therefore, more rapid rebuilding. and much higher yields are possible with case 4 than with the other three cases. Case 4 may be beyond the upper range of our expectations concerning the resiliency of Pacific ocean perch stocks.

Cost and revenue functions were added to the SRA simulation models to estimate equilibrium profit as well as other economic variables. Revenue is assumed to be the product of catch in metrictons and a constant real ex-vessel price of $330 per metric ton ($0.15 per pound). Real harvesting cost is assumed to equal revenue in year 1 of the simulation, (i.e., it is assumed that economic profits equaled zero in 1983, year 1 in the simulation); and cost is assumed to change proportionally with F.

Terminal yields and profits in 200-yr simulations provide approximations of the equilibrium values associated with each F. They are approximations, because for cases 1-3 and F less than 0.1 equilibrium values are closely approached but not reached in 200 years. The resulting equilibrium yield and profit curvesare depicted in Figures 16-23. A dominant characteristics of the equilibrium yield curves is that they are relatively flat for F greater than 0.03 for cases 1-3 or F greater than 0.1 for case 4. Maximum sustainable yield (MSY) for each area occurs at F = 0.048 for cases 1-3 or at F = 0.360 for case 4 (Table 15). Note that F remains unconstrained in case 4, as opposed to the estimation of MSY by SRA earlier where F was assumed equal to M.

The equilibrium profit curves differ from the yield curves in the following ways: the profit curves are not as flat, the profit curves peak at significantly lower Fs, and the maximum sustainable profit (MSP) F varies by case (Table 16). The MSY and the yield associated with the MSP for a given case often differ by much less than the MSY and MSP Fs. It should be noted that although the MSP F is necessarily less than the MSY F due to the relatively flat yield curves, the MSP F is sensitive to the harvesting cost function as well as the biological functions used in the simulations.

Therefore, the confidence intervals about the point estimates of MSP Fs may be quite large.

The equilibrium yield and profit curves and the associated MSYs and MSPs provide some useful information; however, with a long-lived and slow-growing species such as Pacific ocean perch, the concepts of MSY and MSP are of limited use in evaluating alternative rebuilding schedules. Fifty year biomass and yield time paths, were estimated for four constant Fs (0.01, 0.03, 0.05, and 0.07) for each area and case (Figs. 24-47). The general characteristics of these time paths are similar for the three areas. Therefore, the following characterization of the Gulf of Alaska is valid for the Aleutian Islands and eastern Bering Sea as well.

<u>Case, 1</u> (r = 0.5, P= 0.111)

1. Biomass and yield increase over the 50-yr simulation for any F < 0.07.

2. Total yield for the 50-yr simulation is higher for F = 0.07 than for F = 0.01, 0.03, or 0.05.

<u>Case 2</u> (r = 0.5, P =0.194)

1. Biomass and yield increase over the 50-yr simulation for any F < 0.05 and decrease for any F > 0.07.

2. Total yield for the 50-yr simulation is higher for F = 0.07 than for F = 0.01, 0.03, or 0.05.

<u>Case 3</u> (r = 0.5, P = 0.303)

1. Biomass and yield increase over the 50-yr simulation for any F < 0.03 and decrease for any F > 0.05.

2. Total yield for the 50-yr simulation is higher for F = 0.07 than for F = 0.01; 0.03, or 0.05.

<u>Case 4</u> (r = 0.0, P = 0.240)

1. Biomass and yield increase over the 50-yr simulation for any F < 0.07.

2. Total yield for the 50-yr simulation is higher for F = 0.07 than for F = 0.01, 0.03, or 0.05.

Although the yield and biomass time paths summarize the degree to which rebuilding occurs in each case and area for each of the four constant Fs, they do not provide sufficient information to rank these alternatives. They are inadequate in that: 1) it may be unreasonable to assume that F would be held constant for 50-yr, and 2) they do not provide an adequate measure of the net benefits of alternative rebuilding schedules. The cumulative discounted profit (CDP) time paths depicted in Figures 48-59 at least partially eliminate these two problems. The former problem is examined by having a constant F of 0.01, 0.03, 0.05, or 0.07 for years 2 through 21 and F of 0.05 for years 22 through 50. This allows a comparison of four 20-yr rebuilding schedules. The latter problem is reduced because. both harvesting costs and the need to discount future benefits and costs are addressed when cumulative discounted profit is used as a measure of the performance of alternative rebuilding schedules. The CDP is reported for years 2 through 50 because an estimate of the actual F in 1983 for each case and area is used in year 1 of each simulation.

The CDP time paths are summarized as follows:

1. For cases 1-3 of each area, CDP is higher by year 50 with a 20-yr rebuilding F of 0.01 than with an F of 0.03, 0.05, or 0.07.

2. For cases 1 and 2 of each area, there are a number of years prior to the 15th year for which CDP is higher with a rebuilding F greater than 0.01.

3. For case 3 of each area, there are few years for which CDP is not higher with a rebuilding F equal to 0.01.

4. For case 4 of each area, CDP beyond year 24 is higher with an initial rebuilding F of 0.05 than with an F of 0.01, 0.03. or 0.07.

These results suggest that among the four rebuilding schedules considered and in terms of maximizing CDP, the optimal rebuilding F is 0.01 for cases 1-3. It is interesting to note that although the optimal rebuilding F is the same for these three cases, the year 2 yield associated with an F of 0.01 varies by a factor of 6 between cases 1 and 3. Therefore, although knowing which of these cases is a more accurate description of the population may not be critical in determining the correct F, it is critical in terms of translating that F into a quota.

It should be noted that the ranking of alternative rebuilding schedules in terms of CDP is affected by the discount rate and cost function used in the simulation models. A real discount rate of 5% was used to generate the CDP curves discussed above. The general effects of alternative discount rates and cost functions are as follows:

1. As the discount rate is increased, CDP decreases for each F and-the CDP for a high F increases relative to the CDP for a low F.

2. As harvesting cost is increased, CDP decreases for each F and the CDP for a high F decreases relative to the CDP of a low F.

Therefore, if a quota is set on this basis, of the CDPs of alternative Fs, a lower discount rate and/or higher harvesting costs would tend to result in a more restrictive quota.

The choice of the discount rate to be used is in part a policy decision. Since a real discount rate of between 5 and 10% is probably reasonable, the simulations were re-run with a real discount rate of 10%. With the exception of case 1, the rebuilding schedule that provided the highest CDP was the same whether the real discount rate was 5 or 10%. For case 1 in each area, an F of 0.01 and 0.03 produced the highest CDP after 50 years for discount rates of 5 and 10%, respectively (see Table 17).

The sensitivity of the models results to the harvesting cost function was tested for two reasons. First, detailed cost information is not readily available; and second, harvesting costs vary among the vessels that would be expected to participate in Pacific ocean perch fisheries. The simulations were run with both 50% reductions and increases in the initial cost functions. The use of higher costs decreases the CDP of each rebuilding schedule and increases the relative CDP of lower F schedules. An increase in costs does not affect the choice of rebuilding schedules for cases 1-3 because an F of 0.01 (the lowest F) results in the highest CDP in year 50 for cases 1-3 under the initial cost conditions. For case 4 of each area, the highest CDP in year 50 isprovided by the 0.05 and 0.01 F rebuilding schedules! respectively, for the initial and 50% higher cost functions (see Tables 17 and 18).

The use of the 50% lower cost function increases the CDP of each rebuilding schedule and increases the relative CDP of the higher F schedules. The relative increase is sufficient to change the rankings of the four schedules in terms of CDP in year 50. For case 3 of each area, Fs of 0.01 and 0.05 provide the highest CDP in year 50 for the intitial and lower costs, respectively. For all other cases of each area, the 0.07 rebuilding schedule provides the highest CDP in year 50 with the lower costs. With the initial costs, the F resulting in highest year 50 CDP is 0.01 for cases 1 and 2 and 0.05 for case 4.

To determine if a variable F rebuilding schedule might be preferable to the four constant F schedules discussed above, simulations were run for 18 additional schedules. Estimates of the cumulative 50-yr yield and discounted profit for the 22 schedules are presented by area and case in Tables 19-30. The first 5 schedules are: 1) a constant F of 0.01, 2) an F that increases from 0.01 to 0.05 in 20 years with constant increments each year, 3) an F that increases from 0.01 to 0.05 in 20 years with in creasing increments each year, and 4) and 5) an F similar to that in 3 but with, smaller increments during the first 10 years. The next three sets of 5 schedules are similar to the first set but have base Fs of 0.02, 0.03, and 0.04 instead of 0.01. The 21st and 22nd schedules have constant Fs of 0.05 and 0.07, respectively (see Table 31). For each schedule, F equals 0.05 for years 22 through 50.

The CDP estimates presented in the aforementioned tables indicate that the schedule that results in highest CDP is dependent on the case, costs, and discount rate used; and as noted above, the quota associated with each rebuilding schedule varies by case.

The simulations discussed to this point have had foreign fishing mortality (FF) equal zero. In order to estimate the impact of alternative FFs on the simulated domestic fishery, the simulations were run for the 22 rebuilding schedules with year 2 through 6 FF equal to 50, 100, 150, 200 and 250% of the estimated FFs in 1983. The cumulative impacts on the domestic fleet in terms of yield, discounted profit or revenue, and discounted profit per metric ton of foreign Pacific ocean perch harvest are presented by area and case in Tables 32-67. Domestic costs are assumed to be determined by domestic F and not FF. Therefore, for a given schedule of domestic Fs, the impacts on the profit and revenue of the domestic fleet are equal for a given FF because domestic profit is only affected by the resulting reduction in domestic yield and revenue.

The following statements highlight the data presented in the impact tables:

1. The impacts in terms of decreased domestic yield or discounted profit increase roughly proportionally with FF; therefore, the impact per metric ton of foreign catch is relatively stable with respect to FF.

2. For a given FF, the decreases in both domestic yield and discounted profit are necessarily greater for less restrictive (i.e., higher F) rebuilding schedules. However, discounted profits are affected more than yield.

3. The estimated reductions in domestic profit per ton of foreign catch are similar for cases 1-3 for a given rebuilding schedule, but they are significantly lower for case 4.

These statements suggest that the rebuilding schedule and not the level of foreign effort is the principal determinant of the impact per metric ton of foreign catch. This is an important conclusion if fees are to be used to control foreign catch.

The short-term implications of the alternative rebuilding schedules can be put into perspective by comparing the near-term yield associated with different schedules for each case. During the first year of rebuilding, the annual yields for rebuilding schedules that begin with an F of 0.01, 0.02, or 0.03 are as follows:

	Case 1	Case 2	Case 3	Case 4
Gulf of Alaska				
Actual 1983 catch	7,391	7,391	7,391	7,391
F = 0.01	1,500	2,800	5,000	3,700
F = 0.02	3,100	5,600	10,000	7,400
F = 0.03	4,600	8,400	15,000	11,100
Aleutian Islands				
Actual 1983 catch	667	667	667	667
F = 0.01	600	1,100	1,900	1,300
F = 0.02	1,200	2,200	3,800	2,600
F = 0.03	1,800	3,300	5,700	3,900
Eastern Bering Sea				
Actual 1983 catch	431	431	431	431
F = 0.01	240	440	820	600
F = 0.02	480	880	1,620	1,200
F = 0.03	710	1,310	2,430	1,790

These estimates indicate that, with the exception of case 1, annual yields at or above the 1983 level are attainable in the eastern Bering Sea and Aleutian Islands area with F equal 0.01. For case 1, the 1983 yield level is attainable with Fs of approximately 0.018 and 0.011, respectively, for the eastern Bering Sea and Aleutians. Therefore, for these two areas, the highest CDP rebuilding schedules are, with one exception, attainable with catch at or above the 1983 level.

For the Gulf of Alaska, the 1983 level of catch could be obtained for the four cases with Fs of approximately 0.049, 0.026, 0.015, and 0.02, respectively. Therefore, a rebuilding schedule that began with an F of 0.01 would result in a harvest that is less than that taken in 1983 and presumably less than what will be taken in 1984. At this date, August 13, it is difficult to predict what the 1984 harvest will be because much of the annual harvest can be taken between August and December. The 1984 optimum yield-total allowable catches (OY-TACS), domestic annual processing (DAPs), joint venture processing (JVPs), and total allowable level of foreign fishing (TALFFs) set by the North Pacific Fishery Management Council provide upper bounds on total catch and catch by different fleet groups. However., the 1984 OYs or TACs are significantly greater than the 1983 harvest and it is not clear that they will be attained in 1984.

1984	OY-TAC	Reserve	DAP	JVP	TALFF
Gulf of Alaska	11,475	2,295	1,082	3,770	4,328
Aleutian Islands	2,700	--	550	1,745	0
Eastern Bering Sea	1,780	--	550	150	813

One of the factors that affect the viability of alternative OYs is the by-catch of Pacific ocean perch in trawl fisheries targeting on other groundfish. The analyses presented in a following section, Possible Effects of Reduced Pacific Ocean Perch Quotas on Existing Fisheries, suggest that in the Gulf of Alaska, foreign Pacific ocean perch catch could be reduced to 2,500 t with only a minimal impact on the foreign catch of other species. This level of foreign catch and the 1983 level of domestic and joint-venture catch would result in Fs for the four cases of approximately 0.03, 0.016, 0.009, and 0.012, respectively. With sufficiently high incentives for the foreign fleets to reduce Pacific ocean perch by-catch, foreign catch would be less than 2,500 t. If, for example, the foreign tonnage fee for perch were set equal to the domestic ex-vessel price of approximately $330, foreign fleets would probably have sufficient incentive to end all targeting and reduce by-catch. A tonnage fee at this level would be higher than the estimated impact on domestic fleets per ton of foreign catch (see Tables 40-43).

In comparing the alternative rebuilding schedules, it should be noted that although for cases 1-3 rebuilding schedules, that began with F equal to 0.01 generated the highest CDP in year 50, schedules with an initial F of 0.03 generated higher or approximately the same CDP through year 42, 26, and 22, respectively, for. cases 1, 2, and 3 (Figs. 48-59). It should also be noted that for cases 1-3 an F of 0.03 would result in rebuilding, although not as rapid rebuilding as would result with lower Fs (Figs. 25,27, and 29).

POSSIBLE EFFECTS OF REDUCED PACIFIC OCEAN PERCH QUOTAS ON EXISTING FISHERIES

Rebuilding Pacific ocean perch stocks to some optimal level of abundance may require a reduction in the harvest rate which, in turn, may require at least a short-term reduction in catch quotas. The potential impact of such reduced Pacific ocean perch quotas on existing groundfish fisheries depends largely on the fishing strategies employed by the various fleets. If fleets specifically direct their fishing activities or target on Pacific ocean perch, then the main impact is simply a reduced perch catch; but if fleets incidentally catch Pacific ocean perch while targeting on other species, then the impact could be much greater. The primary objective of this section is to assess whether or not Pacific ocean perch is a targeted species, and, if it is, to estimate the proportion of the total catch which is taken in directed fishing operations. In addition, anassessment is made, in terms of both catch and revenue, of the potential impact of reduced Pacific ocean perch quotas on existing fisheries.

At the outset, we simplify the discussion in two respects. First, reference to Pacific ocean perch will actually be references to a complex of five species which includes, in addition to Pacific ocean perch, shortraker, sharpchin, northern and rougheye rockfishes. These five species were considered jointly both because they occur in similar habitats and are often caught together and because they are similar in appearance and not consistently distinguished in the catch data. Second, the analysis will only consider the activities of two classes of Japanese fishing vessels operating in the Gulf of Alaska. As can be seen from the 1982 best blend catches by nation and area (Table 68), of the total Pacific ocean perch catch, 90% is taken by Japan and 79% is taken within the Gulf of Alaska. Furthermore, of the Japanese Pacific ocean perch catch within the Gulf of Alaska, 90% is taken by small trawlers and large freezer trawlers.

To determine whether or not Japanese trawlers target on Pacific ocean perch, we examined the U.S. observer catch data, haul by haul, sequentially over each cruise sampled during 1982. A total of 31 cruises aboard small trawlers and 13 cruises aboard large freezer trawlers were examined. Although these data describe the daily activities of individual vessels, they are not entirely adequate to unequivocally specify if these activities are indeed targeting. This is true because targeting implies intent and, presumably, some prior knowledge of the likelihood of catching Pacific ocean perch; but, due to chance and due to the poor selectivity of bottom trawls, the catches may not reflect intent. Considering that Pacific ocean perch is one of the most valuable groundfish species groups and often forms dense schools which can be detected by sonar, it is likely that some trawlers have the incentive and probably the means to maximize the Pacific ocean perch contribution to their catch, but catches will not consistently be pure perch. The question is therefore: How consistent and how pure must the catches be to indicate that a vessel intended to fish specifically for Pacific ocean perch?

There is no clear answer to this question, but the relative performance of vessels can be judged by comparing indices of various aspects of targeting. Three indices of targeting were considered: 1) percentage by weight of Pacific ocean perch in the total catch of each observed cruise; 2) percentage of the Pacific ocean perch catch taken in hauls in which perch comprised at least 50% of the catch; 3) percentage of all hauls in which Pacific ocean perch comprised, at least 50% of the catch. The first index is a measure of the Pacific ocean perch contribution to the overall catch. When the percentage of Pacific ocean perch in the catch is high, it is likely that the vessel was specifically fishing for perch. The second index is a measure of catch purity. When a high percentage of the total Pacific ocean perch catch is, taken in hauls that are primarily pure Pacific ocean perch, it indicates that schools, rather than isolated individuals, were caught. Although this suggests targeting, it could also indicate the occasional chance catch of Pacific ocean perch schools. The third index is a measure of consistency. When the percentage of all hauls containing at least 50% Pacific ocean perch is large, it indicates that the Pacific ocean perch catch was due to repeated, directed effort rather than a chance catch of-a large school.

Percentage of Pacific ocean perch catch taken in hauls with >50% Pacific ocean perch and percentage of hauls that had >50% Pacific ocean perch are each plotted against percentage Pacific ocean perch in the total catch (Fig. 60). Note the clear difference between vessel classes. Large, freezer trawlers have, in most cases, relatively high scores for all three indices of targeting; that is, a high percentage of Pacific ocean perch in the total catch and a relatively high percentage of all hauls that are: nearly pure Pacific ocean perch. Large freezer trawlers therefore appear to target on Pacific ocean perch. Conversely, small trawlers tend to have a low percentage of Pacific ocean perch in the total catch and, in most cases, a low percentage of hauls with a high percentage of Pacific ocean perch. However, for some small trawlers, although the total Pacific ocean perch catch was small, it was taken in hauls with a high percentage of Pacific ocean perch. This could merely reflect the highly aggregated (schooling) distribution of Pacific ocean perch, however, in many cases, the catch records indicated that a vessel interrupted its fishing activites of walleye pollock or flounders, then moved into deeper water and began taking nearly pure catches of Pacific ocean perch. Such large Pacific ocean perch catches might be obtained 5 to 10 times in succession before the vessel returned to its original activities in shallower water. Although small trawlers generally do not target on Pacific ocean perch, this pattern suggests short-term directed effort, or switch targeting, to Pacific ocean perch by some vessels.

Although this type of analysis cannot clearly show intent, it does suggest that most large freezer trawlers and a few small trawlers were directing their fishing activities specifically at Pacific ocean perch. Ignoring switch targeting and assuming that a total catch >20% Pacific ocean perch by weight signifies targeting, then 9 of 13 large freezer trawlers and 2 of 31 small trawlers targeted on perch in 1982. Of the 1,923 t of Pacific ocean perch taken by small trawlers on 1982, 25% was taken by the two targeting vessels. Of the 5,042 t of Pacificocean perch taken by large freezer trawlers in 1982, 92% was taken by the nine targeting vessels. Therefore, more than 5,100 t [(.25)(1923)+(.92)(5042) = 5,119] of Pacific ocean perch were apparently taken with directed perch effort. This is 72% of the total 1982 Japanese Pacific ocean perch catch for the Gulf of Alaska.

Considering that Pacific ocean perch is quite valuable in Japan and that the Japanese are allocated a Pacific ocean perch quota, it is not surprising that Japanese vessels appear to target on perch. Pacific ocean perch targeting is important because it means that at least part of the perch catch can be separated from the catch of other species. The Pacific ocean perch catch can be viewed as being composed of two parts, the directed catch and the incidental catch. If the Pacific ocean perch allocation were reduced, the Japanese would first respond by reducing their directed catch. If the Pacific ocean perch allocation were reduced still further, below the level that would allow any directed catch, then the Japanese would have to either alter their fishing tactics (i.e., time, depth, gear) to minimize the incidental catch, or face the prospect of early area closures (an area is closed when the allocation of any of the various species is reached). Such changes in fishing tactics would undoubtedly either reduce catch rates or increase harvesting costs and consequently would be unwelcome to Japanese fishermen. Therefore, if Pacific ocean perch allocations are to be reduced, then it may be appropriate to set low enough allocations to eliminate the directed catch, but not so low that they interfere with the ability of Japan or other nations to obtain their allocation of other species.

We attempted both to estimate Pacific ocean perch allocations that might meet these criteria and to assess the potential economic impact of such reduced allocations on Japanese trawlers in the Gulf of Alaska. Our approach was to examine the effect of sequentially eliminating targeted Pacific ocean perch catch from the total catch, using increasingly inclusive definitions of targeting. The procedure was as follows. First, all hauls having X% Pacific ocean perch or greater were eliminated from the catch records of the 13 large freezer trawlers and 31 small trawlers examined by U.S. observers in 1982. Second, the remaining catches of each species were summed over vessels within each vessel class, then expressed as a percentage by dividing by the total catches. Third, the estimated percentages remaining were multiplied by the annual best blend catch estimates by species and vessel class then summed over vessel class. Fourth, the remaining revenue was estimated by multiplying the remaining catch of each species by the price per ton, then summing over species (prices were based on 1982 and 1983 species prices paid by joint venture processors to U.S. fishermen - Table 69). This analysis is summarized in Table 70 which shows the remaining catches of each species and the remaining- combined revenue after eliminating targeted hauls where the definition of targeting ranged from hauls with 90% or greater Pacific ocean perch to hauls with 10% or greater Pacific ocean perch.

Since there is no clear definition of Pacific ocean perch targeting, it is impossible to precisely specify what the 1982 Japanese catch of perch would have been if there had been no directed effort. However, if we assume, for example, that all hauls which had more than 50% Pacific ocean perch were targeted, then the perch catch would have been reduced from 6,965 t to 2,207 t, or by 68%, if no targeting had occurred. Since the remaining catch of Pacific ocean perch is presumably all taken incidentally to other species, a Pacific ocean perch allocation of 2,207 t would have eliminated directed catch yet would have allowed the Japanese trawlers to take their allocations of other species. Since most targeted hauls contain little beside Pacific ocean perch, the elimination of these hauls leaves the catches of most other species nearly unaltered (the only exception is the category "other rockfish," in which catch is reduced by 55%). Assuming a worst case, that is, that Pacific ocean perch effort is not redirected to other species, the Japanese trawlers would have experienced a 29% decrease in gross revenue, due almost entirely to the loss in Pacific ocean perch catch (Table 70).

The same methodology used in the above analysis was applied to the 1983 U.S. observer catch data. The results (Table 71) showed similar trends to those of 1982 (Table 70). For example, assuming that all hauls which had more than 50% Pacific ocean perch were targeted, the perch catch in 1983 would have been reduced from 4,887 t to 2,012 t, or by 59%. The gross revenue, however, would have decreased by only 21% due almost entirely to the loss in Pacific ocean perch catch (Table 71).

SUMMARY

This paper examined the depleted Pacific ocean perch, *Sebastes alutus,* stocks in waters off Alaska. The biology of the species was reviewed and the exploitation history recounted. Virtual population analysis and stock reduction analysis were used to estimate current status and productivity of the stocks. A predictive model was used to estimate stock rebuilding rates under a range of fishing rates. Finally, long-term yields and profits were examined in an economic analysis and the effects reduced quotas would have on existing fisheries were studied.

Biology

Pacific ocean perch belongs to the family Scorpaenidae and is one of 54 or more species of the genus *Sebastes* occurring in the North Pacific Ocean and Bering Sea. The species is semidemersal and inhabits the outer continental shelf and upper slope regions along the North American coast from La Jolla, California to the Aleutian Archipelago and eastern Bering Sea. Pacific ocean perch is usually associated with gravel or rocky type substrate found in and along canyons and submarine depressions of the upper continental shelf. The bathymetric range of S. *alutus* is reported as 70 to 640 m, with commercial quantities generally occurring between 110 and 457 m. Pacific ocean perch undergo a seasonal bathymetric migration associated with spawning behavior. This migration. is characterized by a movement into deep water during the late winter and early spring to spawn.

Daily vertical shifts, apparently a function of light and feeding, have been documented. Perch dwell near the bottom during the day and migrate off the sea floor during the night. Information concerning movement along the continental slope, however, is fragmentary. In this study, it is assumed that migration of juvenile and adults from one region to another is negligible.

Pacific ocean perch reach sexual maturity at 26-31 cm in length; males at 6-7 years and females at 8-9 years. Maturation of both sexes appears to depend more on the size of the fish than on its age.

Pacific ocean perch are ovoviviparous. During the late fall or early winter, the eggs are fertilized internally and are retained in the ovary during incubation. The eggs are hatched within the female and the larvae then extruded during the late winter or early spring at depths ranging from 250-450 m. The larvae ascend to the upper layers of the water column and. drift with the currents. Spawning sites are believed to be associated with circular or slow moving currents so that the pelagic larvae are not carried far from the spawning grounds.

The length of time the larvae remain planktonic has been a point of contention in the literature. Various authors estimate a pelagic existence of from less than 1 year to as much as 5 years.

Age determinations from scales and surfaces of otoliths suggest that the longevity of Pacific ocean perch is about 30 years. However, recent studies indicate considerably greater longevity and suggest that the maximum age of Pacific ocean perch is around 90 years. Growth analyses are complicated by these age determination difficulties, but it is clear that Pacific ocean perch are long-lived and slow-growing.

Description of the Fishery

Japan and the Soviet Union have been the principal nations exploiting the Bering Sea and Gulf of Alaska Pacific ocean perch stocks. Most of the Pacific ocean perch catch is headed, eviscerated, and quick frozen, and is used primarily for direct human consumption.

The Japanese fishery for Pacific ocean perch can be organized into three major categories: the land-based fleet, the mothership fleet, and the North Pacific trawl fleet. The Soviets have employed two basic types of vessels in their fishing operations, side trawlers and stern trawlers. Only minor catches of perch have been made by other nations. Productive fishing areas in the Gulf of Alaska have included the Shumagin Island grounds, the Albatross Bank off Kodiak Island, the Portlock Bank south of the Kenai Peninsula, and the trawlable areas off Yakutat and southeastern Alaska. In the Bering Sea, catches are taken along the entire length of the eastern slope region, with the largest catches usually being taken from both sides of the Aleutian Islands.

Pacific ocean perch are caught year round in the Gulf of Alaska and during most of the year in the eastern slope region. Pacific ocean perch catches from both regions are taken by a directed fishery as well as appearing incidentally in other directed fisheries, such as those for walleye pollock, *Theragra chalcogramma*; flounders; and Pacific cod, *Gadus macrocephalus*. In the Aleutian Islands region, most of the 1964 to 1979 Japanese Pacific ocean perch catch was caught during a 6-month period from April to October.

The foreign fishery for Pacific ocean perch began in about 1960. During the first year the foreign fleets removed about 6,100 t of Pacific ocean perch from, the eastern slope region. By 1962, the fishery had expanded into the Gulf of Alaska and Aleutian Islands regions. Growth of this new fishery was rapid. Within just 6 years of its inception, total removals (all regions combined) peaked with a harvest of 474,100 t. Soon after, total removals declined almost as rapidly as they had increased. In 1982 total catches amounted to only 1.6% of the 1965 peak catch.

Previous Stock Assessments

Previous assessments of Pacific ocean perch have been based primarily on changes in catch per unit of effort (CPUE) in the commercial trawl fisheries. CPUE data, however, have become increasingly difficult to interpret as an index of stock abundance. Quota restrictions, effort shifts to different target species, and rapid improvements in fishing technology and fishing skill have confounded the analyses of CPUE data.

Data from the 1979-82 cooperative U.S.-Japan trawl surveys provide a biomass estimate of 13,600 t for Pacific ocean perch in the eastern Bering Sea.

The exploitable biomass of Pacific ocean perch in the Aleutian Islands region (long 170°E to 170°W) was estimated at 107,800 t. The bulk of the biomass (86.2%) occurred in the depth range from 100 to 300 m.

Although many trawl surveys have been conducted in the Gulf of Alaska, there currently exists no reasonable biomass estimates for Pacific ocean perch in the region. However, the 1984 comprehensive resource assessment survey in the Gulf of Alaska should provide these data.

The biomass estimates from the above-mentioned trawl surveys probably underestimate the true population size of Pacific ocean perch.

Cohort analysis gives an alternative to commercial CPUE and trawl survey stock assessment methods of estimating abundance. This method circumvents the need for effort statistics and estimates stock abundance in actual numbers.

The abundance results from cohort analysis do not depend on fishing effort; moreover, stock size is measured in terms of absolute numbers of fish, rather than as an index. Although cohort analysis is free from errors associated with the estimation of fishing effort, this type of analysis is subject to its own errors such as incorrect estimation of natural mortality, fishing mortality, and the age of fish in the catch. However, regardless of which parameter combinations were used, the estimated trend in Pacific ocean perch biomass was always decreasing.

Current Stock Assessments

Stock assessments presented in this report are based on Virtual Population Analysis (VPA) and Stock Reduction Analysis (SRA). The assumptions of VPA and SRA differ significantly, so that the two models are capable of providing relatively independent assessments.

The aging controversy is particularly relevant to these assessments of Pacific ocean perch. Mis-aging affects estimates of natural mortality, estimates of the age distributions of the catch, and estimates of growth. Because VPA examined catch, and age data determined by surface reading of otoliths, a natural mortality coefficient (M) of 0.15 was used in all applications of VPA.

Because SRA analyzes annual catch in weight rather than annual catch in numbers at age, M = 0.05 was used in SRA without concern for age distribution of the catch.

Not only are VPA and SRA assessments based on different natural mortality rates, but they may also define the population biomass differently. For VPA, the population biomass was estimated using either ages 5+ or 9+; and for SRA, the population biomass was the fishable biomass (ages 9+).

The VPA results indicated a long-term, decreasing trend in biomass for all three Pacific ocean perch stocks. Depending on the parameters chosen, the eastern Bering Sea stock decreased 60.4-98.8% during the 16-year period from 1963 to 19-79. The results further suggested that biomass in the Aleutian Islands stock may have declined 76.7-98.2% from 1964 to 1979. The Gulf of Alaska stock apparently underwent large reductions in biomass as well. The 1979 biomass estimates for this stock represented a reduction of 69.1-99.5% from levels present in 1963.

The resulting VPA biomass trends always converged toward similar estimates of virgin biomass. Assuming M = 0.15, reasonable estimates of total virgin biomass are 188,000 t 535,.000 t, and 1,910,000 t, for the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska stocks, respectively.

Estimates of maximum sustainable yield (MSY) were calculated from the VPA runs for each stock and are shown below.

Region	Estimates of MSY based on VPA
Eastern Bering Sea	10,050 t
Aleutian Islands	28,950 t
Gulf of Alaska	93,525 t
	Total 132,525 t

These MSY estimates are considerably lower than earlier estimates for these stocks.

Stock Reduction Analysis (SRA) was also used to analyze Pacific ocean perch in the Gulf of Alaska, the Aleutian Islands region, and the eastern Bering Sea. Virgin biomass was estimated and is shown below.

Region	SRA estimates of virgin biomass (t)
Eastern Bering Sea	240,000
Aleutian Islands	560,000
Gulf of Alaska	1,450,000
Total	2,250,000

Estimates of MSY were calculated from the SRA equations. High estimates of MSY were calculated assuming a constant recruitment, and middle estimates were calculated assuming a moderate stock recruitment relationship. The SRA estimates of MSY are shown below.

Region	Constant recruitment	Moderate stock-recruitment relationship
Eastern Bering Sea	4,984 t	2,840 t
Aleutian Islands	11,865 t	6,627 t
Gulf of Alaska	30,849 t	17,160 t
Total	47,698 t	26,627 t

One of the principal tasks in this report was to predict possible rebuilding scenarios given current stock conditions. This was done using the modeling results from SRA, and then projecting these results into the future using a delay-difference equation.

The rapidity of the stock rebuilding process is largely dependent on the, assumed recruitment relationship. If recruitment is constant, rebuilding is rapid even from low stock levels. With a moderate stock-recruitment relationship, rebuilding is relatively slow even when there is no fishing. If recruitment is proportional to stock biomass, no rebuilding can occur.

At this time, we do not know which recruitment assumption is correct. In fact, as far as modeling rebuilding goes, different values of recruitment may be appropriate at different stock biomass levels. As a stock rebuilds, strong recruitment becomes more likely.

To properly understand the results of the rebuilding predictions, it is important to realize that when the stock is subject to a fishery, the equilibrium biomass (EB) is significantly smaller than virgin biomass (B_1).

An important fact is that for our moderate recruitment relationship and with a fishing mortality (F) coefficient of 0.05, there is virtually no rebuilding, and EB = $0.25B_1$. However, for F = 0.02 and EB =$0.51B_1$, asympototic yield is nearly the same as if F =0.05. Therefore, an F of 0.02 appears to be the maximum allowable value consistent with concern for these stocks. Even smaller values of F are desirable, allowing for more rapid rebuilding, and providing a cushion for modeling and survey bias. These arguments are based on equilibrium conditions and do not consider costs involved in reaching these equilibria.

Economic Analysis

Cost and revenue functions were added to the SRA simulation models for the three areas and for four cases. The four cases differ in terms of estimated 1983 biomass and/or recruitment. The models were used to: 1) generate equilibrium yield and profit curves; 2) generate 50-yr biomass and yield time paths for four alternative levels of fishing mortality (F); 3) estimate the 50-yr cumulative yield and cumulative discounted profit (CDP) of 22 alternative rebuilding schedules for a range of harvesting cost functions and discount rates; and 4) estimate the impact of alternative levels of foreign catch on domestic Pacific ocean perch fishermen.

Among the 22 rebuilding schedules considered, the optimal schedule is determined by: 1) the criteria used to rank the schedules; 2) the case that is assumed to most closely approximate reality; 3) the discount rate used; and 4) the cost function used. The highest cumulative 50-yr yield occurs for schedule 22. This is the least restrictive schedule with a constant F of 0.07 for years 2 through 21. However, for cases 1 through 3, the difference between the cumulative yields for the most and least restrictive schedules ranges only from approximately 10 to 15%.

If the alternative schedules are ranked in terms of cumulative discounted profit, the optimal schedule is determined by the case, discount rate, and cost function used. With the exception of the lowest cost function, the optimal schedules for cases 1 to 3 are quite conservative or restrictive, with F beginning at 0.01 and, in some instances, remaining at or near that level for much of the 20-yr rebuilding period. Less restrictive schedules are optimal for case 4. With the lowest cost function, one of the two least restrictive schedules (F = 0.05 or 0.07) is optimal for each case.

It should be noted that because the rebuilding schedules are defined in terms of F time paths, and because the estimated 1983 biomasses vary by case, the quotas associated with a given rebuilding schedule vary by case, Therefore, even if the optimal schedule is the same or similar for several cases the associated optimal quotas will differ significantly.

The estimated impact of foreign fishing on domestic discounted profit increases roughly proportionally with foreign catch; therefore, the impact per metric ton of foreign catch is relatively constant with respect to foreign catch. The impact of foreign catch increases as domestic effort increases.

Possible Effects of Reduced Pacific Ocean Perch Quotas on Existing Fisheries

Rebuilding Pacific ocean perch stocks to some optimal level of abundance may require a reduction in the harvest rate which, in turn, may require reduction in catch quotas. The primary objective of this section is to assess whether or not Pacific ocean perch is a targeted species, and, if it is, to estimate the proportion of the total catch which is taken in directed fishing operations. In addition, an assessment is made of the potential impact of reduced Pacific ocean perch quotas on existing fisheries.

To determine whether or not Japanese trawlers target on Pacific ocean perch, we examined the U.S. observer catch data, haul by haul, sequentially over each cruise sampled during 1982. Three indices of targeting were considered: 1) percent by weight of Pacific ocean perch in the total catch of each observed cruise; 2) percent of the catch taken in hauls in which Pacific ocean perch comprised at least 50% of the catch; and 3) percent of all hauls in which Pacific ocean perch comprised at least 50% of the catch. The first index is a measure of the Pacific ocean perch contribution to the overall catch. When the percent of Pacific ocean perch in the catch is high, it is likely that the vessel was specifically fishing for perch. The second index is a measure of catch purity. When a high percent of the total Pacific ocean perch catch is taken in hauls that are primarily perch, it indicates that schools, rather than isolated individuals, were caught. Although this suggests targeting, it could also indicate the occasional chance catch of Pacific ocean perch schools. The third index is a measure of consistency. When the percent of all hauls containing at least 50% Pacific ocean perch is large, it indicates that the perch catch was due to repeated; directed effort, rather than a chance catch of a large school.

Large-freezer trawlers have, in most cases, relatively high scores for all three indices of targeting and therefore appear to target on Pacificocean perch. Conversely, small trawlers tend to have a low percentage of Pacific ocean perch in the total catch and, in most cases, a low percentage of hauls with a high percentage of perch. Although smaller trawlers generally do not target on Pacific ocean perch, this pattern suggests short-term directed effort, or switch targeting, to perch by some vessels.

Although this type of analysis cannot clearly show intent, it does suggest that most large freezer trawlers and a few small trawlers were directing their fishing activities specifically at Pacific ocean perch. More than 5,100 t of Pacific ocean perch was apparently taken with directed perch effort. This is 72% of the total 1982 Japanese Pacific ocean perch catch for the Gulf of Alaska. If Pacific ocean perch allocations are to be reduced, it may be appropriate to set these allocations such that they are low enough to eliminate the directed catch, but not so low that they interfere with the ability of Japan or other nations to obtain their allocation of other species.

We attempted to estimate Pacific ocean perch allocations that might meet these criteria and to assess the potential impact of such reduced allocations on Japanese trawlers in the Gulf of Alaska. If we assume that all hauls which had more than 50% Pacific ocean perch were targeted, then the perch catch would have been reduced from 6,965 t to 2,207 t, or by 68%, if no targeting had occurred. Since the remaining catch of Pacific ocean perch is presumably all taken incidentally to other species, a perch allocation of 2,207 t in 1982 would have eliminated directed catch yet would have allowed the Japanese trawlers to take their allocations of other species. Similar trends were observed in the results of the 1983 U.S. observer catch data analysis.

REFERENCES

Alverson, D. L., and S. J. Westrheim.
1961. A review of the taxonomy and biology of the Pacific ocean perch and its fishery. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 150:12-27.

Anonymous.
1978. U.S.S.R. groundfish catches (m.t.) in the northeastern Pacific by INPFC area, 1975-77. Unpubl. manuscr., 4 p. All-Union Research Institute' of Marine Fisheries and Oceanography. (VNIRO), Moscow, (Submitted to the International North Pacific Fisheries Commission as INPFC Doc. 2072.)

Archibald; C. P., D. Fournier, and B. M. Leaman.
1983. Reconstruction of stock history and development of rehabilitation strategies for Pacific ocean perch in Queen Charlotte Sound, Canada. N. Am. J. Fish. Manage. 3:283-294.

Archibald, C. P., W. Shaw, and B. M. Leaman.
1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Bakkala, R., W. Hirschberger, and K. King.
1979. Condition of groundfish resources of the eastern Bering Sea and Aleutian Island regions. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 41:1-24.

Bakkala, R. G., K. Wakabayashi, and T. Sample.
1982. Results of the demersal trawl surveys. In R. G. Bakkala and K. Wakabayashi (editors), Results of cooperative U.S.-Japan groundfish investigations in the Bering Sea during May-August 1979. Unpubl. manuscr., 410 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Barsukov, V. V.
1964a. Interspecies variability of the Pacific ocean perch (*Sebastes alutus,* Gilbert). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rbyn. Khoz. Okeanogr. 51): 231-252. In Russ. (Transl. 1968, p. 241-267, in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 2, available U.S Dep. Commey., Natl. Tech. Inf. Serv., Springfield, VA, as TT.67-51204.)

Barsukov, V. V.
1964b. Key to the fishes of the family Scorpaenidae. Tr. Vses. Nauchno-issled. Int. Morsk. Rybn. Khoz. Okeanogr. 53 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 52). In Russ. (Transl. 1968,

p. 226-262 in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 3, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51205.)

Beamish, R. J.

1979. New information on the longevity of Pacific ocean perch (Sebastes alutus). J. Fish. Res. Board Can. 36:1395-1400.

Beamish, R. J., and D. E. Chilton.

1982. Preliminary evaluation of a method to determine the age of sablefish (Anoplopoma fimbria). Can. J. Fish. Aquat. Sci. 39:277-287.

Beamish, R. J., and G. A. McFarlane.

1983. The forgotten requirement for age validation in, fisheries biology. Trans. Am. Fish. Soc. 112:735-743.

Bennett, J. T., G. W. Boehlert, and K. K. Turekian.

1982. Confirmation of longevity in Sebastes diploproa (Pisces: Scorpaenidae) from $^{210}Pb/^{226}Ra$ measurements in otoliths. Mar. Biol. (Berl.) 71:209-215.

Carlson, H. R., and R. E. Haight.

1976. Juvenile life of Pacific ocean perch, Sebastes alutus, in coastal fiords of southeastern Alaska: their environment, growth, food habits, and schooling- behavior. Trans. Am. Fish. Soc. 105:191-201.

Carlson, H. R., and R. R. Straty.

1981. Habitat and nursery grounds of Pacific rockfish, Sebastes spp., in rocky coastal areas of southeastern Alaska. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 43:13-19.

Chikuni, S.

1975. Biological study on the population of the Pacific ocean perch in the North Pacific. Bull. Far Seas Fish. Res. Lab. (Shimizu) 12:1-199. In Jpn. (Transl. 1978, Can. Fish. Mar. Serv. Transl. Ser. 4182.1

Chilton, D. E., and R. J. Beamish.

1982. Age determination methods for fishes studied by the Goundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Clemens, W. A., and G. V. Wilby.

1961. Fishes of the Pacific Coast of Canada.. 2nd ed. Bull. Fish. Res. Board Can. 68, 443 p.

Deriso, R. B.

1980. Harvesting strategies and parameter estimation for an age-structured model. Can. J. Fish. Aquat. Sci. 37:268-282.

Fadeev, N. S.

1968. Migrations of Pacific ocean perch. Izv. Tihookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 65:170-177. In Russ. (Transl. Fish. Res. Board Can. Transl. Ser. 1447.)

Francis, R. C.

1974. Relationship of fishing mortality to natural mortality at the level of maximum sustainable yield under the logistic production model. J. Fish. Res. Board Can. 31:1539-1542.

Gritsenko, O. F.

1963. Age and growth rate of Pacific rockfish of the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 50):313-316. In Russ. (Transl. 1968, p. 328-331, in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 1, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.)

Gulland, J. A.

1965. Estimation of mortality rates. Annex to Arctic Fisheries, Working Group Report (meeting in Hamburg, January 1965). Int. Counc. Explor. Sea, C.M. 1965, Dot. No. 3 (mimeographed).

Gulland, J. A.

1970. The fish resources of the ocean. Food Agric. Organ. U.N., Rome, FAO Fish. Tech. Pap. 97:425 p.

Gunderson, D. R.

1971. Reproductive patterns of Pacific ocean perch (<u>Sebastes alutus</u>) off Washington and British Columbia and their relation to bathymetric distribution and seasonal abundance. J. Fish. Res. Board Can. 28:417-425.

Gunderson, D. R.

1977. Population biology of Pacific ocean perch, <u>Sebastes alutus</u>, stocks in the Washington-Queen Charlotte Sound region, and their response to fishing. U.S. Natl. Mar. Fish. Serv., Fish. Bull. 75:369-403.

Hart, J. L.

1973. Pacific fishes of Canada. Bull. Fish. Res. Board Can. 180, 740 p.

Hebard, J. F.

1959. Currents in the southeastern Bering Sea and possible effects upon king crab larvae. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. 293, 11 p.

Hughes, S. E., and L. L. Ronholt.

1976. Catch per hour of Pacific ocean perch in the central Gulf of Alaska, 1961 and 1962 vs. 1975. Unpubl. manuscr., 6 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Submitted to the International North Pacific Fisheries Commission as INPFC Doc. 1871.)

Ito, D. H.

1982. A cohort analysis of Pacific ocean perch stocks from the Gulf of Alaska and Bering Sea regions. M.S. Thesis, Univ. Washington, Seattle, WA, 157 p.

Kimura, D. K.

1984. Forecasting stock biomass and variability by modeling recruitment. Unpubl. manuscr., 24 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., 2725 Montlake Blvd. E., Seattle, WA 98112.

Kimura,. D. K., J. W. Balsiger, and D. H. Ito.

1984. Generalized stock reduction analysis. Can. J. Fish. Aquat. Sci. In press.

Kimura, D. K., and J. V. Tagart.

1982. Stock reduction analysis, another solution to the catch. equations. Can. J. Fish. Aquat. Sci. 39:1467-1472.

Lestev, A. V..

1961. The trawl fishery for rockfish in the Bering Sea. Moscow, Izd. Rbyn. Khoz. (Tekhnika Rybolovstva Seriya), 26 p. In Russ. (Preliminary transl., Fish. Res. Board Can. Transl. Ser. 439.)

Lisovenko, L. A.

1964. Distribution of larval Pacific ocean perch (Sebastes alutus G.) in the Gulf of Alaska. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz.

Okeanogr. 52):223-231. In Russ. (Transl. 1968, p. 217-225 in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 3, available U.S. Dep. Commer,. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51205.)

Lisovenko, L. A.

1965. On the fecundity of Sebastes alutus Gilbert in the Gulf of Alaska. Tr. Vses. Nauchno-issled. Inst. Morsk, Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53):171-178. In Russ. (Transl. 1968, p. 162-169 in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 4, available U.S. Dep. Commer. Natl. Tech. Inf. Serv., Springfield, VA, as TT.67-51206.)

Lisovenko, L. A.

1970. A study of spermatogenesis in Pacific rockfish (Sebastes alutus Gilbert) from the Gulf of Alaska. Tr. Vses. Nauchno-issled. Morsk. Rbyn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Koz. Okeanogr. 72):246-264. In Russ. (Transl. 1972, p. 248-266 in P. A. Moiseev (editor), Soviet fisheries investigations in the northeastern Pacific, Part 5, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT71-50127.)

Low, L. L.

1974: A study of. four major groundfish fisheries of the Bering Sea. Ph.D. Thesis, Univ. Washington, Seattle, WA, 240 p.

Lyubimova, T. G.

1963. Basic aspects of the biology and distribution of Pacific rockfish (Sebastes alutus) in the Gulf of Alaska. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 50):293-303. In Russ. (Transl. 1968, p. 308-318 in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 1, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Sprinqfield, VA, as TT67-51203:)

Lyubimova, T. G.

1964. Biological characteristics of the school of Pacific rockfish (Sebastodes alutus G.) in the Gulf of Alaska. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 52):213-221. In Russ. (Trans. 1968, p. 208-216, in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 3, avalable U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51205.)

Lyubimova, T. G.

1965. Main stages in the life cycle of the rockfish Sebastodes alutus Gilbert in the Gulf of Alaska. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanoqr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanoqr. 53):95-120. In Russ. Transl. 1968, p. 85-111, in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific,, Part 4, available U.S. Dep. Commer.; Natl. Tech. Inf. Serv., Springfield, VA; as TT67-51206.)

Major, R. L., and H. H. Shippen.

1970. Synopsis of biological data on Pacific ocean perch Sebastodes alutus. U.S. Natl. Mar. Fish. Serv., Circ. 347, 38 p. (FAO Fisheries Synopsis 79).

Moiseev, P. A., and I. A. Paraketsov.

1961. Information on the ecology of rockfish (family Scorpaenidae) of the northern part of the Pacific Ocean; Vop. Ikhtiol. Vol. 1, No. 1(18):39-45. (Preliminary transl. Fish. Res. Board Can. Transl. Ser. 358.)

Nelson, R., Jr., R. French, and J. Wall.

1981. Sampling by U.S. observers on foreign fishing vessels in the eastern Bering Sea and Aleutian Island region, 1977-78. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 43(5):1-19.

Okada, K., H. Yamaguchi, T. Sasaki, and K. Wakabayashi.

1980. Condition of groundfish stocks in the Bering Sea and northeast Pacific. Unpubl. manuscr., 42 p. Far Seas Fish. Res. Lab., Jpn. Fish. Agency, 1000 Orido, Shimizu 424, Jpn. (Submitted to the International North Pacific Fisheries Commission as INPFC Doc. 2312.)

Paraketsov, I. A.

1963. On the biology of Sebastodes alutus of the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 50):305-312. In Russ. (Transl. 1968, p. 319-327, in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 1, available U.S. Dep. Commer., Natl. Tech. .Inf. Serv., Springfield, VA, as TT67-51203.)

Pautov, G. B.

1972. Some characteristic features of the biology of Pacific ocean perch (Sebastodes alutus Gilbert) in the Bering Sea. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 81:91-117. In Russ. (Transl. 1973, Fish. Res. Board Can. Transl. Ser. 2828.)

Phillips, J. B.,

1957. A review of the rockfishes of California (Family Scorpaenidae). Calif. Dep. Fish Game, Fish Bull. 104, 158 p.

Pope, J. G.

1972. An investigation of the accuracy of virtual population analysis using cohort analysis. Int. Comm. Northwest Atl. Fish. Res. Bull. 9: 65-74.

Pruter, A. T.

1973. Development and present status of bottomfish resources in the Bering Sea. J. Fish. Res. Board Can. 30:2373-2385.

Pruter, A. T.

1976. Soviet fisheries for bottomfish and herring off the Pacific and Bering Sea coasts of the United States. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 38(12):1-14.

Quast, J. C.

1972. Reduction in stocks of the Pacific ocean perch, an important demersal fish off Alaska. Trans. Am. Fish. Soc. 101:64-74.

Robinson, G. A.

1972. A study of the Pacific ocean perch fisheries of the northeastern Pacific Ocean. Ph.D. Thesis, Univ. Washington, Seattle, WA, 219 p.

Ronholt, L. L., and L. L. Low.

1978. Trends in abundance of Pacific ocean perch and other rockfish stocks in the Gulf of Alaska as indicated by trawl surveys in 1961 and 1973-76.. Unpubl. manuscr., 10 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Submitted to the International North Pacific Fisheries Commission as INPFC Doc. 2115.)

Skalkin, V. A.

1964. Diet of rockfish in the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):151-166. In Russ. (Transl. 1968, p. 159-1-74, in P. A. Moiseev (editor), Soviet fisheries investigations in the northeast Pacific, Part 2, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51204.)

Snytko, V. A.

1971. Biology and peculiarities of distribution of Pacific ocean perch (Sebastodes alutus Gilbert) in Vancouver-Oregon area. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 79:3-41. In Russ. (Transl. 1973, J. Fish. Res. Board Can. Transl. Ser. 2805.)

Tagart, J. V.

1982. Status of yellowtail rockfish (Sebastes flavidus) fishery. Washington Dept. Fish. Tech. Rep. 71, 64 p.

Ultang, O.

1977. Sources of error in and limitations of virtual population analysis (cohort analysis). J. Cons., Cons. Int. Explor. Mer 37:249-260.

Wall, J., R. French, and R. Nelson, Jr.

1981. Foreign fisheries in the Gulf of Alaska, 1977-78. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 43(5):20-35.

Westrheim, S. J.

1958. On the biology of the Pacific ocean perch, Sebastodes alutus (Gilbert). M.S. Thesis, Univ. Washington, Seattle, WA, 106 p.

Westrheim, S. J.

1973. Age determination and growth of Pacific ocean perch (Sebastes alutus) in the northeast Pacific Ocean. J. Fish. Res. Board Can. 30:235-247.

Westrheim, S. J.

1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32:2399-2411.

Westrheim, S. J., and W. E. Ricker.

1978. Bias in using an age-length key to estimate age-frequency distributions. J. Fish. Res. Board Can. 35:184-189.

Westrheim, S. J., and V. A. Syntko.

1974. Length-weight relations of Pacific ocean perch (*Sebastes alutus*) in the North Pacific Ocean. J. Fish. Res. Board Can. 31,:363-366.

APPENDIX A

PRODUCTION STATISTICS

The production statistics employed in this study (Table 1) were derived from a variety of data sources. In the case of the Japanese Pacific ocean perch catches, Chikuni's (1975) estimates were used for the years 1960-63. Thereafter, catches reported either through International North Pacific Fisheries Commission (INPFC) channels or directly to the United States were used in compiling the remaining Japanese production statistics. Modification of the catch data was often necessary to distinguish catches of Sebastes alutus from the catches of other rockfish species.

Prior to 1969, Pacific ocean perch catches from the Japanese land-based fleet were incorporated into a "rockfish" category. This category not only included S. alutus, but other rockfish species as well. Because of the need to account for all Pacific ocean perch removals, an effort was made to estimate the fraction of this species in the pre-1969 land-based rockfish catch.

Land-based catches taken in 1969 and 1970 were used to estimate this fraction. They were the first 2 years in which the rockfish catches were partitioned into two categories--Pacific ocean perch and "other rockfish." These catches were summed for both years by region and by category. The proportion of Pacific ocean perch within the 1969-70 rockfish catch was then determined. The results showed that S. alutus accounted for about 65% of the total rockfish catch in the eastern Bering Sea slope region, and about 85% of the catch in the Aleutian Islands region. Estimates of pure Pacific ocean perch catches were then obtained under the assumption that the 1969 and 1970 proportions were representative of Pacific ocean perch in the pre-1969 land-based rockfish catch.

Rockfish catches by the Japanese mothership and North Pacific trawl fleets were originally reported either by major species or lumped into a category called "other rockfish." Since 1979 the category of "other rockfish" has been split into two groups (A and B). Group A is comprised of those species with similar color and physical characteristics as S. *alutus*, including northern (S. *polyspinis*), rougheye (S. *aleutianus*), shortraker (S. *borealis*), and sharpchin (S. *zacentrus*) rockfishes, and may have been reported as S. *alutus* prior to 1979; group B includes all other rockfishes not reported by species. The production statistics in Table 1 were based only on reported S. *alutus* catches.

Catch statistics of the Soviet Union's Pacific ocean perch harvest, prior to 1977, were extracted from published sources. Chikuni's (1975) estimates of the Soviet Union's catches were used in this study for the years 1960-72. Soviet production statistics published in INPFC documents (Anonymous 1978; Okada et al. 1980) were employed for the period 1973-76. From 1977 to the present, catch statistics reported via conventions set forth by the Magnuson Fishery Conservation and Management Act (MFCMA) were employed in this study.

Catches of Pacific ocean perch by nations other than Japan and the Soviet Union were combined under the cateogry of "other nations." The United States, Canada, Poland, Republic of Korea, and Taiwan were included in this group. Production statistics for. these nations, prior to 1977, were obtained through INPFC statistical yearbooks and documents. After 1977, catch statistics were obtained through reporting conventions of the MFCMA.

APPENDIX B

SUMMARY OF SRA METHODS

We shall provide a brief description of the Stock Reduction Analysis (SRA) model that we hope will give the reader the ability to understand the SRA stock assessment. A detailed explanation of SRA is given by Kimura et al. (1984), and the method of projecting future stock biomass is described in Kimura (1984).

Consider the following definitions of variables used in the SRA model.

Fundamental SRA variables:

i = the year index.

k = the age at recruitment to the fishable biomass, assumed to be known prior to SRA.

n = the number of years of catch data to be analyzed.

c_i = the catch in weight in year i; these are the numbers to be analyzed.

B_i = the fishable population biomass at the beginning of year i, including recruitment for that year.

R_i = the recruitment biomass to be added to the fishable stock at the beginning of year i.

$P = B_{n+1}/B_1$, the. ratio. of final biomass to initial biomass.

Instantaneous mortality rates:

M = the annual instantaneous natural mortality rate, assumed to be known prior to SRA.

F_i= the annual instantaneous fishing mortality rate for year i, to be estimated using SRA.

Z_i= F_i + M, the total instantaneous mortality rate for year i.

Parameters in the Deriso delay-difference equation:

s_i= $\exp(-Z_i)$, the survival in the fishable biomass in year i.

p = the Brody weight coefficient, estimated prior to SRA.

Parameters in the Cushing recruitment model:

r = the exponent in the Cushing recruitment model, assumed to be known prior to SRA.

R_1= the Cushing recruitment coefficient to be estimated using SRA.

Parameters related to sustainable yield:

F = the fixed, long-term instantaneous fishing mortality rate for which B and Y are calculated.

S = the equilibrium survival rate in the fishable biomass.

U = the equilibrium exploitation rate.

B = the equilibrium population biomass under the fishing rate F.

Y = the equilibrium yield under the fishing rate F.

SRA is defined by the set of three. simultaneous nonlinear equations:

$$C_i = B_i F_i (1-s_i)/Z_i, \quad (1)$$

$$B_i = (1 + p) s_{i-1} B_{i-1} - o s_{i-1} s_{i-2} B_{i-2} + R_i, \quad \text{and} \quad (2)$$

$$P = B_{n+1}/B_1, \quad (3)$$

Equation (1) is the usual catch equation; equation (2) is the Deriso (1980) delay-difference equation; and equation (3) describes the relative change in stock biomass. In equation (21, recruitment in year i is described by the Cushing model:

$$R_i = R_1 \ (B_{i-k}/B^1)^r, \qquad (4)$$

For r = 0.0 equation (4) is a constant recruitment model, and for r = 1.0 recruitment is proportional to biomass. Thus, the increase in r from 0.0 to 1.0 describes an increase in dependence of recruitment on stock size.

It turns out that if M, p, and r are assumed to be known, equations (1) and (3) can be viewed as a system of n+l simultaneous equations in n+3 unknowns (B_1, R_1, P, and F_1, . . . F_n). If we further assume that B_1 is a virgin biomass (and we can in our present assessment of Pacific ocean perch), solutions to equations (1) and (3) are constrained to the expected recruitment line (Fig. 9):

$$R_1 = B_1 \ B_1\{[l - \exp(-M)] + p[\exp(-2M) - \exp(-M)]\}- \qquad (5)$$

What all this means is that if M, p, and r are assumed to be known, then fixing any one of the other unknowns (B_1, R_1, P, F_1, ... F_n) will define a unique solution to the SRA equations (i.e., define a unique n+3-tuple (B_1, R_1, P, F_1, ... T_n)).

In our assessment of Pacific ocean perch, the parameters M = 0.05 and p = 0.38 were fixed and never changed. We varied the quantities B_1 and r, each set of values defining a solution point (B_1, R_1, P, F_1, ... F_n). For each combination, of B_1 and r, we note the value P (Tables 9-11). Because P is the single parameter that best describes current stock condition, we have centered our assessment on nominal values of P. The MSY was estimated from SRA models assuming $P \approx 0.25$ and r = 0.0, as well as $P \approx 0.2$ and r = 0.5.

Given a solution to the SRA equations (B_1, R_1 P, $F_1, \ldots, F_n$) and a fixed long-term instantaneous fishing rate F, the equilibrium biomass curve can be estimated by

$$B = \{(\hat{R}_1/\hat{B}_1^{\,r})/[1 + \rho s^2 - (1 + \rho)s\}^{\frac{1}{1-r}}, \qquad (6)$$

and the equilibrium yield can be estimated by

$$Y = UB, \qquad (7)$$

where U = F(1-s)/Z. Maximum sustainable yield (MSY) occurs at that F where (7) is. maximized, or if (7) is monotoic, we select Y where F = M.

The value of r is a critical parameter when MSY is being estimated. Given SRA stock assessments with the same nominal value of P, for r = 0.0 recruitment is constant and MSY is relatively large, while for r>O.O recruitment is dependent on stock size and the MSY will be smaller. Thus, for a given value of P as r approaches 1.0, MSY becomes progressively smaller until MSY = 0.0 when r = 1.0.

Stock rebuilding projections were made by projecting estimates of current stock biomass into the future using the Deriso (1980) delay-difference equation (equation 2). For the initial conditions of these projections, we used solutions to the SRA equations assuming nominal P values of $P \approx 0.25$ with r = 0.0, and $P \approx 0.1$, 0.2, and 0.3 with r = 0.5.

Because recruitment does not depend on stock biomass when r = 0.0, stock rebuilding is most rapid under this assumption. As r increases, recruitment becomes increasingly dependent on stock size, and stock rebuilding is at a slower pace. If r + 1.0, recruitment is proportional to stock size and the stock is unable to rebuild.

Table 1. Annual catch of Pacific ocean perch from the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska regions (thousands of metric tons).

	Eastern Bering Sea				Aleutian Islands				Gulf of Alaska			
Year	Japan	USSR	Other nations	Total	Japan	USSR	Other nations	Total	Japan	USSR	Other nations	Total
1960	1.1	5.0	---	6.1	---	---	---	---	---	---	---	---
1961	13.0	34.0		47.0	---	---	---	---	---	16.0	---	16.0
1962	12.9	7.0	---	19.9	0.2	---	---	0.2	---	65.0	---	65.0
1963	17.5	7.0	---	24.5	0.8	20.0	---	20.8	6.3	130.0	---	136.3
1964	13.6	11.5	---	25.1	29.2	61.0	---	90.2	13.4	230.0	---	243.4
1965	8.5	9.0	---	17.5	37.0	71.0	---	108.0	42.6	306.0	---	348.6
1966	16.5	2.7	---	19.2	32.4	57.7	---	90.1	65.0	135.8	---	200.8
1967	20.8	Tr	---	20.8	14.1	46.6	---	60.7	53.5	66.5	---	120.0
1968	24.4	3.1	---	27.5	23.7	26.6	---	50.3	55.0	45.2	---	100.2
1969	15.0	Tr	---	15.0	15.6	23.2	---	38.8	53.6	18.8	0.2	72.6
1970	8.7	Tr	---	8.7	13.6	53.3	---	66.9	44.4	Tr	0.5	44.9
1971	9.0	Tr	---	9.0	14.6	7.2	---	21.8	47.8	29.7	---	77.5
1972	4.8	0.2	---	5.0	8.6	24.6	---	33.2	50.6	24.0	3.0	77.6
1973	2.6	1.0	---	3.6	9.4	2.5	---	11.9	47.4	5.6	3.4	56.4
1974	6.0	7.4	---	13.4	21.7	0.8	---	22.5	37.0	11.0	3.0	51.0
1975	3.4	5.4	Tr	8.8	9.4	8.1	Tr	17.5	34.1	13.3	3.0	50.4
1976	2.6	12.1	0.6	15.3	10.8	3.7	Tr	14.5	35.4	8.5	1.6	45.5
1977	2.9	0.1	0.5	3.5	5.7	0.8	0.1	6.6	19.2	1.8	0.6	21.6
1978	2.0	Tr	0.4	2.4	4.8	0.2	0.2	5.2	3.9	0.6	3.5	8.0
1979	1.7	Tr	0.2	1.9	5.3	Tr	0.2	5.5	6.7	0.8	0.8	8.3
1980	0.4	0.0	0.0	0.4	3.3	0.0	0.4	3.7	9.2	1.2	0.4	10.8
1981	0.8	0.0	0.4	1.2	3.3	0.0	0.2	3.5	8.	0.0	2.0	10.5
1982	0.4	0.0	0.2	0.6	1.3	0.0	0.2	1.5	4.6	0.0	0.8	5.4

Table 2.--Pacific ocean perch catch and effort data of stern trawlers in the Japanese mothership and North Pacific trawl fishery by vessel class in the eastern Bering sea slope region, 1968-1979.

	Vessel class a/						
Year	3	4	5	6	7	8	9
(A) Catch in Metric Tons.							
1968	895	3,847	695	1,938	378	10,012	1,776
1969	361	3,709	102	258	94	4,037	2,103
1970	77	215	78	55	301	3,168	1,495
1971	96	1,558	35	203	992	1,855	459
1972	8	997	317	15	404	316	1,310
1973	--	377	--	199	487	146	398
1974	--	640	90	520	700	609	735
1975	--	578	204	343	784	171	293
1976	--	310	188	152	772	70	545
1977	--	380	357	155	114	193	534
1978	--	531	154	178	54	130	545
1979	--	731	201	42	104	44	85
(B) Fishing Effort in Number of Hours Trawled.							
1968	10,360	29,815	2,627	1,770	148	6,697	4,564
1969	9,505	26,462	1,617	1,463	1,228	9,542	12,536
1970	10,346	29,370	1,778	239	3,420	12,241	13,945
1971	12,548	41,096	2,082	1,914	3,522	14,614	26,638
1972	16,630	30,207	2,896	1,831	5,823	16,081	24,502
1973	--	25,674	1,307	1,612	3,494	11,810	39,696
1974	--	28,953	2,720	3,941	3,668	17,096	39,112
1975	--	41,734	5,506	4,063	3,792	15,797	36,325
1976	--	48,293	4,064	455	1,899	14,720	25,958
1977	--	44,420	3,018	1,533	465	9,869	31,791
1978	--	59,446	5,589	3,802	468	9,853	35,256
1979	--	52,733	5,093	3,095	1,523	9,330	29,140
(C) Catch in Metric Tons per Hour Trawled.							
1968	.086	.129	.265	1.095	2.554	1.495	.389
1969	.038	.140	.063	.176	.076	.423	.168
1970	.007	.007	.044	.230	.088	.259	.107
1971	.008	.038	.017	.106	.282	.127	.017
1972	.001	.033	.110	.008	.069	.020	.054
1973	---	.015	---	.123	.139	.012	.010
1974	---	.022	.033	.132	.191	.036	.019
1975	---	.014	.037	.084	.207	.011	.008
1976	---	.006	.046	.334	.406	.005	.015
1977	---	.009	.118	.010	.245	.020	.017
1978	---	.009	.028	.047	.115	.013	.016
1979	---	.014	.040	.014	.068	.005	.003

a/ No data for classes 1 and 2. 1973-1979 data converted to pre-1973 gross tonnage classification of:

1= 71-100	4= 301-500	7=1501-2500
2=101-200	5= 501-1000	8=2501-3500
3=201-300	6=1001-1500	9=3501 and above

Table 3.--Pacific ocean parch catch, and effort data of stern trawlers in the Japanese mother ship and North Pacific trawl fishery by vessel class in the Aleutian region, 1968-1979.

	Vessel class a/					
Year	4	5	6	7	8	9
(A) Catch in Metric Tons.						
1968	12,157	280	32	2,711	6,787	532
1969	7,290	440	--	4,839	1,125	144
1970	2,384	1,227	--	7,741	249	82
1971	3,322	889	1,038	4,984	2,249	449
1972	3,527	1,318	645	2,035	188	135
1973	4,596	--	995	11,881	--	--
1974	10,679	1,564	1,326	2,507	25	16
1975	3,916	972	764	1,815	666	--
1976	4,862	823	786	1,600	83	--
1977	2,802	771	219	580	37	--
1978	2,342	480	140	855	183	--
1979	2,265	691	50	696	141	16
(B) Fishing Effort in Number of Hours Trawled.						
1968	8,575	115	8	216	759	772
1969	1,952	335	--	910	179	38
1970	1,755	600	--	976	161	25
1971	4,543	634	383	720	785	176
1972	6,534	546	493	423	114	56
1973	3,999	--	658	533	36	--
1974	13,912	1,822	967	529	70	22
1975	12,337	1,233	543	521	509	--
1976	10,179	897	698	575	251	--
1977	7,599	1,096	248	411	89	--
1978	8,889	961	206	595	315	--
1979	9,517	1,110	68	631	213	29
(C) Catch in Metric Tons per Hour Trawled.						
1968	1.42	2.43	4.00	12.55	8.94	0.69
1969	3.73	1.31	--	5.32	6.28	3.79
1970	1.36	2.04	--	7.93	1.55	3.28
1971	0.73	1.40	2.71	6.92	2.86	2.55
1972	0.54	2.41	1.31	4.81	1.65	2.41
1973	1.15	--	1.51	3.53	--	--
1974	0.77	0.86	1.37	4.74	0.36	0.73
1975	0.32	0.79	1.41	3.48	1.31	--
1976	0.48	0.92	1.13	2.78	0.33	--
1977	0.37	0.70	0.88	1.41	0.42	--
1978	0.26	0.50	0.68	1.44	0.58	--
1979	0.24	0.62	0.74	1.10	0.66	0.55

[a]/ No data for classes 1, 2, and 3 which are mainly side and pair trawls.

1973-1979 data converted to pre-1973 gross tonnage classification of:

1 = 71-100	4 = 301-501	7 = 1501-2500
2 = 101-200	5 = 501-1000	8 = 2501-3500
3 = 201-300	6 = 1001-1500	0

Table 4.--Pacific ocean perch catch and effort data of stern trawlers in the Japanese mothership and North pacific trawl fishery by vessel class in the, Gulf of Alaska region, 1968-1979.

	Vessel class a/					
Year	4	5	6	7	8	9
(A) Catch in Metric Tons.						
1968	1,149	3,401	235	12,465	21,727	15,827
1969	4,227	2,143	360	10,096	28,008	8,700
1970	5,482	1,511	--	9,472	21,614	6,110
1971	2,887	2,772	--	13,088	14,522	14,371
1972	4,332	2,618	2,830	12,388	13,560	13,827
1973	12,315	2,691	2,350	10,342	7,317	12,333
1974	7,492	3,009	2,858	2,947	10,692	9,897
1975	2,338	4,568	4,644	4,928	10,941	6,706
1976	1,613	6,434	4,556	3,463	10,135	9,151
1977	2,522	2,357	1,682	2,281	6,511	3,891
1978	508	233	326	621	1,230	984
1979	1,046	234	696	952	1,935	1,631
(B) Fishing Effort in Number of Hours Trawled.						
1968	1,246	3,496	51	2,255	4,185	4,846
1969	5,510	2,459	241	2,351	7,394	5,886
1970	4,559	1,159	--	1,687	4,108	3,166
1971	5,860	2,265	6	2,506	3,239	4,990
1972	11,437	1,957	1,256	2,979	4,401	5,930
1973	18,048	2,782	2,345	4,955	3,858	5,411
1974	14,380	3,318	3,250	1,702	6,476	7,314
1975	13,736	5,406	6,319	1,310	7,107	5,106
1976	11,674	7,315	4,828	1,015	4,758	5,205
1977	12,497	6,010	2,556	2,117	6,770	3,789
1978	11,387	2,824	2,639	1,933	6,786	2,328
1979	8,711	1,844	2,509	1,788	5,591	2,503
(C) Catch in Metric Tons per Hour Trawled.						
1968	0.92	0.97	4.61	5.53	5.19	3.27
1969	0.77	0.87	1.49	4.29	3.79	1.48
1970	1.20	1.30	--	5.61	5.26	1.93
1971	0.49	1.22	--	5.22	4.48	2.88
1972	0.38	1.34	2.25	4.16	3.08	2.33
1973	0.68	0.97	1.00	2.09	1.90	2.28
1974	0.52	0.91	0.88	1.73	1.65	1.35
1975	0.17	0.84	0.73	3.76	1.54	1.31
1976	0.14	0.88	0.94	3.41	2.13	1.76
1977	0.20	0.39	0.66	1.08	0.96	1.03
1978	0.04	0.08	0.12	0.32	0.18	0.42
1979	0.12	0.13	0.28	0.53	0.35	0.65

a/ Excluding minor catches from classes 1, 2, and 3. 1973-1979 data converted to pre-1973 gross tonnage classification of:

1 = 71-100	4 = 301-501	7 = 1501-2500
2 = 101-200	5 = 501-1000	8 = 2501-3500
3 = 201-300	6 = 1001-1500	9 = 3501 and above,

Table 5--Average catch per unit of effort (CPUE) for S. alutus in the Gulf of Alaska, 1961 and 1973-76, by region and depth zone.[1]

Region[2]	1961 CPUE (kg/h) 101-200 m	1961 CPUE (kg/h) 201-400 m	1973-76 CPUE (kg/h) 101-200 m	1973-76 CPUE (kg/h) 201-400 m
Fairweather	7.4	149.7	2.9	0.0
Yakutat	66.3	85.0	4.6	6.2
Prince William	48.8	80.1	10.9	1.5
Kenai	80.4	31.8	4.7	0.0
Kodiak	25.2	2.9	2.4	11.7
Shelikof	2.4	10.5	1.4	1.0
Chirikof	135.0	67.8	18.3	0.4
Shumagin	29.3	431.4	-	-
Sanak	7.2	228.6	0	53.5
Total	50.1	75.6	6.1	3.4

1/ Source: Ronholt, Shippen, and Brown 1978.
2/ Regions do not correspond to International North Pacific Fisheries Commission statistical areas.

Table 6.--Relative abundance of Sebastes alutus (catch in kg/h) in resource assessment surveys, 1978-81.

Year	Area	No. of station samples	Relative abundance (kg/h)	Reference
1978	Southeastern	74	53	1/
1978	Yakutat	100	4	1/
1978	Kodiak	53	4	1/
1978	Chirikof	24	4	1/
1979	Kodiak	73	114	2/
1979	Chirikof	55	98	2/
1979	Shumagin	43	131	2/
1979	Southeastern	15	84	2/
1981 3/	Yakutat	63	335	4/
1981 3/	Yakutat	59	193	4/
1981 3/	Cape Ommaney	72	143	4/
1981 3/	Kodiak	17	80	4/

1/ Feldman and Rose 1981.

2/ Cruise results, Nore-Dick 79-1.

3/ Beginning with 1981, surveys were confined to index sites which were areas of recorded high production by commercial fisheries and thus are not directly comparable to earlier surveys.

4/ Cruise results, Ocean Harvester 81-1 and Pat San Marie 81-2.

Table 7.--Estimated catch per unit effort (CPUE), population numbers, and biomass of Pacific ocean perch in the eastern Bering Sea (EBS) region as shown by data from cooperative U.S.-Japan trawl surveys in 39.79-82 and the trawl survey cunducted by Japan in 1969.

Depth strata	Year	CPUE (kg/ha)	Mean estimates: Population numbers (millions)	Mean estimates: Biomass (t)	95% confidence intervals for biomass estimates (t)
>100 m	1979	1.20	6.322	4,459	0 - 9,217
	1981	2.63	14.317	9,821	5,567 - 14,074
	1982	1.48	7.781	5,505	3,074 - 7,937
				6,595	Average
			+	7,000	Aleutian Islands portion of EBS[a]
				13,595	Entire EBS region
189-366 m	1969	22.64	--	31,329	12,732 - 49,926
	1979	3.15	6.273	4,363	---
	1981	5.41	10.814	7,486	4,065 - 10,908
	1982	3.80	7.490	5,254	2,834 - 7,673

[a]/ Biomass estimate of the Aleutian Islands portion of the eastern Bering Sea region, not sampled in the 1979-82 EBS surveys. Estimate is based on data from the 1980 U.S.-Japan Aleutian Islands survey.

Table 8.--Estimates of total virgin biomass (ages 5+) and exploitable biomass (ages 9+) by region, based on virtual population analysis results employing. M=0.15 and a range of intial F-values.

			Midpoint estimates (1,000 t)	
Region	Year	F-value range	Total virgin biomass (ages 5+)	Exploitable virgin biomass (ages 9+)
Eastern Bering Sea	1963	0.05-1.00	188	134
Aleutian Islands	1964	0.05-1.00	535	386
Gulf of Alaska	1963	0.01-0.50	1,910	1,247
		Total	2,633	1,767

Table 9.--For Pacific ocean perch in the Gulf of Alaska, stock reduction analysis (SRA) estimated of $P=B_{n+1}/B_1$, the proportion of virgin biomass B_1) remaining in 1983 as a function of B_1 (in thousands of t) and r, assuming M=0.05 and p=0.38. Underlined values are highlighted in the analysis; n.s. means no solution exists to the SRA equations.

Virgin biomass B_1	SRA parameter r				
	0.	0.25	0.50	0.75	1.0
1,650	0.451	0.371	0.308	0.259	0.221
1,600	0.433	0.348	0.283	0.233	0.195
1,500	0.391	0.296	0.226	0.175	0.137
1,450	0.366	0.266	0.194	0.142	0.104
1,400	0.339	0.231	0.156	0.104	0.067
1,350	0.307	0.190	0.112	0.059	0.023
1,300	0.266	0.136	0.049	n.s.	
1,250	n.s.				

Table 10.--For Pacific ocean perch in the Aleutian Islands, stock reduction analysis (SRA) estimate $P=B_{n+1}/B_1$, the proportion of virgin biomass (B_1) remaining in 1983 as a function of B_1 (in thousands of t) and r, assuming M=0.05 and p=0.38. Underlined values are highlighted in the analysis; n.s. means no solution exists to the SRA equation.

Virgin biomass B_1	SRA parameter r				
	0.0	0.25	0.50	0.75	1.0
630,000	0.437	0.361	0.303	0.258	0.223
620,000	0.427	0.349	0.290	0.244	0.209
500,000	0.406	0.324	0.262	0.216	0.181
580,000	0.383	0.296	0.232	0.185	0.150
560,000	0.357	0.264	0.198	0.150	0.116
540,000	0.328	0.228	0.159	0.111	0.078
520,000	0.292	0.183	0.111	0.064	0.031
500,000	0.240	0.114	n.s.		
495,000	n.s.				

Table 11 .--For Pacific ocean perch in the Eastern Bering Sea, stock reduction analysis (SRA) estimates of $P=B_{n+1}/B_1$, the proportion of virgin biomass (B_1) remaining in 1983 as a function of B_1 (in thousands of t) and r, assuming M=0.05 and P =0.38. Underlined values are highlighted in the analysis; n.s. means no solution exists to the SRA equations.

Virgin biomass B_1	SRA parameter r				
	0.0	0.25	0.50	0.75	1.0
270,000	0.452	0.368	<u>0.301</u>	0.247	<u>0.204</u>
260,000	0.430	0.340	0.270	0.215	0.171
250,000	0.404	0.309	0.236	0.180	0.136
240,000	0.377	0.275	<u>0.198</u>	0.140	0.097
230,000	0.345	0.235	0.154	0.095	0.052
220,000	0.308	0.187	<u>0.101</u>	0.038	n.s.
210,000	<u>0.261</u>	0.121	n.s.		
200,000	n.s.				

Table 12.-- For Pacific ocean perch in the Gulf of Alaska, stock rebuilding schedules (assuming M=0.05 and P =0.38) for stock reduction analysis (SRA) fits P ≈ 0.1, 0.2, and 0.3 with r=0.5 and P ≈ 0.25 with r=0.0. Biomass estimates are in thousands of t, F is the instantaneous fishing mortality rate, year 1 is 1983.

	r=0.5, P=0.112			r=0.5, P=0.194			r=0.5, P=0.308			r=0.0, P=0.266		
Year of projection	F=0.0	0.02	0.05	F=0.0	0.02	0.05	F=0.0	0.02	0.05	F=0.0	0.02	0.05
1	152	152	152	281	281	281	508	508	508	346	346	346
5	197	185	168	336	315	285	572	534	483	518	488	446
10	246	218	184	396	349	292	642	564	467	691	617	525
15	301	256	204	458	386	303	710	593	460	826	709	574
20	358	292	220	521	420	311	777	620	452	931	773	603
25	416	327	235	582	451	318	841	644	445	1,012	819	621
30	474	360	248	642	481	324	903	665	440	1,076	851	632
35	531	392	260	700	507	330	961	685	435	1,126	874	638
40	587	421	271	756	532	334	1,015	702	431	1,164	889	642
45	642	448	280	809	554	338	1,067	718	428	1,194	901	645
50	694	473	288	859	574	341	1,115	732	426	1,218	909	646
Equilibrium biomass	1,350	687	336	1,450	738	361	1,650	840	410	1,300	927	648
Virgin biomass	1,350	1,350	1,350	1,450	1,450	1,450	1,650	1,650	1,650	1,300	1,300	1,300
Recruitment to virgin biomass	42	42	42	45	45	45	51	51	51	40	40	40
B_{50}/EB	0.51	0.69	0.86	0.59	0.78	0.94	0.68	0.87	1.04	0.94	0.98	1.00
EB/VB	1.00	0.51	0.25	1.00	0.51	0.25	1.00	0.51	0.25	1.00	0.71	0.50

Table 13.-- For Pacific ocean perch in the Aleutian Islands, stock rebuilding schedules (assuming M=0.05 and P=0.38) for stock reduction analysis (SRA) fits P ≈ 0.1, 0.2, and 0.3 with r=0.5 and P ≈ 0.25 with with r=0.0. Biomass estimates are in thousands of t, F is the instantaneous fishing mortality rate, and year 1 is 1983.

	r=0.5, P=0.111			r=0.5, P=0.198			r=0.5, P=0.303			r=0.0, P=0.240		
Year of projection	F=0.0	0.02	0.05	F=0.0	0.02	0.05	F=0.0	0.02	0.05	F=0.0	0.02	0.05
1	58	58	58	111	111	111	191	191	191	120	120	120
5	75	70	64	132	123	112	215	201	181	189	178	163
10	94	84	70	155	137	115	242	212	176	258	231	197
15	115	98	78	179	151	118	268	224	174	311	268	217
20	137	112	84	203	164	121	294	234	171	353	294	230
25	159	125	90	227	176	124	318	244	169	385	313	238
30	182	138	95	250	187	126	342	252	167	411	326	242
35	204	150	100	273	197	128	364	260	165	431	335	245
40	225	162	104	294	207	130	385	267	164	446	341	247
45	246	172	108	314	215	131	405	273	163	458	346	248
50	267	182	111	334	223	132	423	278	162	467	349	248
Equilibrium biomass	520	265	129	560	285	139	630	321	157	500	357	249
Virgin biomass	520	520	520	560	560	560	630	630	630	500	500	500
Recruitment to virgin biomass	16	16	16	17	17	17	20	20	20	16	16	16
B_{50}/EB	0.51	0.69	0.86	0.60	0.78	0.95	0.67	0.87	1.03	0.93	0.98	1.00
EB/VB	1.00	0.51	0.25	1.00	0.51	0.25	1.00	0.51	0.25	1.00	0.71	0.50

Table 14.-- For Pacific ocean perch in the eastern Bering Sea, stock rebuilding schedules (assuming M=0.05 and p =0.38) for stock reduction analysis (SRA) fits P 0.1, 0.2, and 0.3 with r=0.5 and P .25 with r=0.0. Biomass estimates are in thousands of t, F is the instantaneous fishing mortality rate, and year 1 is 1983.

	r=0.5, P=0.101			r=0.5, P=0.198			r=0.5, P=0.301			r=0.0, P=0.261		
Year of projection	F=0.0	0.02	0.05	F=0.0	0.02	0.05	F=0.0	0.02	0.05	F=0.0	0.02	0.05
1	22	22	22	48	48	48	81	81	81	55	55	55
5	30	28	26	57	54	49	92	86	78	83	78	71
10	37	33	28	67	59	49	103	91	75	111	99	84
15	46	39	31	77	65	51	115	96	74	133	114	92
20	55	45	34	87	70	52	126	100	73	150	125	97
25	65	51	37	98	76	53	136	104	72	163	132	100
30	74	57	39	107	80	54	146	108	71	174	137	102
35	84	62	41	117	85	55	156	111	71	182	141	103
40	93	67	43	126	89	56	165	114	70	188	144	104
45	102	71	45	135	92	56	173	117	70	193	145	104
50	110	75	46	143	96	57	181	119	69	197	147	104
Equilibrium biomass	220	112	55	240	122	60	270	137	67	210	150	105
Virgin biomass	220	220	220	240	240	240	270	270	270	210	210	210
Recruitment to virgin biomass	7	7	7	7	7	7	8	8	8	7	7	7
B_{50}/EB	0.50	0.67	0.84	0.60	0.79	0.95	0.67	0.87	1.03	0.94	0.98	0.
EB/VB	1.00	0.51	0.25	1.00	0.51	0.25	1.00	0.51	0.25	1.00	0.71	0.50

Table 15.--Estimated Pacific ocean perch maximum sustainable yield (MSY) and associated biomass by area and case.

Region	Case 1 (r=0.5, P≈0.1)	Case 2 (r=0.5, P≈0.2)	Case 3 (r=0.5, P≈0.3)	Case 4 (r=0.0, P≈0.25)
	---------- 1,000 t	----------	----------	----------
Gulf of Alaska				
MSY	16.0	17.2	19.5	47.5
Biomass	363.9	375.4	427.5	161.0
Aleutian Islands				
MSY	6.2	6.6	7.5	18.3
Biomass	134.5	145.0	163.2	61.9
Eastern Bering Sea				
MSY	2.6	2.8	3.2	7.7
Biomass	56.9	62.1	69.9	26.0

Note - The MSY F for each area and cases 1-3 is 0.048, for case 4 it is 0.36.

Table 16.--Estimated Pacific ocean perch maximum sustainable profit (MSP) and associated yield and biomass by area and case.

Region	Case 1 (r=0.5, P≈0.1)	Case 2 (r=0.5, P≈0.2)	Case 3 (r=0.5, P≈0.3)	Case 4 (r=0.0, P≈0.25)
	---------- 1,000's	----------	----------	----------
Gulf of Alaska				
MSP ($)	3,560	2,900	2,210	4,695
Yield (t)	14.8	14.7	14.6	27.6
Biomass (t)	550	694	941	721
Aleutian Islands				
MSP	1,365	1,095	855	1,990
Yield	5.7	5.5	5.6	11.9
Biomass	212	284	359	249
Eastern Bering Sea				
MSP	598	470	370	766
Yield	2.4	2.3	2.4	4.5
Biomass	90	122	154	116

Table 17.--Estimated 50-year cumulative discounted profit for four rebuilding schedules, by discount rate, case and area.

Region	Case 1 (r=0.5, P≈ 0.1)	Case 2 (r=0.5, P≈ 0.2)	Case 3 (r=0.5, P≈ 0.3)	Case 4 (r=0.0, P≈ 0.25)
	Discount rate = 5%			
	$Million			
Gulf of Alaska				
F=0.01	18.1*	16.4*	10.8*	44.7
0.03	17.7	13.3	2.3	52.6
0.05	14.9	6.3	-12.8	53.8*
0.07	10.3	- 3.8	-32.7	49.8
Aleutian Islands				
F=0.01	7.0*	6.2*	4.2*	18.3
0.03	6.8	5.0	1.0	21.9
0.05	5.7	2.1	- 4.6	23.0*
0.07	3.9	- 1.9	-12.1	22.1
Eastern Bering Sea				
F=0.01	3.0*	2.7*	1.9*	7.3
0.03	3.0	2.2	0.5	8.6
0.05	2.6	1.0	- 1.9	8.9*
0.07	2.0	- 0.7	- 5.0	8.2

Region	Case 1 (r=0.5, P≈ 0.1)	Case 2 (r=0.5, P≈ 0.2)	Case 3 (r=0.5, P≈ 0.3)	Case 4 (r=0.0, P≈ 0.25)
	Discount rate = 10%			
	$Million			
Gulf of Alaska				
F=0.01	5.2	5.1*	4.0*	14.4
0.03	6.0*	4.9	1.6	20.7
0.05	5.4	2.2	- 5.1	22.8*
0.07	3.5	- 2.4	-15.0	21.7
Aleutian Islands				
F=0.01	2.0	1.9*	1.6*	5.9
0.03	2.3*	1.8	0.7	8.6
0.05	2.1	0.8	- 1.8	9.8*
0.07	1.4	- 1.1	- 5.5	9.7
Eastern Bering Sea				
F=0.01	0.9	0.8*	0.7*	2.4
0.03	1.0*	0.8*	0.3	3.4
0.05	1.0	0.4	- 0.7	3.8*
0.07	0.7	- 0.4	- 2.3	3.6

Note- An * indicates the rebuilding schedule with the highest CDP.

Table 18.--Estimated 50-year cumulative discounted profit for four rebuilding schedules and for harvesting costs that are 50% higher and 50% lower than the initial costs by case and area.

Region	50% Higher costs Case 1 (r=0.5, $P\approx 0.1$)	Case 2 (r=0.5, $P\approx 0.2$)	Case 3 (r=0.5, $P\approx 0.3$)	Case 4 (r=0.0, $P\approx 0.25$)
	---------------------	----$ Million----	---------------------	---------------------
Gulf of Alaska				
F=0.01	8.8*	- 1.0*	-20.9*	23.2*
0.03	2.7	-14.7	-48.7	18.1
0.05	- 5.7	-32.3	-82.9	6.2
0.07	-16.0	-52.9	-122.1	-10.9
Aleutian Islands				
F=0.01	3.4*	- 0.7*	- 7.7*	10.8*
0.08	1.0	- 6.2	-18.2	9.8
0.05	- 2.3	-13.3	-31.1	6.3
0.07	- 6.3	-21.5	-45.9	0.9
Eastern Bering Sea				
F=0.01	1.6*	- 0.3*	- 3.2*	3.9*
0.03	0.8	- 2.6	- 7.6	3.1
0.05	- 0.4	- 5.6	-13.1	1.2
0.07	- 1.9	- 9.1	-19.4	- 1.4

Region	50% Lower costs Case 1 (r=0.5, $P\approx 0.1$)	Case 2 (r=0.5, $P\approx 0.2$)	Case 3 (r=0.5, $P\approx 0.3$)	Case 4 (r=0.0, $P\approx 0.25$)
	---------------------	----$ Million----	---------------------	---------------------
Gulf of Alaska				
F=0.01	27.4	33.8	42.5	66.1
0.03	32.6	41.3	53.2	87.2
0.05	35.5	44.8	57.4*	101.4
0.07	36.5*	45.4*	56.7	110.4*
Aleutian Islands				
F=0.01	10.6	13.2	16.2	25.8
0.03	12.6	16.1	20.3	34.0
0.05	13.7	17.5	21.9*	39.6
0.07	14.1*	17.7*	21.7	43.3*
Eastern Bering Sea				
F=0.01	4.4	5.7	7.0	10.7
0.03	5.2	6.9	8.7	14.1
0.05	5.7	7.6	9.4*	16.5
0.07	5.9*	7.7*	9.3	17.9*

Note - An * notes the rebuilding schedule with the highest CDP with a real discount rate of 5%.

Table 19. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, Gulf Of Alaska, Case 1.

		Discount Rate = 5%			Discount Rate = 10%		
	Cost Factor	50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	500.1	27.4	18.1	8.8	8.5	5.2	1.8
2	530.1	32.9	18.5	4.2	12.6	6.5	0.4
3	523.7	31.3	18.9	6.5	11.2	6.3	1.4
4	519.6	30.5	18.9	7.4	10.5	6.0	1.6
5	516.8	29.9	18.9	7.8	10.0	5.9	1.8
6	513.6	30.3	18.2	6.1	11.0	5.8	0.6
7	533.3	33.7	17.8	2.0	13.6	6.4	-0.9
8	529.0	32.8	18.3	3.9	12.7	6.3	-0.0
9	526.3	32.3	18.4	4.6	12.2	6.3	0.3
10	524.5	31.9	18.5	5.0	12.0	6.2	0.4
11	524.6	32.6	17.7	2.7	13.1	6.0	-1.0
12	536.0	34.4	17.0	-0.4	14.6	6.1	-2.3
13	533.5	33.9	17.4	0.9	14.0	6.2	-1.6
14	532.0	33.6	17.6	1.5	13.8	6.2	-1.4
15	530.9	33.5	17.6	1.8	13.6	6.2	-1.3
16	533.4	34.3	16.5	-1.2	14.7	5.9	-3.0
17	538.4	35.0	16.0	-3.0	15.4	5.8	-3.8
18	537.3	34.8	16.3	-2.3	15.1	5.9	-3.4
19	536.6	34.7	16.4	-1.9	15.0	5.9	-3.2
20	536.2	34.6	16.4	-1.8	15.0	5.9	-3.2
21	540.4	35.5	14.9	-5.7	16.1	5.4	-5.3
22	550.2	36.5	10.3	-16.0	17.9	3.5	-10.9

Table 20. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates; and 3 cost factors, Gulf of Alaska, Case 2.

		Discount Rate = 5%			Discount Rate = 10%		
	Cost Factor	50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	664.2	33.8	16.4	-1.0	11.3	5.1	-1.2
2	716.7	41.1	14.3	-12.6	17.0	5.5	-5.9
3	703.7	38.9	15.7	-7.6	14.9	5.7	-3.5
4	696.2	37.8	16.1	-5.6	13.9	5.6	-2.6
5	691.2	37.0	16.3	-4.5	13.3	5.6	-2.2
6	689.4	38.1	15.4	-7.3	15.1	5.3	-4.4
7	724.0	42.4	12.6	-17.1	18.6	5.0	-8.6
8	715.3	41.1	14.0	-13.1	17.3	5.4	-6.5
9	710.3	40.4	14.5	-11.4	16.6	5.4	-5.8
10	707.1	40.0	14.8	-10.4	16.3	5.4	-5.4
11	710.3	41.3	13.3	-14.7	18.1	4.9	-8.3
12	730.6	43.4	10.8	-21.9	20.0	4.3	-11.5
13	725.4	42.8	11.9	-19.0	19.3	4.6	-10.0
14	722.5	42.4	12.3	-17.8	18.9	4.8	-9.4
15	720.6	42.2	12.6	-17.1	18.7	4.8	-9.1
16	727.6	43.5	10.2	-23.1	20.5	3.8	-12.8
17	736.5	44.2	8.6	-27.0	21.2	3.3	-14.6
18	734.2	44.0	9.3	-25.5	20.9	3.6	-13.8
19	732.9	43.9	9.6	-24.8	20.8	3.7	-13.4
20	732.1	43.8	9.7	-24.4	20.7	3.7	-13.3
21	741.8	44.8	6.3	-32.3	22.3	2.2	-17.8
22	762.7	45.4	-3.7	-52.9	24.5	-2.4	-29.4

Table 21. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, Gulf of Alaska, Case 3.

		Discount Rate = 5%			Discount Rate = 10%		
Cost Factor		50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	919.2	42.5	10.8	-20.9	15.4	4.0	-7.4
2	1008.6	52.1	3.3	-45.6	23.3	2.5	-18.3
3	984.7	49.1	6.7	-35.6	20.3	3.6	-13.2
4	971.3	47.5	8.0	-31.4	18.8	3.8	-11.2
5	962.8	46.5	8.7	-29.1	18.1	3.9	-10.2
6	964.3	48.7	7.5	-33.8	21.1	3.4	-14.3
7	1023.3	54.1	-0.1	-54.2	25.9	1.1	-23.6
8	1007.2	52.4	3.1	-46.3	24.0	2.3	-19.4
9	998.4	51.5	4.4	-42.8	23.1	2.7	-17.7
10	992.8	50.9	5.0	-40.8	22.6	2.9	-16.9
11	1002.0	53.2	2.3	-48.7	25.5	1.6	-22.4
12	1036.7	55.6	-3.9	-63.4	28.1	-0.6	-29.3
13	1027.1	54.8	-1.5	-57.7	27.0	0.4	-26.2
14	1021.9	54.4	-0.4	-55.2	26.6	0.8	-25.0
15	1018.6	54.1	0.2	-53.8	26.3	1.0	-24.4
16	1033.6	56.0	-4.6	-65.1	29.0	-1.3	-31.5
17	1048.9	56.7	-8.1	-73.0	29.9	-2.7	-35.3
18	1044.6	56.4	-6.8	-70.0	29.5	-2.1	-33.6
19	1042.3	56.3	-6.2	-68.7	29.3	-1.8	-33.0
20	1040.8	56.3	-5.8	-67.9	29.2	-1.7	-32.6
21	1059.9	57.4	-12.8	-82.9	31.4	-5.1	-41.6
22	1099.9	56.7	-32.7	-122.1	34.1	-15.0	-64.1

Table 22. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, Gulf of Alaska, Case 4.

		Discount Rate = 5%			Discount Rate = 10%		
	Cost Factor	50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	1129.4	66.1	44.7	23.2	22.1	14.4	6.7
2	1284.9	87.4	54.3	21.2	35.4	21.2	7.1
3	1242.1	80.9	52.1	23.4	30.5	19.2	7.9
4	1218.3	77.4	50.6	23.9	28.2	18.0	7.8
5	1203.4	75.2	49.6	23.9	26.8	17.3	7.7
6	1204.7	77.6	49.6	21.6	30.1	18.1	6.1
7	1311.3	91.6	54.8	18.1	38.9	22.1	5.3
8	1281.4	87.2	53.7	20.3	35.6	20.9	6.3
9	1265.1	84.9	52.9	21.0	34.1	20.2	6.4
10	1254.8	83.5	52.4	21.2	33.2	19.8	6.4
11	1270.9	87.2	52.6	18.1	36.9	20.7	4.4
12	1335.9	95.2	54.9	14.5	42.1	22.7	3.2
13	1317.4	92.7	54.5	16.3	40.2	22.1	4.1
14	1307.4	91.3	54.2	17.0	39.2	21.8	4.3
15	1301.2	90.5	53.9	17.3	38.7	21.5	4.4
16	1329.2	95.0	53.9	12.9	42.7	22.2	1.7
17	1359.0	98.5	54.5	10.6	45.0	22.9	0.8
18	1350.4	97.4	54.5	11.6	44.1	22.7	1.3
19	1345.8	96.8	54.4	12.0	43.7	22.6	1.5
20	1342.9	96.5	54.3	12.2	43.5	22.5	1.5
21	1380.7	101.4	53.8	6.2	47.6	22.8	−1.9
22	1466.7	110.4	49.8	−10.9	55.0	21.7	−11.6

Table 23. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, Aleutian Islands, Case 1.

		Discount Rate = 5%			Discount Rate = 10%		
Cost Factor		50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	193.6	10.6	7.0	3.4	3.3	2.0	0.7
2	205.4	12.7	7.2	1.6	4.9	2.5	0.1
3	202.8	12.1	7.3	2.5	4.3	2.4	0.5
4	201.2	11.8	7.3	2.8	4.1	2.3	0.6
5	200.1	11.6	7.3	3.0	3.9	2.3	0.7
6	198.9	11.8	7.0	2.3	4.3	2.3	0.2
7	206.6	13.1	6.9	0.7	5.3	2.5	-0.4
8	204.9	12.7	7.1	1.4	4.9	2.5	-0.0
9	203.9	12.5	7.1	1.7	4.7	2.4	0.1
10	203.2	12.4	7.1	1.9	4.6	2.4	0.1
11	203.2	12.6	6.8	1.0	5.1	2.3	-0.4
12	207.7	13.3	6.6	-0.2	5.7	2.4	-0.9
13	206.7	13.1	6.7	0.3	5.4	2.4	-0.6
14	206.1	13.0	6.8	0.5	5.3	2.4	-0.5
15	205.7	13.0	6.8	0.6	5.3	2.4	-0.5
16	206.7	13.3	6.4	-0.5	5.7	2.3	-1.2
17	208.6	13.6	6.2	-1.2	6.0	2.2	-1.5
18	208.2	13.5	6.3	-0.9	5.9	2.3	-1.3
19	207.9	13.4	6.3	-0.8	5.8	2.3	-1.3
20	207.7	13.4	6.3	-0.8	5.8	2.3	-1.3
21	209.4	13.7	5.7	-2.3	6.2	2.1	-2.1
22	213.3	14.1	3.9	-6.3	7.0	1.4	-4.3

Table 24. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, Aleutian Islands, Case 2.

		Discount Rate = 5%			Discount Rate = 10%		
Cost Factor		50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	260.1	13.2	6.2	-0.7	4.4	1.9	-0.6
2	281.0	16.0	5.3	-5.4	6.7	2.1	-2.5
3	275.8	15.2	5.9	-3.4	5.8	2.2	-1.5
4	272.8	14.7	6.1	-2.6	5.4	2.1	-1.1
5	270.8	14.4	6.1	-2.1	5.2	2.1	-1.0
6	270.2	14.9	5.8	-3.2	5.9	2.0	-1.8
7	283.9	16.5	4.7	-7.2	7.3	1.9	-3.6
8	280.5	16.0	5.2	-5.6	6.8	2.0	-2.7
9	278.5	15.8	5.4	-4.9	6.5	2.1	-2.4
10	277.2	15.6	5.5	-4.5	6.4	2.1	-2.3
11	278.5	16.1	4.9	-6.2	7.1	1.8	-3.4
12	286.6	17.0	3.9	-9.1	7.9	1.6	-4.7
13	284.5	16.7	4.4	-8.0	7.6	1.7	-4.1
14	283.4	16.6	4.6	-7.5	7.4	1.8	-3.9
15	282.6	16.5	4.6	-7.2	7.4	1.8	-3.8
16	285.4	17.0	3.7	-9.6	8.0	1.4	-5.2
17	289.0	17.3	3.1	-11.2	8.4	1.2	-5.9
18	288.1	17.2	3.3	-10.5	8.2	1.3	-5.6
19	287.6	17.1	3.4	-10.3	8.2	1.3	-5.5
20	287.2	17.1	3.5	-10.1	8.1	1.4	-5.4
21	291.1	17.5	2.1	-13.3	8.8	0.8	-7.3
22	299.5	17.7	-1.9	-21.5	9.6	-1.1	-11.9

Table 25. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, Aleutian Islands, Case 3.

		Discount Rate = 5%			Discount Rate = 10%		
Cost Factor	Yield (1,000 t)	50%	100%	150%	50%	100%	150%
		Cumulative Discounted Profit ($ million)					
1	349.5	16.2	4.2	-7.7	5.9	1.6	-2.7
2	383.4	19.9	1.4	-17.0	8.9	1.0	-6.9
3	374.4	18.7	2.7	-13.3	7.7	1.4	-4.9
4	369.3	18.1	3.2	-11.7	7.2	1.5	-4.2
5	366.1	17.7	3.5	-10.8	6.9	1.5	-3.8
6	366.6	18.6	3.0	-12.6	8.0	1.3	-5.3
7	389.0	20.6	0.2	-20.3	9.9	0.5	-8.9
8	382.9	20.0	1.3	-17.3	9.1	0.9	-7.2
9	379.5	19.6	1.8	-16.0	8.8	1.1	-6.6
10	377.4	19.4	2.1	-15.3	8.6	1.2	-6.3
11	380.9	20.3	1.0	-18.2	9.7	0.7	-8.4
12	394.0	21.2	-1.3	-23.7	10.7	-0.1	-11.0
13	390.4	20.9	-0.4	-21.6	10.3	0.2	-9.8
14	388.4	20.7	0.0	-20.7	10.1	0.4	-9.4
15	387.2	20.7	0.3	-20.1	10.0	0.4	-9.1
16	392.8	21.4	-1.5	-24.4	11.0	-0.4	-11.8
17	398.6	21.6	-2.9	-27.4	11.4	-0.9	-13.2
18	397.0	21.5	-2.4	-26.2	11.2	-0.7	-12.6
19	396.1	21.5	-2.1	-25.7	11.2	-0.6	-12.4
20	395.6	21.5	-2.0	-25.5	11.1	-0.6	-12.2
21	402.8	21.9	-4.6	-31.1	12.0	-1.8	-15.6
22	417.9	21.7	-12.1	-45.9	13.0	-5.5	-24.1

Table 26. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding, schedules, 2 discount rates, and 3 cost factors, Aleutian Islands, Case 4.

		Discount Rate = 5%			Discount Rate = 10%		
	Cost Factor	50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	431.8	25.8	18.3	10.8	8.6	5.9	3.2
2	490.5	34.2	22.6	11.0	13.7	8.8	3.8
3	474.5	31.6	21.5	11.5	11.8	7.9	3.9
4	465.5	30.2	20.9	11.5	10.9	7.4	3.8
5	459.9	29.4	20.4	11.4	10.4	7.1	3.7
6	460.0	30.3	20.5	10.7	11.6	7.4	3.2
7	500.3	35.8	22.9	10.1	15.1	9.2	3.3
8	489.1	34.0	22.3	10.6	13.8	8.7	3.5
9	482.9	33.1	22.0	10.8	13.2	8.4	3.5
10	479.1	32.6	21.7	10.8	12.9	8.2	3.5
11	484.8	34.0	21.9	9.8	14.3	8.6	2.9
12	509.4	37.2	23.1	9.0	16.3	9.5	2.7
13	502.5	36.2	22.8	9.5	15.5	9.2	2.9
14	498.7	35.6	22.6	9.6	15.2	9.1	3.0
15	496.4	35.3	22.5	9.7	15.0	9.0	3.0
16	506.7	37.1	22.7	8.3	16.5	9.3	2.2
17	518.0	38.5	23.1	7.7	17.4	9.7	2.0
18	514.8	38.0	23.0	8.0	17.1	9.6	2.1
19	513.0	37.8	23.0	8.1	16.9	9.5	2.1
20	512.0	37.7	22.9	8.2	16.8	9.5	2.2
21	526.1	39.6	23.0	6.3	18.4	9.8	1.1
22	558.4	43.3	22.1	0.9	21.4	9.7	-1.9

Table 27. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, eastern Bering Sea, Case 1.

		Discount Rate = 5%			Discount Rate = 10%		
Cost Factor		50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	79.2	4.4	3.0	1.6	1.4	0.9	0.4
2	83.8	5.3	3.1	1.0	2.0	1.1	0.2
3	82.8	5.0	3.2	1.3	1.8	1.0	0.3
4	82.2	4.9	3.2	1.4	1.7	1.0	0.4
5	81.8	4.8	3.1	1.5	1.6	1.0	0.4
6	81.3	4.9	3.1	1.3	1.8	1.0	0.2
7	84.2	5.4	3.0	0.7	2.2	1.1	0.0
8	83.6	5.3	3.1	0.9	2.0	1.1	0.1
9	83.2	5.2	3.1	1.0	2.0	1.1	0.2
10	82.9	5.1	3.1	1.1	1.9	1.0	0.2
11	82.9	5.2	3.0	0.8	2.1	1.0	-0.0
12	84.6	5.5	2.9	0.3	2.3	1.1	-0.2
13	84.3	5.4	3.0	0.5	2.2	1.1	-0.1
14	84.0	5.4	3.0	0.6	2.2	1.1	-0.1
15	83.9	5.4	3.0	0.6	2.2	1.1	-0.0
16	84.2	5.5	2.9	0.2	2.4	1.0	-0.3
17	85.0	5.6	2.8	-0.1	2.5	1.0	-0.4
18	84.8	5.6	2.8	0.1	2.4	1.0	-0.3
19	84.7	5.6	2.8	0.1	2.4	1.0	-0.3
20	84.6	5.6	2.8	0.1	2.4	1.0	-0.3
21	85.3	5.7	2.6	-0.4	2.6	1.0	-0.6
22	86.7	5.9	2.0	-1.9	2.9	0.7	-1.4

Table 28. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, eastern Bering Sea, Case 2.

		Discount Rate = 5%			Discount Rate = 10%		
	Cost Factor	50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	111.6	5.7	2.7	-0.3	1.9	0.8	-0.2
2	120.6	6.9	2.3	-2.3	2.9	0.9	-1.0
3	118.4	6.5	2.6	-1.4	2.5	0.9	-0.6
4	117.1	6.3	2.6	-1.1	2.3	0.9	-0.5
5	116.2	6.2	2.7	-0.9	2.3	0.9	-0.4
6	116.0	6.4	2.5	-1.3	2.6	0.9	-0.8
7	121.9	7.1	2.0	-3.0	3.2	0.8	-1.5
8	120.4	6.9	2.3	-2.3	2.9	0.9	-1.1
9	119.5	6.8	2.4	-2.0	2.8	0.9	-1.0
10	119.0	6.7	2.4	-1.9	2.8	0.9	-0.9
11	119.6	6.9	2.2	-2.6	3.1	0.8	-1.4
12	123.0	7.3	1.7	-3.9	3.4	0.7	-2.0
13	122.1	7.2	1.9	-3.4	3.3	0.8	-1.7
14	121.6	7.1	2.0	-3.1	3.2	0.8	-1.6
15	121.3	7.1	2.0	-3.0	3.2	0.8	-1.6
16	122.5	7.3	1.6	-4.0	3.5	0.6	-2.2
17	124.1	7.5	1.4	-4.7	3.6	0.6	-2.5
18	123.7	7.4	1.5	-4.5	3.6	0.6	-2.4
19	123.4	7.4	1.5	-4.3	3.5	0.6	-2.3
20	123.3	7.4	1.6	-4.3	3.5	0.6	-2.3
21	125.0	7.6	1.0	-5.6	3.8	0.4	-3.1
22	128.6	7.7	-0.7	-9.1	4.2	-0.4	-5.0

Table 29, Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, eastern Bering Sea, Case 3.

		Discount Rate = 5%			Discount Rate = 10%		
	Cost Factor	50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	149.5	7.0	1.9	-3.2	2.5	0.7	-1.1
2	163.9	8.5	0.7	-7.1	3.8	0.5	-2.9
3	160.1	8.0	1.2	-5.6	3.3	0.6	-2.1
4	157.9	7.8	1.4	-4.9	3.1	0.7	-1.7
5	156.5	7.6	1.5	-4.5	3.0	0.7	-1.6
6	156.8	8.0	1.4	-5.3	3.4	0.6	-2.2
7	166.3	8.9	0.2	-8.5	4.2	0.3	-3.7
8	163.7	8.6	0.7	-7.3	3.9	0.4	-3.0
9	162.3	8.4	0.9	-6.7	3.8	0.5	-2.8
10	161.4	8.3	1.0	-6.4	3.7	0.5	-2.6
11	162.9	8.7	0.5	-7.6	4.2	0.3	-3.5
12	168.5	9.1	-0.4	-10.0	4.6	-0.0	-4.6
13	166.9	9.0	-0.1	-9.1	4.4	0.1	-4.1
14	166.1	8.9	0.1	-8.7	4.3	0.2	-3.9
15	165.5	8.9	0.2	-8.5	4.3	0.2	-3.8
16	168.0	9.2	-0.5	-10.3	4.7	-0.1	-5.0
17	170.4	9.3	-1.1	-11.5	4.9	-0.3	-5.6
18	169.7	9.3	-0.9	-11.0	4.8	-0.2	-5.3
19	169.4	9.2	-0.8	-10.8	4.8	-0.2	-5.2
20	169.1	9.2	-0.7	-10.7	4.8	-0.2	-5.1
21	172.2	9.4	-1.8	-13.1	5.2	-0.7	-6.6
22	178.7	9.3	-5.0	-19.4	5.6	-2.3	-10.2

Table 30. Estimated cumulative yield and cumulative discounted profit in year 50 for 22 rebuilding schedules, 2 discount rates, and 3 cost factors, eastern Bering Sea, Case 4.

		Discount Rate = 5%			Discount Rate = 10%		
Cost Factor		50%	100%	150%	50%	100%	150%
	Yield (1,000 t)	Cumulative Discounted Profit ($ million)					
1	182.4	10.7	7.3	3.9	3.6	2.4	1.1
2	207.5	14.2	8.9	3.6	5.7	3.5	1.2
3	200.6	13.1	8.5	3.9	4.9	3.1	1.3
4	196.8	12.5	8.3	4.0	4.6	2.9	1.3
5	194.4	12.2	8.1	4.0	4.4	2.8	1.3
6	194.6	12.6	8.1	3.6	4.9	3.0	1.0
7	211.8	14.8	9.0	3.1	6.3	3.6	0.9
8	207.0	14.1	8.8	3.5	5.8	3.4	1.1
9	204.3	13.8	8.7	3.6	5.5	3.3	1.1
10	202.7	13.5	8.6	3.6	5.4	3.2	1.1
11	205.3	14.1	8.6	3.1	6.0	3.4	0.8
12	215.8	15.5	9.0	2.6	6.8	3.7	0.6
13	212.8	15.0	8.9	2.8	6.5	3.6	0.7
14	211.2	14.8	8.9	2.9	6.4	3.6	0.8
15	210.2	14.7	8.8	3.0	6.3	3.5	0.8
16	214.7	15.4	8.9	2.3	6.9	3.7	0.4
17	219.5	16.0	9.0	1.9	7.3	3.8	0.2
18	218.1	15.8	8.9	2.1	7.2	3.7	0.3
19	217.4	15.7	8.9	2.2	7.1	3.7	0.3
20	216.9	15.6	8.9	2.2	7.1	3.7	0.4
21	223.0	16.5	8.8	1.2	7.7	3.8	-0.2
22	236.9	17.9	8.2	-1.4	8.9	3.6	-1.7

Table 31. Fishing mortality time paths for 22 rebuilding schedules.

Schedules 1-11

Year	1	2	3	4	5	6	7	8	9	10	11
2	.0100	.0120	.0101	.0100	.0100	.0200	.0215	.0201	.0200	.0200	.0300
3	.0100	.0140	.0104	.0100	.0100	.0200	.0230	.0203	.0200	.0200	.0300
4	.0100	.0160	.0109	.0101	.0100	.0200	.0245	.0207	.0201	.0200	.0300
5	.0100	.0180	.0116	.0103	.0101	.0200	.0260	.0212	.0202	.0200	.0300
6	.0100	.0200	.0125	.0106	.0102	.0200	.0275	.0219	.0205	.0201	.0300
7	.0100	.0220	.0136	.0111	.0103	.0200	.0290	.0227	.0208	.0202	.0300
8	.0100	.0240	.0149	.0117	.0106	.0200	.0305	.0237	.0213	.0205	.0300
9	.0100	.0260	.0164	.0126	.0110	.0200	.0320	.0248	.0219	.0208	.0300
10	.0100	.0280	.0181	.0136	.0116	.0200	.0335	.0261	.0227	.0212	.0300
11	.0100	.0300	.0200	.0150	.0125	.0200	.0350	.0275	.0238	.0219	.0300
12	.0100	.0320	.0221	.0167	.0137	.0200	.0365	.0291	.0250	.0227	.0300
13	.0100	.0340	.0244	.0186	.0152	.0200	.0380	.0308	.0265	.0239	.0300
14	.0100	.0360	.0269	.0210	.0171	.0200	.0395	.0327	.0282	.0254	.0300
15	.0100	.0380	.0296	.0237	.0196	.0200	.0410	.0347	.0303	.0272	.0300
16	.0100	.0400	.0325	.0269	.0227	.0200	.0425	.0369	.0327	.0295	.0300
17	.0100	.0420	.0356	.0305	.0264	.0200	.0440	.0392	.0354	.0323	.0300
18	.0100	.0440	.0389	.0346	.0309	.0200	.0455	.0417	.0384	.0357	.0300
19	.0100	.0460	.0424	.0392	.0362	.0200	.0470	.0443	.0419	.0397	.0300
20	.0100	.0480	.0461	.0443	.0426	.0200	.0485	.0471	.0457	.0444	.0300
21	.0100	.0500	.0500	.0500	.0500	.0200	.0500	.0500	.0500	.0500	.0300
22	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500

Schedules 12-22

Year	12	13	14	15	16	17	18	19	20	21	22
2	.0310	.0301	.0300	.0300	.0400	.0405	.0400	.0400	.0400	.0500	.0700
3	.0320	.0302	.0300	.0300	.0400	.0410	.0401	.0400	.0400	.0500	.0700
4	.0330	.0305	.0301	.0300	.0400	.0415	.0402	.0400	.0400	.0500	.0700
5	.0340	.0308	.0302	.0300	.0400	.0420	.0404	.0401	.0400	.0500	.0700
6	.0350	.0313	.0303	.0301	.0400	.0425	.0406	.0402	.0400	.0500	.0700
7	.0360	.0318	.0305	.0302	.0400	.0430	.0409	.0403	.0401	.0500	.0700
8	.0370	.0324	.0309	.0303	.0400	.0435	.0412	.0404	.0402	.0500	.0700
9	.0380	.0332	.0313	.0305	.0400	.0440	.0416	.0406	.0403	.0500	.0700
10	.0390	.0341	.0318	.0308	.0400	.0445	.0420	.0409	.0404	.0500	.0700
11	.0400	.0350	.0325	.0313	.0400	.0450	.0425	.0413	.0406	.0500	.0700
12	.0410	.0360	.0333	.0318	.0400	.0455	.0430	.0417	.0409	.0500	.0700
13	.0420	.0372	.0343	.0326	.0400	.0460	.0436	.0422	.0413	.0500	.0700
14	.0430	.0385	.0355	.0336	.0400	.0465	.0442	.0427	.0418	.0500	.0700
15	.0440	.0398	.0369	.0348	.0400	.0470	.0449	.0434	.0424	.0500	.0700
16	.0450	.0413	.0384	.0363	.0400	.0475	.0456	.0442	.0432	.0500	.0700
17	.0460	.0428	.0402	.0382	.0400	.0480	.0464	.0451	.0441	.0500	.0700
18	.0470	.0444	.0423	.0404	.0400	.0485	.0472	.0461	.0452	.0500	.0700
19	.0480	.0462	.0446	.0431	.0400	.0490	.0481	.0473	.0466	.0500	.0700
20	.0490	.0480	.0471	.0463	.0400	.0495	.0490	.0486	.0481	.0500	.0700
21	.0500	.0500	.0500	.0500	.0400	.0500	.0500	.0500	.0500	.0500	.0700
22	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500	.0500

Table 32. Estimated cumulative 50-year reductions, in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, Gulf of Alaska, Case 1.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	11.7	22.6	32.9	42.6	51.6
2	13.3	25.7	37.4	48.3	58.5
3	12.9	25.0	36.3	46.9	56.8
4	12.6	24.5	35.6	46.0	55.7
5	12.5	24.1	35.1	45.4	55.0
6	12.3	23.9	34.7	44.8	54.3
7	13.4	25.9	37.6	48.6	58.8
8	13.1	25.4	36.9	47.6	57.7
9	12.9	25.0	36.4	47.0	57.0
10	12.8	24.8	36.1	46.6	56.5
11	12.8	24.8	36.0	46.6	56.4
12	13.4	26.0	37.7	48.7	59.0
13	13.3	25.7	37.3	48.2	58.4
14	13.2	25.5	37.0	47.8	58.0
15	13.1	25.4	36.8	47.6	57.7
16	13.2	25.5	37.0	47.9	58.0
17	13.4	26.0	37.8	48.8	59.1
18	13.4	25.9	37.6	48.6	58.8
19	13.3	25.8	37.5	48.4	58.7
20	13.3	25.7	37.4	48.3	58.5
21	13.4	26.0	37.8	48.8	59.1
22	13.7	26.5	38.5	49.8	60.3

Table 33. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, Gulf of Alaska, Case 2.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	9.6	18.9	27.9	36.6	44.9
2	11.2	22.0	32.4	42.5	52.2
3	10.8	21.2	31.2	40.9	50.2
4	10.5	20.7	30.5	39.9	49.0
5	10.4	20.4	30.0	39.3	48.3
6	10.3	20.2	29.8	39.1	48.0
7	11.3	22.2	32.8	42.9	52.7
8	11.0	21.7	32.0	41.9	51.4
9	10.9	21.4	31.5	41.2	50.6
10	10.8	21.2	31.2	40.8	50.2
11	10.8	21.2	31.3	41.0	50.4
12	11.4	22.4	33.0	43.2	53.1
13	11.2	22.1	32.5	42.6	52.3
14	11.1	21.9	32.3	42.2	51.9
15	11.1	21.8	32.1	42.0	51.6
16	11.2	22.0	32.4	42.5	52.2
17	11.5	22.5	33.2	43.5	53.4
18	11.4	22.4	33.0	43.2	53.0
19	11.4	22.3	32.8	43.0	52.8
20	11.3	22.2	32.8	42.9	52.7
21	11.5	22.6	33.3	43.6	53.5
22	11.9	23.3	34.3	44.9	55.2

Table 34. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, Gulf of Alaska, Case 3.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	8.3	16.4	24.4	32.2	39.9
2	9.8	19.5	28.9	38.2	47.2
3	9.4	18.6	27.7	36.5	45.2
4	9.1	18.1	26.9	35.5	43.9
5	9.0	17.8	26.4	34.9	43.2
6	9.0	17.8	26.4	34.8	43.1
7	10.0	19.8	29.3	38.7	47.9
8	9.7	19.2	28.5	37.6	46.5
9	9.5	18.9	28.0	36.9	45.7
10	9.4	18.6	27.7	36.5	45.2
11	9.5	18.8	28.0	36.9	45.7
12	10.1	20.0	29.7	39.1	48.4
13	9.9	19.6	29.2	38.5	47.6
14	9.8	19.4	28.9	38.1	47.1
15	9.8	19.3	28.7	37.9	46.9
16	9.9	19.6	29.2	38.5	47.6
17	10.2	20.1	29.9	39.5	48.8
18	10.1	20.0	29.7	39.2	48.5
19	10.1	19.9	29.6	39.0	48.3
20	10.0	19.9	29.5	38.9	48.1
21	10.2	20.3	30.1	39.7	49.1
22	10.6	21.0	31.2	41.2	51.0

Table 35. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules Gulf of Alaska, Case 4.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	5.3	10.4	15.3	20.0	24.6
2	7.5	14.7	21.7	28.5	35.0
3	6.7	13.3	19.5	25.6	31.5
4	6.3	12.5	18.4	24.1	29.6
5	6.1	12.0	17.7	23.2	28.5
6	6.4	12.6	18.6	24.3	29.9
7	7.9	15.4	22.8	29.9	36.7
8	7.3	14.4	21.3	27.9	34.3
9	7.1	13.9	20.5	26.9	33.1
10	6.9	13.6	20.1	26.3	32.4
11	7.3	14.4	21.2	27.8	34.2
12	8.2	16.1	23.7	31.1	38.2
13	7.9	15.5	22.8	29.9	36.8
14	7.7	15.2	22.4	29.3	36.1
15	7.6	15.0	22.1	29.0	35.6
16	8.1	15.9	23.4	30.7	37.8
17	8.4	16.6	24.5	32.1	39.5
18	8.3	16.3	24.1	31.6	38.9
19	8.2	16.2	23.9	31.4	38.6
20	8.2	16.1	23.8	31.2	38.4
21	8.7	17.1	25.2	33.1	40.7
22	9.6	18.8	27.8	36.5	44.9

Table 36. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska, Case 1.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	1.0	2.0	2.9	3.8	4.6	0.4	0.8	1.1	1.5	1.8
2	1.5	2.9	4.2	5.4	6.6	0.7	1.4	2.0	2.5	3.1
3	1.3	2.6	3.8	4.8	5.9	0.6	1.1	1.6	2.1	2.5
4	1.3	2.4	3.5	4.6	5.5	0.5	1.0	1.5	1.9	2.3
5	1.2	2.3	3.4	4.4	5.3	0.5	0.9	1.4	1.8	2.1
6	1.3	2.5	3.6	4.7	5.6	0.6	1.1	1.6	2.1	2.6
7	1.6	3.1	4.5	5.8	7.0	0.8	1.5	2.2	2.8	3.4
8	1.5	2.9	4.2	5.4	6.5	0.7	1.4	2.0	2.5	3.1
9	1.4	2.8	4.0	5.2	6.3	0.7	1.3	1.9	2.4	2.9
10	1.4	2.7	3.9	5.1	6.1	0.6	1.2	1.8	2.3	2.8
11	1.5	2.9	4.2	5.4	6.6	0.7	1.4	2.1	2.7	3.3
12	1.7	3.2	4.7	6.1	7.3	0.9	1.7	2.4	3.1	3.8
13	1.6	3.1	4.5	5.8	7.1	0.8	1.6	2.3	2.9	3.6
14	1.6	3.1	4.4	5.7	6.9	0.8	1.5	2.2	2.9	3.5
15	1.6	3.0	4.4	5.6	6.8	0.8	1.5	2.2	2.8	3.4
16	1.7	3.2	4.7	6.0	7.3	0.9	1.7	2.5	3.2	3.9
17	1.8	3.4	4.9	6.3	7.7	0.9	1.8	2.6	3.4	4.1
18	1.7	3.3	4.8	6.2	7.5	0.9	1.8	2.6	3.3	4.0
19	1.7	3.3	4.8	6.2	7.5	0.9	1.7	2.5	3.3	3.9
20	1.7	3.3	4.8	6.1	7.4	0.9	1.7	2.5	3.2	3.9
21	1.8	3.5	5.1	6.6	8.0	1.0	1.9	2.8	3.6	4.4
22	2.0	3.9	5.7	7.4	8.9	1.2	2.3	3.3	4.3	5.2

Table 37. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska, Case 2.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.9	1.8	2.6	3.4	4.2	0.4	0.7	1.0	1.4	1.7
2	1.3	2.6	3.8	5.0	6.2	0.6	1.3	1.8	2.4	3.0
3	1.2	2.3	3.4	4.4	5.4	0.5	1.0	1.5	2.0	2.4
4	1.1	2.1	3.2	4.1	5.1	0.5	0.9	1.3	1.8	2.2
5	1.0	2.1	3.0	4.0	4.9	0.4	0.9	1.3	1.7	2.0
6	1.1	2.2	3.3	4.3	5.2	0.5	1.0	1.5	2.0	2.5
7	1.4	2.8	4.1	5.4	6.6	0.7	1.4	2.1	2.7	3.3
8	1.3	2.6	3.8	5.0	6.1	0.6	1.3	1.8	2.4	3.0
9	1.3	2.5	3.6	4.8	5.8	0.6	1.2	1.7	2.3	2.8
10	1.2	2.4	3.6	4.6	5.7	0.6	1.1	1.7	2.2	2.7
11	1.3	2.6	3.8	5.0	6.2	0.7	1.3	2.0	2.6	3.2
12	1.5	2.9	4.3	5.7	6.9	0.8	1.6	2.3	3.0	3.7
13	1.4	2.8	4.1	5.4	6.6	0.7	1.5	2.2	2.8	3.5
14	1.4	2.8	4.1	5.3	6.5	0.7	1.4	2.1	2.7	3.4
15	1.4	2.7	4.0	5.2	6.4	0.7	1.4	2.1	2.7	3.3
16	1.5	2.9	4.3	5.6	6.9	0.8	1.6	2.3	3.1	3.8
17	1.6	3.1	4.5	5.9	7.3	0.9	1.7	2.5	3.3	4.0
18	1.5	3.0	4.5	5.8	7.1	0.8	1.6	2.4	3.2	3.9
19	1.5	3.0	4.4	5.8	7.1	0.8	1.6	2.4	3.1	3.9
20	1.5	3.0	4.4	5.7	7.0	0.8	1.6	2.4	3.1	3.8
21	1.6	3.2	4.7	6.2	7.6	0.9	1.8	2.7	3.5	4.3
22	1.8	3.6	5.3	7.0	8.6	1.1	2.2	3.2	4.2	5.1

Table 38. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska, Case 3.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.8	1.6	2.3	3.1	3.8	0.3	0.7	1.0	1.3	1.6
2	1.2	2.4	3.5	4.7	5.8	0.6	1.2	1.7	2.3	2.9
3	1.1	2.1	3.1	4.1	5.1	0.5	1.0	1.4	1.9	2.3
4	1.0	1.9	2.9	3.8	4.7	0.4	0.8	1.3	1.7	2.1
5	0.9	1.9	2.8	3.6	4.5	0.4	0.8	1.2	1.6	1.9
6	1.0	2.0	3.0	4.0	4.9	0.5	1.0	1.5	1.9	2.4
7	1.3	2.6	3.8	5.0	6.2	0.7	1.3	2.0	2.6	3.2
8	1.2	2.4	3.5	4.6	5.7	0.6	1.2	1.7	2.3	2.9
9	1.1	2.3	3.4	4.4	5.5	0.6	1.1	1.6	2.2	2.7
10	1.1	2.2	3.3	4.3	5.3	0.5	1.1	1.6	2.1	2.6
11	1.2	2.4	3.6	4.7	5.8	0.6	1.3	1.9	2.5	3.1
12	1.4	2.7	4.0	5.3	6.6	0.7	1.5	2.2	2.9	3.6
13	1.3	2.6	3.9	5.1	6.3	0.7	1.4	2.0	2.7	3.3
14	1.3	2.5	3.8	5.0	6.1	0.7	1.3	2.0	2.6	3.2
15	1.3	2.5	3.7	4.9	6.1	0.7	1.3	2.0	2.6	3.2
16	1.4	2.7	4.0	5.3	6.6	0.8	1.5	2.2	3.0	3.7
17	1.4	2.9	4.2	5.6	6.9	0.8	1.6	2.4	3.1	3.9
18	1.4	2.8	4.2	5.5	6.8	0.8	1.6	2.3	3.1	3.8
19	1.4	2.8	4.1	5.4	6.7	0.8	1.5	2.3	3.0	3.7
20	1.4	2.8	4.1	5.4	6.7	0.8	1.5	2.3	3.0	3.7
21	1.5	3.0	4.4	5.8	7.2	0.9	1.7	2.6	3.4	4.2
22	1.7	3.4	5.0	6.6	8.2	1.0	2.1	3.1	4.0	5.0

Table 39. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska, Case 4

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.7	1.3	1.9	2.5	3.1	0.3	0.6	1.0	1.3	1.5
2	1.2	2.3	3.4	4.4	5.5	0.7	1.3	1.9	2.5	3.1
3	1.0	1.9	2.8	3.7	4.5	0.5	1.0	1.5	1.9	2.4
4	0.9	1.7	2.5	3.3	4.1	0.4	0.9	1.3	1.7	2.1
5	0.8	1.6	2.4	3.1	3.8	0.4	0.8	1.2	1.6	1.9
6	1.0	1.9	2.8	3.6	4.5	0.5	1.1	1.6	2.1	2.5
7	1.3	2.5	3.7	4.9	6.0	0.8	1.5	2.2	2.9	3.5
8	1.2	2.3	3.3	4.4	5.4	0.7	1.3	1.9	2.5	3.1
9	1.1	2.1	3.2	4.1	5.1	0.6	1.2	1.8	2.3	2.9
10	1.1	2.1	3.1	4.0	4.9	0.6	1.2	1.7	2.2	2.8
11	1.2	2.4	3.5	4.6	5.6	0.7	1.4	2.1	2.7	3.4
12	1.4	2.8	4.1	5.3	6.6	0.8	1.7	2.5	3.2	4.0
13	1.3	2.6	3.8	5.0	6.2	0.8	1.5	2.3	3.0	3.7
14	1.3	2.5	3.7	4.9	6.0	0.8	1.5	2.2	2.9	3.6
15	1.3	2.5	3.7	4.8	5.9	0.7	1.5	2.2	2.9	3.5
16	1.4	2.8	4.1	5.4	6.6	0.9	1.7	2.5	3.3	4.1
17	1.5	3.0	4.4	5.7	7.0	0.9	1.8	2.7	3.6	4.4
18	1.5	2.9	4.3	5.6	6.9	0.9	1.8	2.6	3.4	4.2
19	1.4	2.8	4.2	5.5	6.8	0.9	1.8	2.6	3.4	4.2
20	1.4	2.8	4.2	5.5	6.7	0.9	1.7	2.6	3.4	4.2
21	1.6	3.1	4.6	6.1	7.5	1.0	2.0	2.9	3.9	4.7
22	1.9	3.7	5.4	7.1	8.8	1.2	2.4	3.6	4.7	5.8

Table 40. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska, Case 1.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	67.80	68.38	68.95	69.51	70.07	26.22	26.42	26.61	26.80	26.99
2	99.04	99.71	100.37	101.03	101.68	46.39	46.65	46.92	47.17	47.43
3	87.40	88.05	88.69	89.32	89.94	37.70	37.93	38.17	38.40	38.63
4	81.90	82.54	83.17	83.80	84.41	33.93	34.16	34.38	34.60	34.83
5	78.85	79.49	80.11	80.73	81.34	31.99	32.21	32.43	32.65	32.86
6	85.77	86.42	87.05	87.68	88.31	39.07	39.33	39.59	39.84	40.10
7	107.16	107.87	108.56	109.26	109.94	53.01	53.31	53.62	53.92	54.22
8	99.00	99.69	100.37	101.05	101.72	46.87	47.15	47.44	47.72	48.01
9	95.22	95.91	96.59	97.26	97.92	44.26	44.54	44.82	45.10	45.38
10	93.15	93.83	94.51	95.18	95.83	42.93	43.21	43.49	43.77	44.04
11	101.85	102.55	103.24	103.93	104.61	50.77	51.09	51.41	51.72	52.03
12	114.88	115.62	116.35	117.07	117.79	59.35	59.69	60.04	60.38	60.72
13	109.79	110.52	111.24	111.96	112.66	55.49	55.82	56.16	56.49	56.82
14	107.49	108.21	108.93	109.64	110.35	53.88	54.22	54.55	54.88	55.20
15	106.24	106.96	107.68	108.39	109.09	53.08	53.41	53.74	54.06	54.39
16	116.27	117.02	117.76	118.49	119.22	61.45	61.83	62.20	62.56	62.93
17	122.23	123.00	123.76	124.51	125.25	65.42	65.80	66.18	66.56	66.94
18	119.85	120.61	121.37	122.12	122.85	63.60	63.98	64.36	64.73	65.10
19	118.79	119.56	120.31	121.06	121.79	62.86	63.24	63.61	63.99	64.36
20	118.23	118.99	119.74	120.49	121.22	62.49	62.87	63.24	63.62	63.98
21	129.23	130.02	130.81	131.58	132.35	71.24	71.66	72.07	72.49	72.90
22	151.49	152.34	153.19	154.02	154.85	88.49	88.99	89.48	89.97	90.46

Table 41. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska Case 2.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	60.81	61.07	61.32	61.57	61.82	24.42	24.51	24.60	24.69	24.77
2	91.19	91.48	91.77	92.06	92.34	44.01	44.13	44.25	44.37	44.49
3	79.61	79.89	80.17	80.45	80.72	35.42	35.53	35.63	35.74	35.84
4	74.19	74.47	74.74	75.02	75.29	31.72	31.83	31.93	32.03	32.13
5	71.21	71.49	71.76	72.03	72.30	29.83	29.93	30.03	30.13	30.23
6	78.54	78.83	79.11	79.40	79.68	37.06	37.19	37.31	37.43	37.55
7	99.31	99.63	99.94	100.25	100.55	50.59	50.73	50.88	51.02	51.16
8	91.20	91.50	91.81	92.11	92.41	44.52	44.66	44.79	44.92	45.06
9	87.48	87.78	88.08	88.38	88.68	41.97	42.10	42.23	42.36	42.49
10	85.46	85.76	86.06	86.36	86.66	40.68	40.81	40.94	41.07	41.20
11	94.40	94.72	95.03	95.34	95.65	48.58	48.73	48.89	49.04	49.19
12	107.05	107.38	107.70	108.03	108.36	56.89	57.06	57.22	57.39	57.55
13	101.98	102.31	102.63	102.96	103.28	53.08	53.24	53.40	53.56	53.72
14	99.71	100.04	100.36	100.68	101.01	51.51	51.67	51.83	51.99	52.14
15	98.50	98.82	99.14	99.47	99.79	50.73	50.89	51.05	51.20	51.36
16	108.62	108.96	109.30	109.64	109.97	59.10	59.28	59.46	59.63	59.81
17	114.40	114.75	115.10	115.44	115.78	62.94	63.12	63.30	63.49	63.67
18	112.04	112.38	112.72	113.07	113.40	61.14	61.32	61.50	61.69	61.87
19	111.00	111.34	111.68	112.02	112.36	60.41	60.60	60.78	60.96	61.14
20	110.45	110.79	111.13	111.47	111.81	60.06	60.24	60.42	60.60	60.78
21	121.41	121.77	122.13	122.49	122.84	68.73	68.93	69.13	69.33	69.54
22	143.37	143.76	144.15	144.54	144.92	85.70	85.95	86.19	86.43	86.67

Table 42. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska, Case 3.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	56.10	56.21	56.33	56.45	56.57	23.20	23.24	23.29	23.33	23.37
2	85.86	86.00	86.13	86.27	86.40	42.39	42.45	42.50	42.56	42.62
3	74.33	74.46	74.59	74.72	74.85	33.87	33.92	33.97	34.02	34.07
4	68.97	69.10	69.22	69.35	69.48	30.22	30.27	30.32	30.37	30.42
5	66.04	66.17	66.29	66.42	66.55	28.37	28.42	28.47	28.51	28.56
6	73.66	73.80	73.93	74.07	74.20	35.71	35.77	35.83	35.90	35.96
7	94.00	94.15	94.30	94.44	94.59	48.95	49.02	49.09	49.16	49.23
8	85.92	86.06	86.20	86.35	86.49	42.94	43.00	43.07	43.13	43.20
9	82.24	82.38	82.52	82.66	82.81	40.42	40.48	40.55	40.61	40.68
10	80.26	80.40	80.54	80.68	80.82	39.15	39.22	39.28	39.35	39.41
11	89.37	89.52	89.67	89.82	89.97	47.10	47.18	47.26	47.34	47.41
12	101.75	101.90	102.06	102.21	102.37	55.24	55.32	55.40	55.48	55.57
13	96.70	96.86	97.01	97.17	97.32	51.46	51.54	51.62	51.70	51.78
14	94.46	94.61	94.77	94.92	95.08	49.91	49.99	50.07	50.15	50.23
15	93.27	93.42	93.57	93.73	93.88	49.15	49.23	49.31	49.38	49.46
16	103.46	103.62	103.79	103.95	104.11	57.51	57.60	57.69	57.78	57.87
17	109.11	109.28	109.45	109.61	109.78	61.26	61.35	61.45	61.54	61.63
18	106.76	106.92	107.09	107.25	107.41	59.48	59.57	59.67	59.76	59.85
19	105.73	105.89	106.06	106.22	106.39	58.77	58.86	58.95	59.04	59.14
20	105.19	105.35	105.52	105.68	105.85	58.42	58.51	58.60	58.70	58.79
21	116.13	116.30	116.48	116.65	116.82	67.04	67.14	67.24	67.35	67.45
22	137.88	138.07	138.26	138.45	138.64	83.83	83.96	84.08	84.21	84.33

Table 43. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Gulf of Alaska, Case 4.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	37.36	37.40	37.43	37.47	37.51	18.62	18.65	18.68	18.71	18.74
2	66.58	66.63	66.69	66.75	66.80	37.24	37.29	37.34	37.38	37.43
3	54.50	54.54	54.58	54.62	54.67	28.57	28.61	28.64	28.67	28.71
4	48.95	48.99	49.03	49.07	49.11	24.89	24.93	24.96	24.99	25.02
5	45.99	46.03	46.07	46.11	46.15	23.06	23.09	23.12	23.15	23.18
6	55.10	55.16	55.23	55.30	55.36	31.03	31.08	31.14	31.19	31.25
7	75.01	75.09	75.17	75.24	75.32	43.85	43.92	43.98	44.05	44.11
8	66.53	66.60	66.67	66.74	66.81	37.73	37.78	37.84	37.90	37.96
9	62.73	62.80	62.86	62.93	63.00	35.19	35.25	35.30	35.36	35.41
10	60.73	60.80	60.87	60.93	61.00	33.94	34.00	34.05	34.11	34.17
11	70.96	71.05	71.14	71.23	71.33	42.32	42.40	42.48	42.56	42.63
12	83.04	83.14	83.24	83.33	83.43	50.18	50.26	50.35	50.43	50.51
13	77.75	77.84	77.93	78.03	78.12	46.34	46.41	46.49	46.57	46.65
14	75.43	75.52	75.61	75.70	75.80	44.78	44.86	44.93	45.01	45.09
15	74.23	74.32	74.41	74.51	74.60	44.02	44.10	44.18	44.26	44.33
16	85.19	85.30	85.41	85.53	85.64	52.63	52.73	52.83	52.92	53.02
17	90.70	90.81	90.92	91.04	91.15	56.25	56.35	56.45	56.55	56.65
18	88.22	88.33	88.44	88.55	88.66	54.43	54.53	54.63	54.73	54.82
19	87.16	87.27	87.38	87.49	87.60	53.72	53.81	53.91	54.01	54.11
20	86.62	86.73	86.84	86.95	87.06	53.38	53.47	53.57	53.67	53.76
21	97.99	98.12	98.25	98.38	98.51	62.06	62.18	62.29	62.41	62.52
22	119.97	120.12	120.28	120.44	120.60	78.68	78.82	78.97	79.11	79.26

Table 44. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, Aleutian Islands, Case 1.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	1.4	2.9	4.3	5.6	7.0
2	1.6	3.3	4.8	6.4	7.9
3	1.6	3.2	4.7	6.2	7.7
4	1.6	3.1	4.6	6.1	7.5
5	1.5	3.1	4.5	6.0	7.4
6	1.5	3.0	4.5	5.9	7.3
7	1.7	3.3	4.9	6.4	8.0
8	1.6	3.2	4.8	6.3	7.8
9	1.6	3.2	4.7	6.2	7.7
10	1.6	3.1	4.7	6.2	7.6
11	1.6	3.1	4.7	6.2	7.6
12	1.7	3.3	4.9	6.5	8.0
13	1.6	3.3	4.8	6.4	7.9
14	1.6	3.2	4.8	6.3	7.8
15	1.6	3.2	4.8	6.3	7.8
16	1.6	3.2	4.8	6.3	7.8
17	1.7	3.3	4.9	6.5	8.0
18	1.7	3.3	4.9	6.4	8.0
19	1.7	3.3	4.9	6.4	7.9
20	1.6	3.3	4.8	6.4	7.9
21	1.7	3.3	4.9	6.5	8.0
22	1.7	3.4	5.0	6.6	8.2

Table 45. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, Aleutian Islands, Case 2.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	1.2	2.3	3.5	4.6	5.7
2	1.4	2.7	4.1	5.4	6.7
3	1.3	2.6	3.9	5.2	6.4
4	1.3	2.6	3.8	5.1	6.3
5	1.3	2.5	3.7	5.0	6.2
6	1.3	2.5	3.7	4.9	6.1
7	1.4	2.8	4.1	5.4	6.8
8	1.3	2.7	4.0	5.3	6.6
9	1.3	2.6	3.9	5.2	6.5
10	1.3	2.6	3.9	5.2	6.4
11	1.3	2.6	3.9	5.2	6.5
12	1.4	2.8	4.1	5.5	6.8
13	1.4	2.7	4.1	5.4	6.7
14	1.4	2.7	4.0	5.4	6.7
15	1.4	2.7	4.0	5.3	6.6
16	1.4	2.7	4.1	5.4	6.7
17	1.4	2.8	4.2	5.5	6.8
18	1.4	2.8	4.1	5.5	6.8
19	1.4	2.8	4.1	5.5	6.8
20	1.4	2.8	4.1	5.4	6.8
21	1.4	2.8	4.2	5.5	6.9
22	1.4	2.9	4.3	5.7	7.1

Table 46. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, Aleutian Islands, Case 3.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	1.0	2.0	3.0	4.0	5.0
2	1.2	2.4	3.6	4.8	6.0
3	1.2	2.3	3.4	4.6	5.7
4	1.1	2.2	3.4	4.5	5.6
5	1.1	2.2	3.3	4.4	5.5
6	1.1	2.2	3.3	4.4	5.5
7	1.2	2.4	3.7	4.9	6.1
8	1.2	2.4	3.6	4.7	5.9
9	1.2	2.3	3.5	4.6	5.8
10	1.2	2.3	3.5	4.6	5.7
11	1.2	2.3	3.5	4.6	5.8
12	1.2	2.5	3.7	4.9	6.1
13	1.2	2.4	3.6	4.8	6.0
14	1.2	2.4	3.6	4.8	6.0
15	1.2	2.4	3.6	4.8	5.9
16	1.2	2.4	3.6	4.8	6.0
17	1.3	2.5	3.7	5.0	6.2
18	1.2	2.5	3.7	4.9	6.1
19	1.2	2.5	3.7	4.9	6.1
20	1.2	2.5	3.7	4.9	6.1
21	1.3	2.5	3.8	5.0	6.2
22	1.3	2.6	3.9	5.2	6.4

Table 47. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, Aleutian Islands, Case 4.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	0.7	1.4	2.0	2.7	3.3
2	1.0	1.9	2.9	3.8	4.7
3	0.9	1.7	2.6	3.4	4.2
4	0.8	1.6	2.4	3.2	4.0
5	0.8	1.6	2.3	3.1	3.8
6	0.8	1.6	2.4	3.2	4.0
7	1.0	2.0	3.0	4.0	4.9
8	0.9	1.9	2.8	3.7	4.6
9	0.9	1.8	2.7	3.6	4.5
10	0.9	1.8	2.6	3.5	4.4
11	0.9	1.9	2.8	3.7	4.6
12	1.1	2.1	3.1	4.1	5.1
13	1.0	2.0	3.0	4.0	5.0
14	1.0	2.0	2.9	3.9	4.9
15	1.0	2.0	2.9	3.9	4.8
16	1.0	2.1	3.1	4.1	5.1
17	1.1	2.2	3.2	4.3	5.3
18	1.1	2.1	3.2	4.2	5.2
19	1.1	2.1	3.2	4.2	5.2
20	1.1	2.1	3.1	4.2	5.2
21	1.1	2.2	3.3	4.4	5.5
22	1.2	2.5	3.7	4.9	6.0

Table 48. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Aleutian Islands, Case 1.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.1	0.3	0.4	0.5	0.6	0.1	0.1	0.1	0.2	0.2
2	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.3	0.4
3	0.2	0.3	0.5	0.6	0.8	0.1	0.1	0.2	0.3	0.3
4	0.2	0.3	0.5	0.6	0.7	0.1	0.1	0.2	0.3	0.3
5	0.2	0.3	0.4	0.6	0.7	0.1	0.1	0.2	0.2	0.3
6	0.2	0.3	0.5	0.6	0.8	0.1	0.1	0.2	0.3	0.3
7	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.5
8	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.3	0.4
9	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.2	0.3	0.4
10	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.2	0.3	0.4
11	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.4
12	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.5
13	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.5
14	0.2	0.4	0.6	0.8	0.9	0.1	0.2	0.3	0.4	0.5
15	0.2	0.4	0.6	0.8	0.9	0.1	0.2	0.3	0.4	0.5
16	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.5
17	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.5	0.6
18	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.5
19	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.5
20	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.5
21	0.2	0.4	0.7	0.9	1.1	0.1	0.2	0.4	0.5	0.6
22	0.3	0.5	0.7	1.0	1.2	0.1	0.3	0.4	0.6	0.7

Table 49. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Aleutian Islands, Case 2.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality ($ million)									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
1	0.1	0.2	0.3	0.4	0.5	0.0	0.1	0.1	0.2	0.2
2	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.2	0.3	0.4
3	0.1	0.3	0.4	0.6	0.7	0.1	0.1	0.2	0.3	0.3
4	0.1	0.3	0.4	0.5	0.7	0.1	0.1	0.2	0.2	0.3
5	0.1	0.3	0.4	0.5	0.6	0.1	0.1	0.2	0.2	0.3
6	0.1	0.3	0.4	0.5	0.7	0.1	0.1	0.2	0.3	0.3
7	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.3	0.4
8	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.2	0.3	0.4
9	0.2	0.3	0.5	0.6	0.8	0.1	0.1	0.2	0.3	0.4
10	0.2	0.3	0.4	0.6	0.7	0.1	0.1	0.2	0.3	0.4
11	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.2	0.3	0.4
12	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.5
13	0.2	0.3	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.4
14	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.3	0.4
15	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.3	0.4
16	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.5
17	0.2	0.4	0.6	0.8	0.9	0.1	0.2	0.3	0.4	0.5
18	0.2	0.4	0.6	0.7	0.9	0.1	0.2	0.3	0.4	0.5
19	0.2	0.4	0.6	0.7	0.9	0.1	0.2	0.3	0.4	0.5
20	0.2	0.4	0.6	0.7	0.9	0.1	0.2	0.3	0.4	0.5
21	0.2	0.4	0.6	0.8	1.0	0.1	0.2	0.3	0.4	0.6
22	0.2	0.5	0.7	0.9	1.1	0.1	0.3	0.4	0.5	0.7

Table 50. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Aleutian Islands, Case 3.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.1	0.2	0.3	0.4	0.5	0.0	0.1	0.1	0.2	0.2
2	0.1	0.3	0.4	0.6	0.7	0.1	0.1	0.2	0.3	0.4
3	0.1	0.3	0.4	0.5	0.6	0.1	0.1	0.2	0.2	0.3
4	0.1	0.2	0.4	0.5	0.6	0.1	0.1	0.2	0.2	0.3
5	0.1	0.2	0.3	0.5	0.6	0.0	0.1	0.1	0.2	0.2
6	0.1	0.3	0.4	0.5	0.6	0.1	0.1	0.2	0.2	0.3
7	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.2	0.3	0.4
8	0.1	0.3	0.4	0.6	0.7	0.1	0.1	0.2	0.3	0.4
9	0.1	0.3	0.4	0.6	0.7	0.1	0.1	0.2	0.3	0.3
10	0.1	0.3	0.4	0.5	0.7	0.1	0.1	0.2	0.3	0.3
11	0.1	0.3	0.4	0.6	0.7	0.1	0.2	0.2	0.3	0.4
12	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.4	0.5
13	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.3	0.3	0.4
14	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.2	0.3	0.4
15	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.2	0.3	0.4
16	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.4	0.5
17	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.5
18	0.2	0.3	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.5
19	0.2	0.3	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.5
20	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.4	0.5
21	0.2	0.4	0.6	0.7	0.9	0.1	0.2	0.3	0.4	0.5
22	0.2	0.4	0.6	0.8	1.0	0.1	0.3	0.4	0.5	0.6

Table 51. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-61 for 22 rebuilding schedule& and for 2 discount rates, Aleutian Islands, Case 4.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
2	0.2	0.3	0.4	0.6	0.7	0.1	0.2	0.2	0.3	0.4
3	0.1	0.2	0.4	0.5	0.6	0.1	0.1	0.2	0.3	0.3
4	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
5	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
6	0.1	0.2	0.4	0.5	0.6	0.1	0.1	0.2	0.3	0.3
7	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.4	0.5
8	0.1	0.3	0.4	0.6	0.7	0.1	0.2	0.2	0.3	0.4
9	0.1	0.3	0.4	0.6	0.7	0.1	0.2	0.2	0.3	0.4
10	0.1	0.3	0.4	0.5	0.7	0.1	0.2	0.2	0.3	0.4
11	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.3	0.4	0.5
12	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.5
13	0.2	0.3	0.5	0.7	0.8	0.1	0.2	0.3	0.4	0.5
14	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.3	0.4	0.5
15	0.2	0.3	0.5	0.6	0.8	0.1	0.2	0.3	0.4	0.5
16	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.5
17	0.2	0.4	0.6	0.8	0.9	0.1	0.2	0.4	0.5	0.6
18	0.2	0.4	0.6	0.7	0.9	0.1	0.2	0.3	0.5	0.6
19	0.2	0.4	0.6	0.7	0.9	0.1	0.2	0.3	0.5	0.6
20	0.2	0.4	0.5	0.7	0.9	0.1	0.2	0.3	0.4	0.6
21	0.2	0.4	0.6	0.8	1.0	0.1	0.3	0.4	0.5	0.6
22	0.2	0.5	0.7	0.9	1.2	0.2	0.3	0.5	0.6	0.8

Table 52. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Aleutian Islands, Case

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	67.12	67.30	67.48	67.66	67.84	26.00	26.06	26.13	26.19	26.25
2	98.23	98.44	98.65	98.85	99.06	46.08	46.16	46.25	46.33	46.41
3	86.63	86.83	87.03	87.23	87.43	37.42	37.50	37.57	37.64	37.71
4	81.14	81.34	81.54	81.74	81.94	33.67	33.74	33.81	33.88	33.95
5	78.10	78.30	78.50	78.69	78.89	31.73	31.80	31.87	31.94	32.01
6	85.01	85.21	85.41	85.61	85.81	38.78	38.86	38.94	39.02	39.10
7	106.31	106.53	106.75	106.97	107.19	52.66	52.75	52.85	52.94	53.04
8	98.17	98.39	98.60	98.82	99.03	46.54	46.63	46.72	46.81	46.90
9	94.41	94.62	94.83	95.05	95.26	43.94	44.03	44.12	44.21	44.29
10	92.35	92.56	92.77	92.98	93.19	42.62	42.71	42.79	42.88	42.97
11	101.02	101.24	101.46	101.68	101.89	50.42	50.52	50.62	50.72	50.82
12	114.00	114.23	114.46	114.69	114.92	58.96	59.07	59.17	59.28	59.39
13	108.93	109.15	109.38	109.61	109.83	55.11	55.22	55.32	55.43	55.53
14	106.63	106.85	107.08	107.30	107.53	53.52	53.62	53.72	53.83	53.93
15	105.38	105.61	105.83	106.06	106.28	52.71	52.81	52.92	53.02	53.12
16	115.38	115.61	115.85	116.08	116.31	61.05	61.16	61.28	61.40	61.51
17	121.32	121.56	121.80	122.04	122.28	65.00	65.12	65.23	65.35	65.47
18	118.95	119.18	119.42	119.66	119.89	63.18	63.30	63.42	63.54	63.65
19	117.89	118.13	118.37	118.60	118.84	62.44	62.56	62.68	62.80	62.91
20	117.33	117.56	117.80	118.04	118.27	62.08	62.20	62.31	62.43	62.55
21	128.29	128.54	128.79	129.03	129.28	70.78	70.91	71.04	71.17	71.30
22	150.47	150.73	151.00	151.26	151.53	87.95	88.10	88.26	88.41	88.57

Table 53. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Aleutian Islands, Case 2.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	60.23	60.30	60.38	60.45	60.53	24.25	24.27	24.30	24.33	24.35
2	90.50	90.59	90.68	90.76	90.85	43.77	43.81	43.84	43.88	43.91
3	78.95	79.03	79.12	79.20	79.28	35.20	35.23	35.26	35.30	35.33
4	73.54	73.62	73.70	73.79	73.87	31.51	31.54	31.58	31.61	31.64
5	70.56	70.65	70.73	70.81	70.90	29.63	29.66	29.69	29.72	29.75
6	77.91	77.99	78.08	78.17	78.25	36.85	36.89	36.92	36.96	37.00
7	98.61	98.70	98.80	98.89	98.99	50.33	50.37	50.42	50.46	50.50
8	90.51	90.60	90.69	90.78	90.87	44.28	44.32	44.36	44.40	44.44
9	86.79	86.89	86.98	87.07	87.16	41.73	41.77	41.81	41.85	41.89
10	84.78	84.87	84.96	85.05	85.14	40.44	40.48	40.52	40.56	40.60
11	93.72	93.82	93.91	94.01	94.10	48.33	48.37	48.42	48.47	48.51
12	106.33	106.43	106.53	106.63	106.72	56.61	56.66	56.71	56.76	56.81
13	101.27	101.37	101.47	101.57	101.67	52.81	52.86	52.91	52.96	53.00
14	99.01	99.10	99.20	99.30	99.40	51.25	51.29	51.34	51.39	51.44
15	97.79	97.89	97.99	98.09	98.18	50.46	50.51	50.56	50.61	50.66
16	107.91	108.01	108.11	108.21	108.32	58.81	58.86	58.92	58.97	59.03
17	113.67	113.77	113.88	113.98	114.09	62.64	62.69	62.75	62.80	62.86
18	111.30	111.41	111.51	111.62	111.72	60.84	60.90	60.95	61.01	61.06
19	110.27	110.37	110.47	110.58	110.68	60.12	60.18	60.23	60.29	60.34
20	109.72	109.82	109.93	110.03	110.13	59.76	59.82	59.88	59.93	59.98
21	120.66	120.77	120.88	120.99	121.10	68.41	68.47	68.53	68.59	68.65
22	142.56	142.68	142.80	142.92	143.04	85.33	85.41	85.48	85.55	85.63

Table 54. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Aleutian Islands, Case 3.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	56.08	56.11	56.15	56.19	56.23	23.18	23.20	23.21	23.22	23.24
2	85.83	85.87	85.92	85.96	86.00	42.36	42.38	42.40	42.42	42.43
3	74.31	74.35	74.39	74.43	74.47	33.85	33.86	33.88	33.90	33.91
4	68.94	68.98	69.03	69.07	69.11	30.20	30.22	30.24	30.25	30.27
5	66.01	66.06	66.10	66.14	66.18	28.35	28.37	28.38	28.40	28.41
6	73.62	73.67	73.71	73.76	73.80	35.68	35.70	35.72	35.74	35.76
7	93.96	94.00	94.05	94.10	94.15	48.91	48.93	48.96	48.98	49.00
8	85.88	85.92	85.97	86.02	86.06	42.90	42.92	42.94	42.96	42.99
9	82.20	82.24	82.29	82.34	82.38	40.38	40.41	40.43	40.45	40.47
10	80.22	80.26	80.31	80.35	80.40	39.12	39.14	39.16	39.18	39.20
11	89.32	89.37	89.42	89.47	89.52	47.06	47.08	47.11	47.13	47.16
12	101.69	101.74	101.79	101.84	101.89	55.19	55.21	55.24	55.27	55.29
13	96.65	96.70	96.75	96.80	96.85	51.41	51.44	51.46	51.49	51.52
14	94.41	94.46	94.51	94.56	94.61	49.87	49.89	49.92	49.94	49.97
15	93.21	93.26	93.31	93.36	93.41	49.10	49.13	49.15	49.18	49.20
16	103.40	103.45	103.50	103.56	103.61	57.45	57.48	57.51	57.54	57.57
17	109.05	109.10	109.16	109.21	109.26	61.20	61.23	61.26	61.29	61.32
18	106.69	106.74	106.80	106.85	106.90	59.42	59.45	59.48	59.51	59.54
19	105.66	105.72	105.77	105.82	105.88	58.71	58.74	58.77	58.80	58.83
20	105.12	105.18	105.23	105.28	105.34	58.36	58.39	58.42	58.45	58.48
21	116.06	116.11	116.17	116.22	116.28	66.97	67.00	67.03	67.07	67.10
22	137.79	137.85	137.91	137.97	138.03	83.75	83.79	83.83	83.87	83.91

Table 55. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, Aleutian Islands, Case 4.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	37.47	37.49	37.50	37.51	37.53	18.65	18.66	18.67	18.68	18.69
2	66.80	66.82	66.84	66.87	66.89	37.34	37.36	37.37	37.39	37.41
3	54.69	54.70	54.72	54.74	54.75	28.65	28.66	28.67	28.69	28.70
4	49.12	49.13	49.15	49.16	49.18	24.96	24.97	24.98	24.99	25.00
5	46.15	46.16	46.18	46.19	46.20	23.11	23.13	23.14	23.15	23.16
6	55.24	55.26	55.29	55.31	55.34	31.07	31.09	31.11	31.13	31.15
7	75.24	75.26	75.29	75.32	75.35	43.94	43.96	43.99	44.01	44.03
8	66.73	66.76	66.78	66.80	66.83	37.80	37.82	37.84	37.86	37.88
9	62.91	62.93	62.96	62.98	63.01	35.25	35.27	35.29	35.31	35.33
10	60.90	60.93	60.95	60.98	61.00	34.00	34.02	34.04	34.06	34.08
11	71.13	71.17	71.20	71.23	71.26	42.37	42.40	42.43	42.46	42.48
12	83.27	83.30	83.34	83.37	83.40	50.26	50.29	50.32	50.35	50.38
13	77.96	77.99	78.02	78.06	78.09	46.41	46.43	46.46	46.49	46.52
14	75.63	75.66	75.69	75.72	75.76	44.84	44.87	44.90	44.92	44.95
15	74.42	74.46	74.49	74.52	74.55	44.08	44.11	44.14	44.17	44.19
16	85.39	85.43	85.47	85.51	85.55	52.69	52.72	52.76	52.79	52.83
17	90.92	90.96	91.00	91.04	91.08	56.32	56.36	56.39	56.43	56.46
18	88.43	88.47	88.51	88.55	88.59	54.50	54.54	54.57	54.61	54.64
19	87.36	87.40	87.44	87.48	87.52	53.78	53.82	53.85	53.88	53.92
20	86.82	86.86	86.90	86.94	86.98	53.44	53.47	53.51	53.54	53.58
21	98.21	98.26	98.30	98.35	98.39	62.13	62.17	62.21	62.25	62.29
22	120.23	120.29	120.35	120.40	120.46	78.76	78.81	78.86	78.91	78.96

Table 56. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules eastern Bering Sea, Case 1.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	0.7	1.5	2.2	2.8	3.5
2	0.8	1.7	2.5	3.2	4.0
3	0.8	1.6	2.4	3.1	3.9
4	0.8	1.6	2.3	3.1	3.8
5	0.8	1.6	2.3	3.0	3.7
6	0.8	1.5	2.3	3.0	3.7
7	0.8	1.7	2.5	3.2	4.0
8	0.8	1.6	2.4	3.2	3.9
9	0.8	1.6	2.4	3.1	3.9
10	0.8	1.6	2.4	3.1	3.8
11	0.8	1.6	2.4	3.1	3.8
12	0.8	1.7	2.5	3.2	4.0
13	0.8	1.6	2.4	3.2	4.0
14	0.8	1.6	2.4	3.2	3.9
15	0.8	1.6	2.4	3.2	3.9
16	0.8	1.6	2.4	3.2	3.9
17	0.8	1.7	2.5	3.3	4.0
18	0.8	1.7	2.5	3.2	4.0
19	0.8	1.7	2.5	3.2	4.0
20	0.8	1.7	2.4	3.2	4.0
21	0.8	1.7	2.5	3.3	4.0
22	0.9	1.7	2.5	3.3	4.1

Table 57. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, eastern Bering Sea, Case 2.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	0.6	1.1	1.6	2.2	2.7
2	0.6	1.3	1.9	2.5	3.1
3	0.6	1.2	1.8	2.4	3.0
4	0.6	1.2	1.8	2.4	2.9
5	0.6	1.2	1.8	2.3	2.9
6	0.6	1.2	1.7	2.3	2.9
7	0.6	1.3	1.9	2.5	3.2
8	0.6	1.3	1.9	2.5	3.1
9	0.6	1.2	1.8	2.4	3.0
10	0.6	1.2	1.8	2.4	3.0
11	0.6	1.2	1.8	2.4	3.0
12	0.7	1.3	1.9	2.6	3.2
13	0.6	1.3	1.9	2.5	3.1
14	0.6	1.3	1.9	2.5	3.1
15	0.6	1.3	1.9	2.5	3.1
16	0.6	1.3	1.9	2.5	3.1
17	0.7	1.3	1.9	2.6	3.2
18	0.7	1.3	1.9	2.6	3.2
19	0.7	1.3	1.9	2.6	3.2
20	0.6	1.3	1.9	2.5	3.2
21	0.7	1.3	2.0	2.6	3.2
22	0.7	1.4	2.0	2.7	3.3

Table 58. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, eastern Bering Sea, Case 3.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	0.5	1.0	1.4	1.9	2.4
2	0.6	1.1	1.7	2.3	2.8
3	0.5	1.1	1.6	2.2	2.7
4	0.5	1.1	1.6	2.1	2.6
5	0.5	1.0	1.6	2.1	2.6
6	0.5	1.0	1.6	2.1	2.6
7	0.6	1.2	1.7	2.3	2.9
8	0.6	1.1	1.7	2.2	2.8
9	0.6	1.1	1.6	2.2	2.7
10	0.5	1.1	1.6	2.2	2.7
11	0.6	1.1	1.6	2.2	2.7
12	0.6	1.2	1.7	2.3	2.9
13	0.6	1.1	1.7	2.3	2.8
14	0.6	1.1	1.7	2.3	2.8
15	0.6	1.1	1.7	2.2	2.8
16	0.6	1.1	1.7	2.3	2.8
17	0.6	1.2	1.8	2.3	2.9
18	0.6	1.2	1.7	2.3	2.9
19	0.6	1.2	1.7	2.3	2.9
20	0.6	1.2	1.7	2.3	2.9
21	0.6	1.2	1.8	2.3	2.9
22	0.6	1.2	1.8	2.4	3.0

Table 59. Estimated cumulative 50-year reductions in domestic catch resulting from 5 levels of foreign fishing during years 2-6 for 22 rebuilding schedules, eastern Bering Sea, Case 4.

	Per Cent of 1983 Foreign Fishing Mortality				
	50%	100%	150%	200%	250%
	(1,000 metric tons)				
1	0.3	0.6	0.9	1.2	1.5
2	0.4	0.9	1.3	1.7	2.1
3	0.4	0.8	1.2	1.5	1.9
4	0.4	0.7	1.1	1.4	1.8
5	0.4	0.7	1.0	1.4	1.7
6	0.4	0.7	1.1	1.5	1.8
7	0.5	0.9	1.3	1.8	2.2
8	0.4	0.8	1.3	1.7	2.1
9	0.4	0.8	1.2	1.6	2.0
10	0.4	0.8	1.2	1.6	2.0
11	0.4	0.8	1.3	1.7	2.1
12	0.5	0.9	1.4	1.9	2.3
13	0.5	0.9	1.3	1.8	2.2
14	0.4	0.9	1.3	1.8	2.2
15	0.4	0.9	1.3	1.7	2.2
16	0.5	0.9	1.4	1.8	2.3
17	0.5	1.0	1.4	1.9	2.4
18	0.5	1.0	1.4	1.9	2.3
19	0.5	0.9	1.4	1.9	2.3
20	0.5	0.9	1.4	1.9	2.3
21	0.5	1.0	1.5	2.0	2.5
22	0.6	1.1	1.6	2.2	2.7

Table 60. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 1.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.1	0.1	0.2	0.3	0.3	0.0	0.0	0.1	0.1	0.1
2	0.1	0.2	0.3	0.4	0.4	0.0	0.1	0.1	0.2	0.2
3	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.2
4	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.2
5	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.1
6	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.2
7	0.1	0.2	0.3	0.4	0.5	0.0	0.1	0.1	0.2	0.2
8	0.1	0.2	0.3	0.4	0.4	0.0	0.1	0.1	0.2	0.2
9	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
10	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
11	0.1	0.2	0.3	0.4	0.4	0.0	0.1	0.1	0.2	0.2
12	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
13	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.1	0.2	0.2
14	0.1	0.2	0.3	0.4	0.5	0.0	0.1	0.1	0.2	0.2
15	0.1	0.2	0.3	0.4	0.5	0.0	0.1	0.1	0.2	0.2
16	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
17	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
18	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
19	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
20	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
21	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
22	0.1	0.3	0.4	0.5	0.6	0.1	0.1	0.2	0.3	0.4

Table 61. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 2.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.1	0.1	0.2	0.2	0.3	0.0	0.0	0.1	0.1	0.1
2	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.2
3	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1
4	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.1
5	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.1
6	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1
7	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
8	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.2
9	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.1	0.2
10	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
11	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
12	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
13	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
14	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
15	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
16	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
17	0.1	0.2	0.3	0.4	0.4	0.0	0.1	0.1	0.2	0.2
18	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
19	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
20	0.1	0.2	0.3	0.3	0.4	0.0	0.1	0.1	0.2	0.2
21	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3
22	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3

Table 62. Estimated 50-year reductions in domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 3.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.1	0.1	0.1
2	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
3	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.1
4	0.1	0.1	0.2	0.2	0.3	0.0	0.0	0.1	0.1	0.1
5	0.1	0.1	0.2	0.2	0.3	0.0	0.0	0.1	0.1	0.1
6	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.1
7	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
8	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
9	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
10	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
11	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
12	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
13	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
14	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
15	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
16	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
17	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
18	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
19	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
20	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
21	0.1	0.2	0.3	0.3	0.4	0.1	0.1	0.2	0.2	0.2
22	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.2	0.3

Table 63. Estimated 50-year reductionsin domestic cumulative discounted profit resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 4.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ million)									
1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.1	0.1	0.1
2	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
3	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.2	0.2	0.0	0.1	0.1	0.1	0.1
5	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.1	0.1	0.1
6	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.2
7	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
8	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.2
9	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.2
10	0.1	0.1	0.2	0.2	0.3	0.0	0.1	0.1	0.1	0.2
11	0.1	0.1	0.2	0.3	0.3	0.0	0.1	0.1	0.2	0.2
12	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
13	0.1	0.2	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
14	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
15	0.1	0.1	0.2	0.3	0.4	0.0	0.1	0.1	0.2	0.2
16	0.1	0.2	0.2	0.3	0.4	0.1	0.1	0.1	0.2	0.2
17	0.1	0.2	0.3	0.3	0.4	0.1	0.1	0.2	0.2	0.3
18	0.1	0.2	0.3	0.3	0.4	0.1	0.1	0.2	0.2	0.3
19	0.1	0.2	0.2	0.3	0.4	0.1	0.1	0.2	0.2	0.3
20	0.1	0.2	0.2	0.3	0.4	0.1	0.1	0.2	0.2	0.3
21	0.1	0.2	0.3	0.4	0.4	0.1	0.1	0.2	0.2	0.3
22	0.1	0.2	0.3	0.4	0.5	0.1	0.1	0.2	0.3	0.3

Table 64. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 1.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	68.52	68.76	69.00	69.23	69.47	26.39	26.47	26.55	26.63	26.71
2	99.83	100.11	100.38	100.66	100.93	46.61	46.72	46.83	46.93	47.04
3	88.19	88.45	88.72	88.98	89.24	37.91	38.01	38.10	38.20	38.29
4	82.68	82.95	83.21	83.47	83.73	34.14	34.23	34.32	34.41	34.50
5	79.63	79.89	80.15	80.41	80.66	32.19	32.28	32.37	32.46	32.55
6	86.51	86.78	87.04	87.30	87.57	39.25	39.35	39.46	39.56	39.67
7	107.96	108.25	108.53	108.82	109.11	53.23	53.35	53.47	53.60	53.72
8	99.79	100.07	100.35	100.63	100.91	47.08	47.19	47.31	47.43	47.54
9	96.01	96.29	96.57	96.85	97.12	44.47	44.58	44.70	44.81	44.92
10	93.93	94.21	94.49	94.77	95.05	43.14	43.25	43.36	43.48	43.59
11	102.61	102.90	103.19	103.47	103.75	50.96	51.09	51.22	51.35	51.48
12	115.69	115.99	116.29	116.59	116.89	59.56	59.70	59.84	59.98	60.12
13	110.59	110.89	111.18	111.48	111.78	55.70	55.83	55.97	56.10	56.24
14	108.28	108.58	108.87	109.17	109.46	54.09	54.23	54.36	54.49	54.63
15	107.03	107.32	107.62	107.91	108.21	53.28	53.42	53.55	53.68	53.82
16	117.05	117.36	117.67	117.97	118.27	61.66	61.81	61.96	62.11	62.26
17	123.04	123.35	123.67	123.98	124.29	65.64	65.79	65.95	66.10	66.25
18	120.66	120.97	121.28	121.59	121.89	63.81	63.97	64.12	64.27	64.42
19	119.60	119.91	120.22	120.53	120.83	63.07	63.22	63.38	63.53	63.68
20	119.03	119.34	119.65	119.96	120.27	62.70	62.86	63.01	63.16	63.31
21	130.04	130.37	130.69	131.01	131.33	71.46	71.63	71.80	71.96	72.13
22	152.35	152.70	153.05	153.39	153.73	88.74	88.94	89.14	89.34	89.53

Table 65. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 2.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	60.26	60.34	60.42	60.51	60.59	24.27	24.30	24.33	24.36	24.39
2	90.56	90.65	90.75	90.85	90.94	43.81	43.85	43.89	43.93	43.97
3	78.99	79.08	79.17	79.26	79.36	35.23	35.26	35.30	35.33	35.37
4	73.57	73.66	73.75	73.84	73.94	31.54	31.57	31.61	31.64	31.67
5	70.60	70.69	70.78	70.87	70.96	29.65	29.68	29.72	29.75	29.78
6	77.96	78.06	78.15	78.25	78.34	36.89	36.93	36.97	37.01	37.05
7	98.68	98.79	98.89	98.99	99.10	50.38	50.43	50.48	50.53	50.57
8	90.57	90.67	90.77	90.87	90.97	44.32	44.37	44.41	44.46	44.50
9	86.85	86.95	87.05	87.15	87.25	41.77	41.82	41.86	41.90	41.95
10	84.84	84.94	85.04	85.14	85.24	40.48	40.53	40.57	40.61	40.66
11	93.80	93.90	94.01	94.11	94.22	48.39	48.44	48.49	48.54	48.59
12	106.42	106.53	106.63	106.74	106.85	56.68	56.73	56.79	56.84	56.90
13	101.36	101.46	101.57	101.68	101.78	52.87	52.93	52.98	53.03	53.08
14	99.09	99.19	99.30	99.41	99.52	51.30	51.36	51.41	51.46	51.51
15	97.87	97.98	98.09	98.19	98.30	50.52	50.58	50.63	50.68	50.73
16	108.01	108.12	108.23	108.34	108.45	58.88	58.94	59.00	59.06	59.12
17	113.78	113.89	114.00	114.12	114.23	62.71	62.78	62.84	62.90	62.96
18	111.41	111.52	111.63	111.75	111.86	60.92	60.98	61.04	61.10	61.16
19	110.37	110.48	110.60	110.71	110.82	60.20	60.26	60.32	60.38	60.44
20	109.82	109.93	110.05	110.16	110.27	59.84	59.90	59.96	60.02	60.08
21	120.78	120.90	121.02	121.14	121.26	68.50	68.57	68.63	68.70	68.77
22	142.72	142.85	142.98	143.11	143.24	85.45	85.53	85.61	85.69	85.77

Table 66. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 3.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	56.16	56.20	56.24	56.28	56.33	23.21	23.23	23.24	23.26	23.27
2	85.94	85.99	86.03	86.08	86.13	42.41	42.43	42.45	42.47	42.49
3	74.40	74.45	74.50	74.54	74.59	33.89	33.90	33.92	33.94	33.96
4	69.04	69.08	69.13	69.17	69.22	30.24	30.26	30.27	30.29	30.31
5	66.11	66.15	66.20	66.24	66.29	28.38	28.40	28.42	28.44	28.45
6	73.72	73.77	73.82	73.87	73.92	35.72	35.74	35.76	35.79	35.81
7	94.07	94.13	94.18	94.23	94.28	48.96	48.99	49.02	49.04	49.07
8	85.99	86.04	86.09	86.14	86.19	42.95	42.97	43.00	43.02	43.04
9	82.31	82.36	82.41	82.46	82.51	40.43	40.45	40.48	40.50	40.52
10	80.32	80.37	80.42	80.47	80.53	39.17	39.19	39.21	39.23	39.26
11	89.43	89.49	89.54	89.60	89.65	47.11	47.14	47.17	47.19	47.22
12	101.81	101.87	101.93	101.98	102.04	55.25	55.28	55.31	55.34	55.37
13	96.77	96.83	96.88	96.94	96.99	51.47	51.50	51.53	51.55	51.58
14	94.53	94.58	94.64	94.69	94.75	49.92	49.95	49.98	50.01	50.04
15	93.33	93.39	93.44	93.50	93.55	49.16	49.18	49.21	49.24	49.27
16	103.52	103.58	103.64	103.70	103.76	57.51	57.55	57.58	57.61	57.65
17	109.18	109.24	109.30	109.36	109.42	61.27	61.30	61.34	61.37	61.40
18	106.82	106.88	106.94	107.00	107.06	59.49	59.52	59.55	59.59	59.62
19	105.79	105.85	105.91	105.97	106.03	58.77	58.81	58.84	58.87	58.91
20	105.25	105.31	105.37	105.43	105.49	58.43	58.46	58.49	58.52	58.56
21	116.19	116.26	116.32	116.38	116.44	67.04	67.08	67.11	67.15	67.19
22	137.95	138.02	138.09	138.15	138.22	83.83	83.88	83.92	83.97	84.01

Table 67. Estimated 50-year reductions in domestic CDP per metric ton of foreign Pacific ocean perch catch resulting from 5 levels of foreign fishing during years 2-6, for 22 rebuilding schedules and for 2 discount rates, eastern Bering Sea, Case 4.

	Discount Rate = 5%					Discount Rate = 10%				
	Per Cent of 1983 Foreign Fishing Mortality									
	50%	100%	150%	200%	250%	50%	100%	150%	200%	250%
	($ per metric ton)									
1	37.34	37.36	37.37	37.38	37.40	18.60	18.61	18.62	18.63	18.64
2	66.56	66.58	66.60	66.62	66.64	37.22	37.24	37.26	37.27	37.29
3	54.48	54.50	54.51	54.53	54.54	28.56	28.57	28.58	28.59	28.61
4	48.94	48.95	48.96	48.98	48.99	24.88	24.89	24.90	24.91	24.92
5	45.98	45.99	46.01	46.02	46.03	23.05	23.06	23.07	23.08	23.09
6	55.07	55.09	55.11	55.14	55.16	31.00	31.02	31.04	31.06	31.08
7	74.98	75.01	75.04	75.06	75.09	43.82	43.84	43.87	43.89	43.91
8	66.50	66.53	66.55	66.58	66.60	37.70	37.72	37.74	37.76	37.78
9	62.70	62.72	62.75	62.77	62.80	35.16	35.18	35.20	35.22	35.24
10	60.70	60.73	60.75	60.77	60.80	33.92	33.93	33.95	33.97	33.99
11	70.92	70.95	70.98	71.02	71.05	42.28	42.31	42.34	42.36	42.39
12	83.00	83.04	83.07	83.10	83.14	50.14	50.17	50.20	50.23	50.26
13	77.71	77.74	77.78	77.81	77.84	46.29	46.32	46.35	46.38	46.41
14	75.39	75.42	75.46	75.49	75.52	44.74	44.76	44.79	44.82	44.85
15	74.19	74.22	74.26	74.29	74.32	43.98	44.01	44.04	44.07	44.09
16	85.14	85.18	85.22	85.26	85.30	52.58	52.61	52.65	52.68	52.72
17	90.64	90.68	90.72	90.76	90.80	56.19	56.23	56.27	56.30	56.34
18	88.16	88.20	88.24	88.28	88.32	54.38	54.42	54.45	54.49	54.52
19	87.10	87.14	87.18	87.22	87.26	53.67	53.70	53.73	53.77	53.80
20	86.56	86.60	86.64	86.68	86.72	53.32	53.36	53.39	53.43	53.46
21	97.93	97.97	98.02	98.06	98.11	62.00	62.04	62.08	62.12	62.16
22	119.89	119.95	120.00	120.06	120.12	78.60	78.65	78.70	78.75	78.80

Table 68.-- Catch (t) of Pacific ocean perch (POP) by nation and area; and Japanese catch by vessel class, 1982.

	Area			
Nation	Bering Sea & Aleutian I.	Gulf of Alaska	Total	Per-cent
Japan	2,045	7,087	9,132	90.3
Korea	111	831	941	9.3
Taiwan	0	35	35	0.3
US-JV	0	3	3	0.0
Total	2,156	7,956	10,112	
Per cent	21.3	78.8		

Japanese POP catch in Gulf of Alaska		
Vessel class	Catch (t)	Per-cent
Small trawler	1,923	27.1
Surimi trawler	80	1.1
Large freezer trawler	5,042	71.1
Longliner	42	0.6

Table 69.--Estimated species prices paid by joint venture processors to U.S. fishermen in the Gulf of Alaska, based on 1982 and 1983 data.

Species	$/t
Pacific ocean perch	290
Walleye pollock	90
Pacific cod	210
Thornyhead	390
Other rockfish	300
Flatfish	140
Atka mackerel	130
Sablefish	390
Squid	330

Table 70.--Catch (t) which would have been harvested in 1982 if all hauls with >X% Pacific ocean perch (POP) had been eliminated.

X	POP	Walleye pollock	Pac. cod	Thorny-head	Other rock fish	Flat fish	Atka mack-erel	Sable-fish	Squid	$ x 10^6
100	6,965	20,760	1,725	442	1,181	6,082	1,731	375	182	6.06
90	5,995	20,622	1,708	439	1,138	6,025	1,721	371	180	5.74
80	4,624	20,553	1,677	437	1,006	5,997	1,707	365	176	5.28
70	3,685	20,528	1,625	429	867	5,955	1,706	358	172	4.94
60	2,786	20,497	1,540	421	683	5,850	1,693	338	169	4.57
50	2,207	20,419	1,482	408	533	5,752	1,676	322	162	4.31
40	1,734	20,250	1,392	385	449	5,600	1,635	304	153	4.07
30	1,293	19,979	1,273	355	375	5,350	1,599	282	143	3.81
20	862	19,565	1,149	315	210	5,027	1,510	251	126	3.48
10	446	18,427	898	235	105	4,404	1,365	210	105	3.01

Table 71 .--Catch (t) which would have been harvested in 1982 if all hauls with >X% Pacific ocean perch (POP) had been eliminated.

X	POP	Walleye pollock	Pac. cod	Thorny-head	Other rock-fish	Flat-fish	Atka mack-erel	Sable-fish	Squid	$ x 10^6
100	4,887	15,846	1,694	506	1,073	6,048	2,564	291	228	5.09
90	4,419	15,739	1,679	503	1,061	5,989	2,552	289	224	4.92
80	3,789	15,739	1,672	498	1,002	5,989	2,542	287	221	4.72
70	3,146	15,688	1,631	490	938	5,913	2,528	283	213	4.48
60	2,528	15,688	1,566	476	855	5,822	2,512	274	207	4.23
50	2,012	15,625	1,507	460	764	5,726	2,489	264	194	4.01
40	1,694	15,565	1,429	436	706	5,563	2,485	255	181	3.84
30	1,201	15,493	1,276	402	599	5,245	2,349	243	158	3.53
20	775	15,233	1,155	331	414	4,766	2,258	220	132	3.18
10	343	14,636	1,014	224	190	3,665	2,098	164	90	2.65

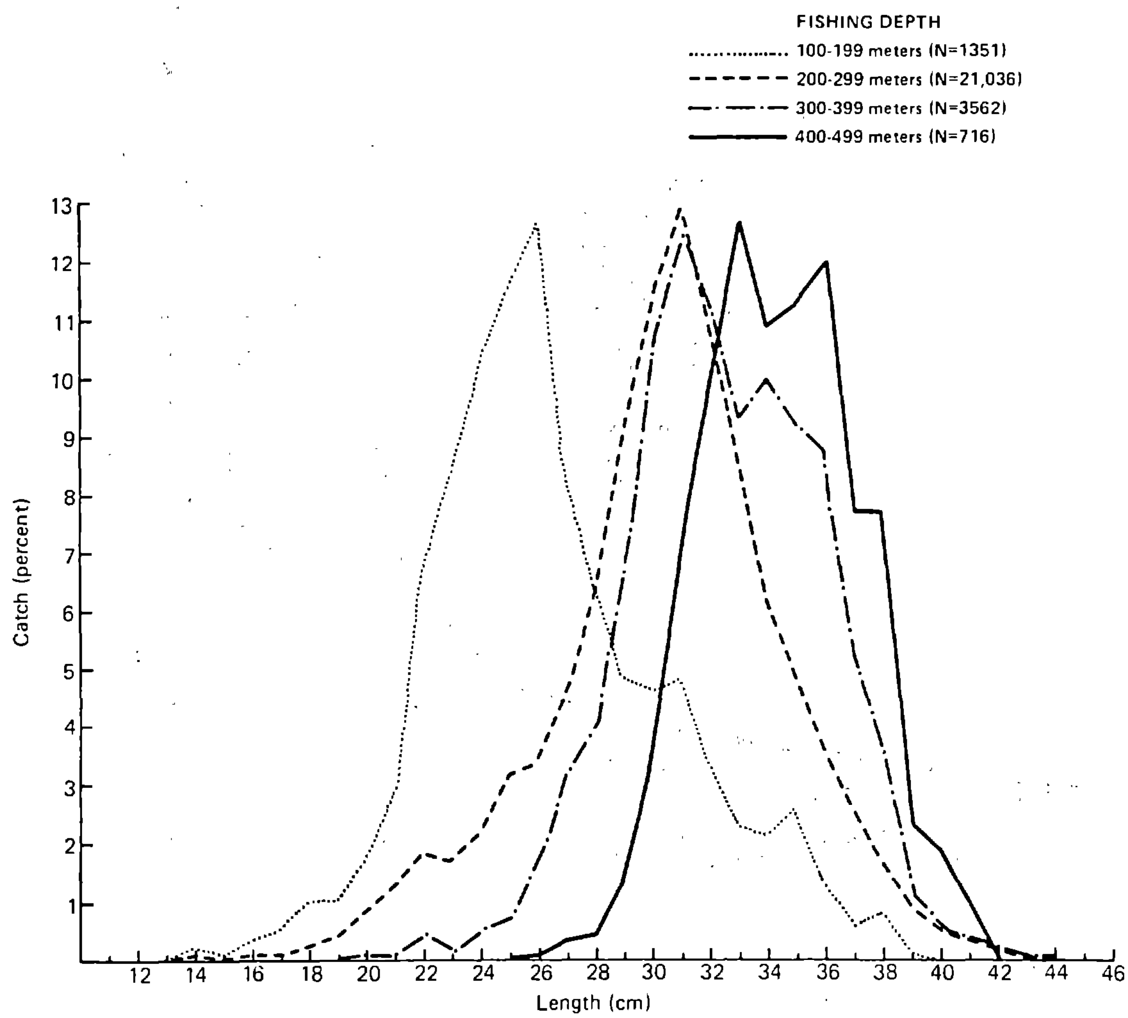

Figure 1. Size composition of Pacific ocean perch by depth from the Japanese Gulf of Alaska groundfish fishery in 1965.

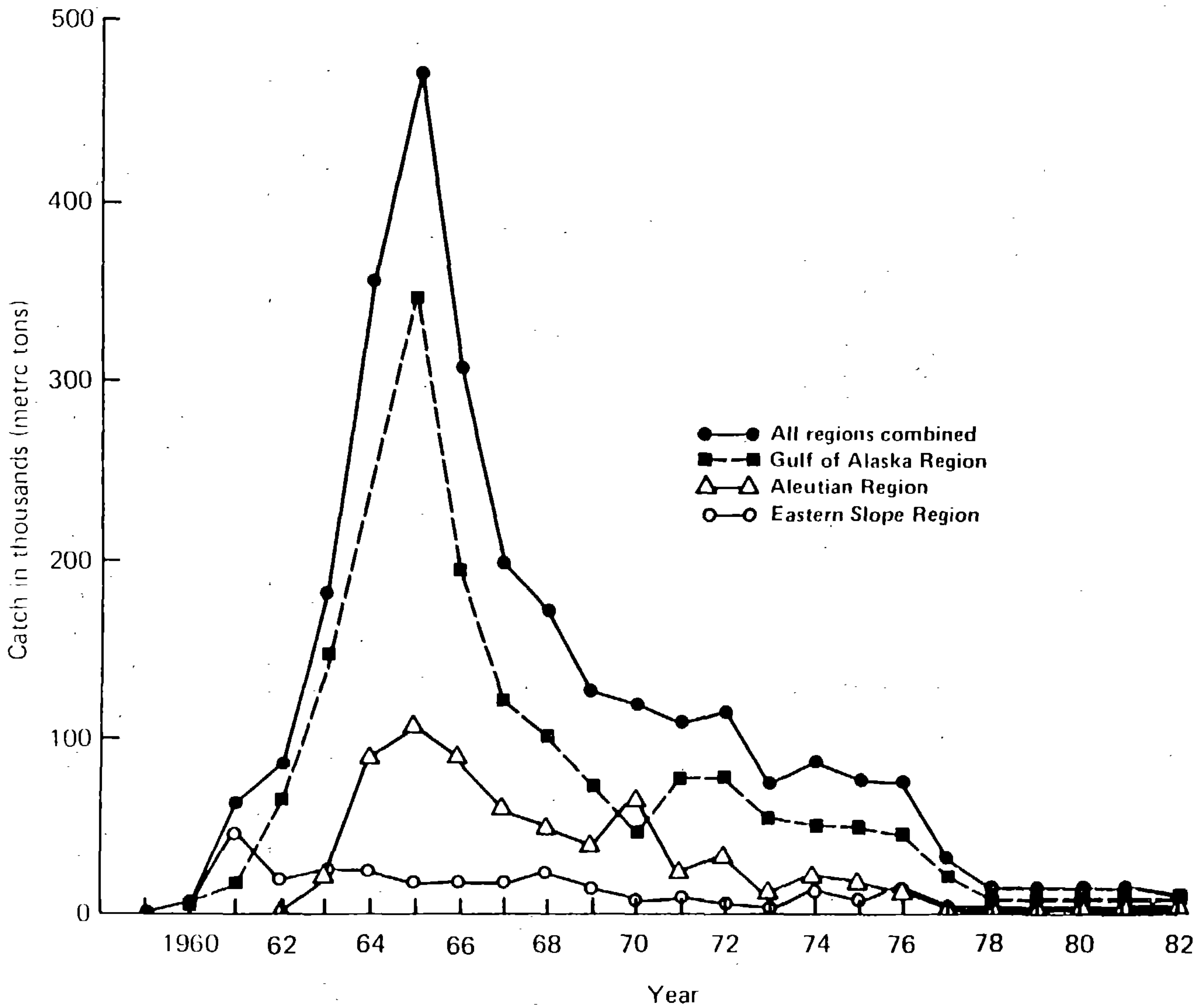

Figure 2. Catch trends of Pacific ocean perch by region, 1960-82.

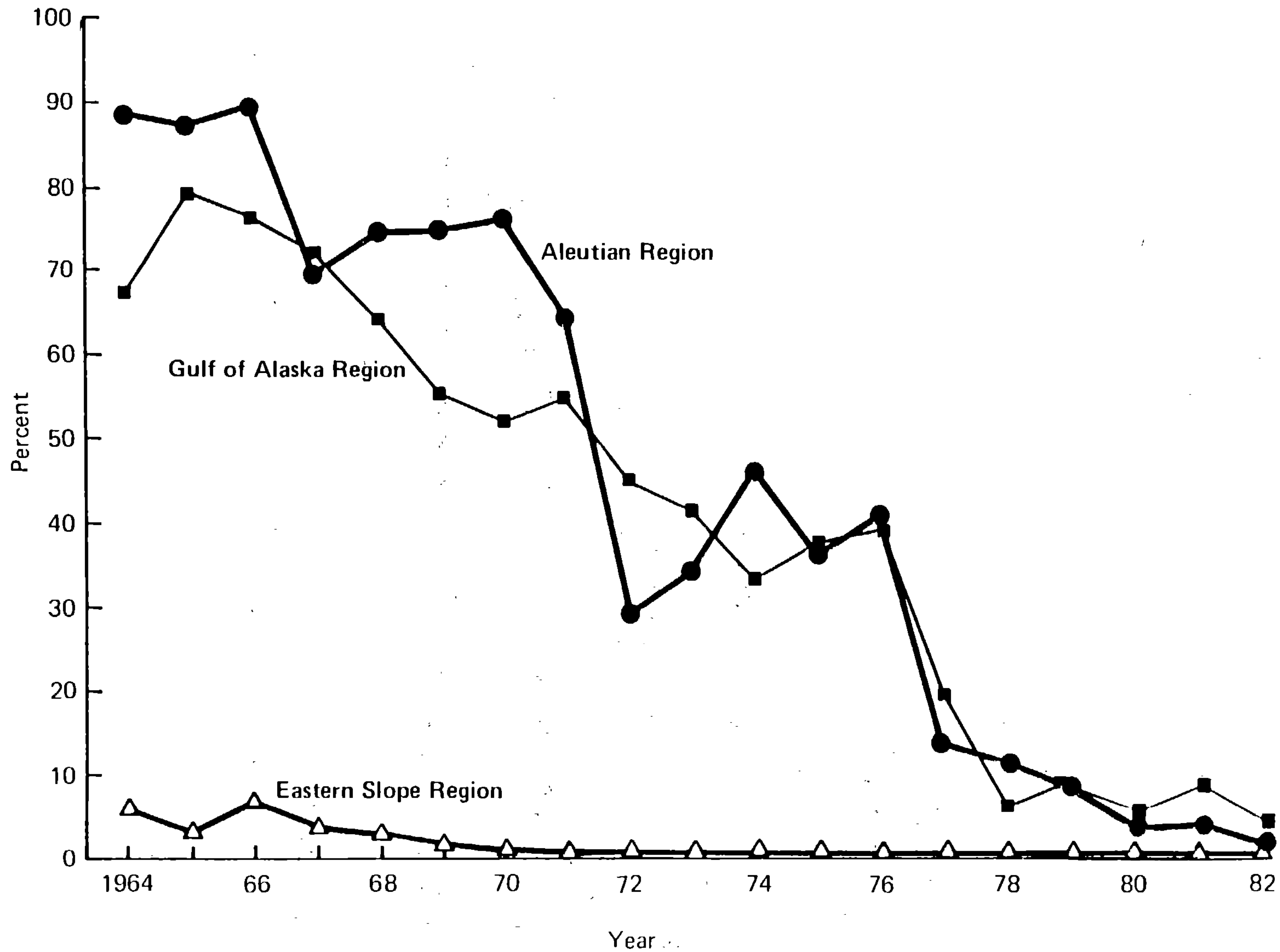

Figure 3. Percent composition of Pacific ocean perch in the total Japanese groundfish catch, by region, 1960-82.

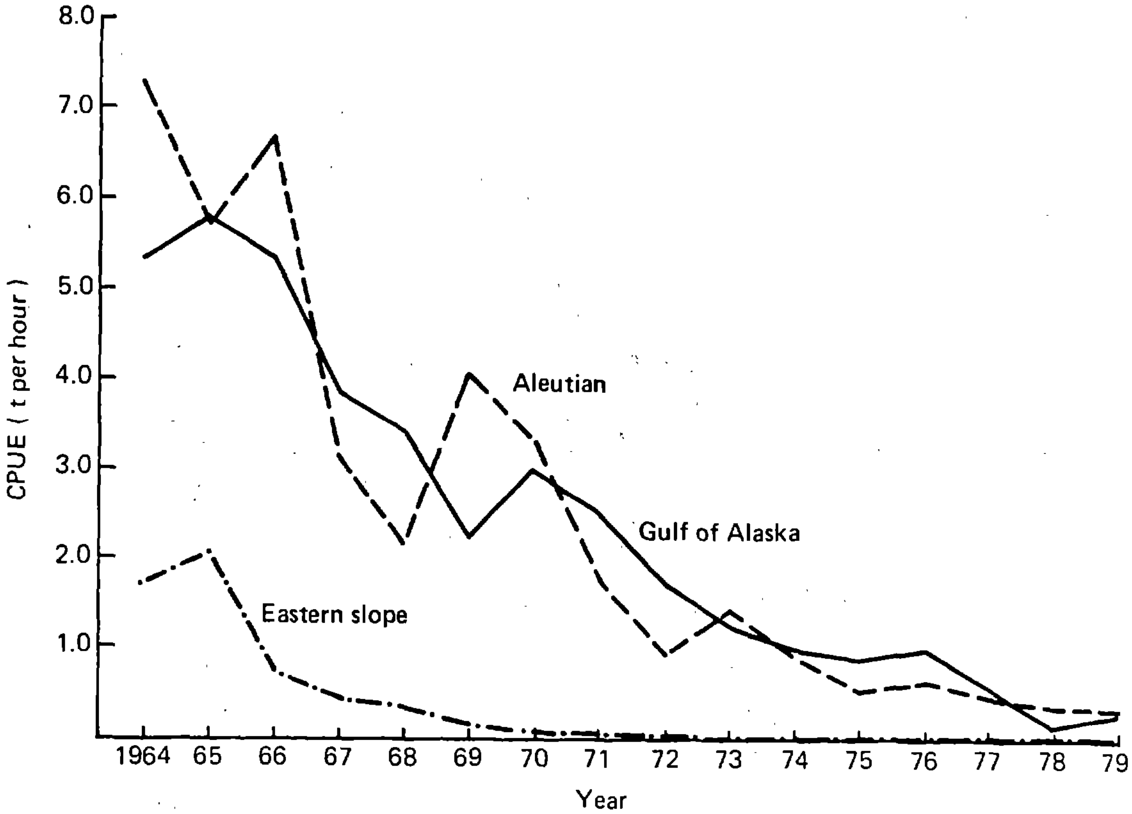

Figure 4. Catch of Pacific ocean perch per stern trawl hour, 1964-79. Based on nominal trawl effort from the Japanese mothership, and North Pacific trawl fisheries, all stern trawlers combined.

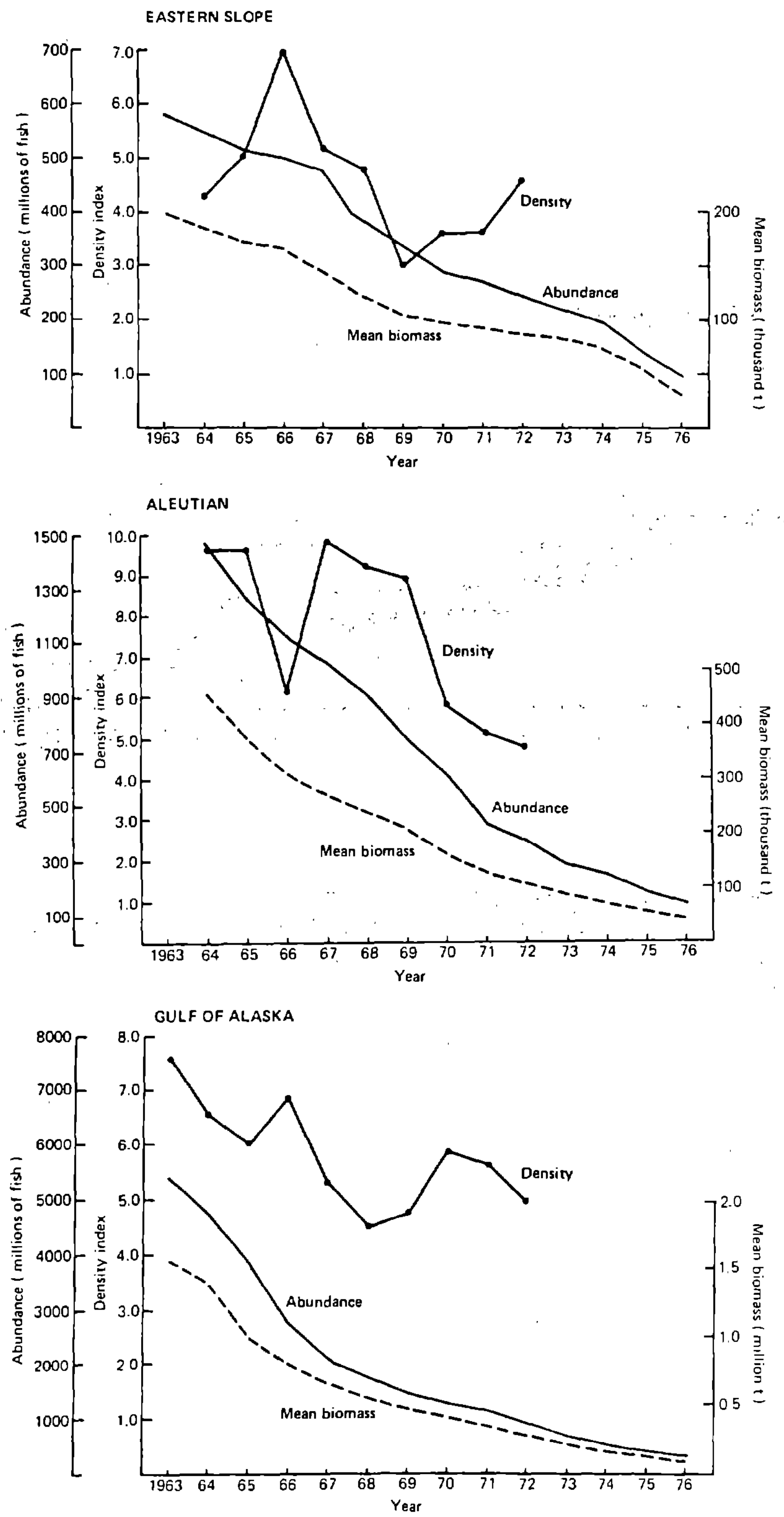

Figure 5. Estimates of population numbers and mean biomass (age 5 to 20) in each stock as determined by the cohort analysis base runs, 1963-1976. Density index derived by Chikuni (1975).

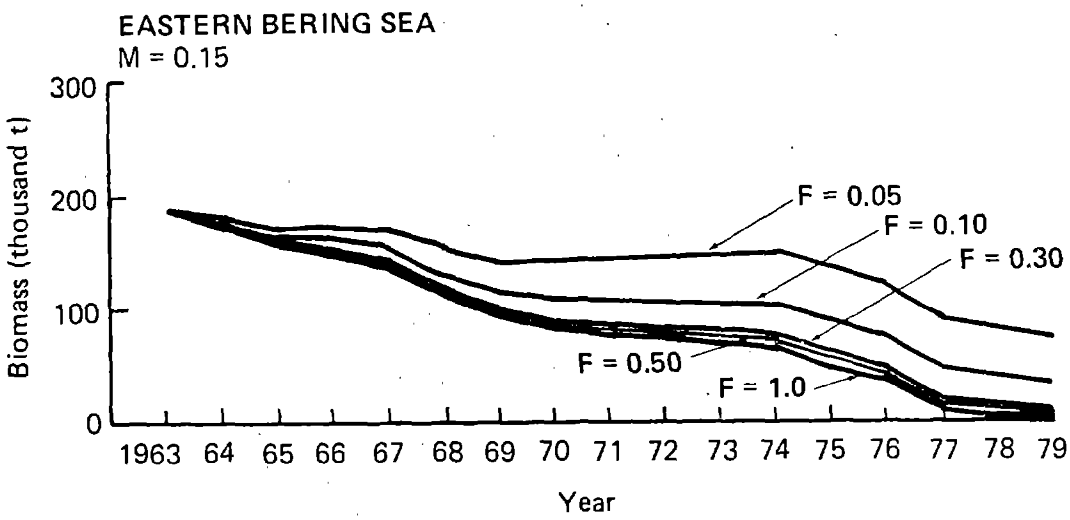

Figure 6. Virtual-population-analysis estimates of biomass by year for Pacific ocean perch in the eastern Bering Sea region using a range of initial F-values from 0.05 to 1.0.

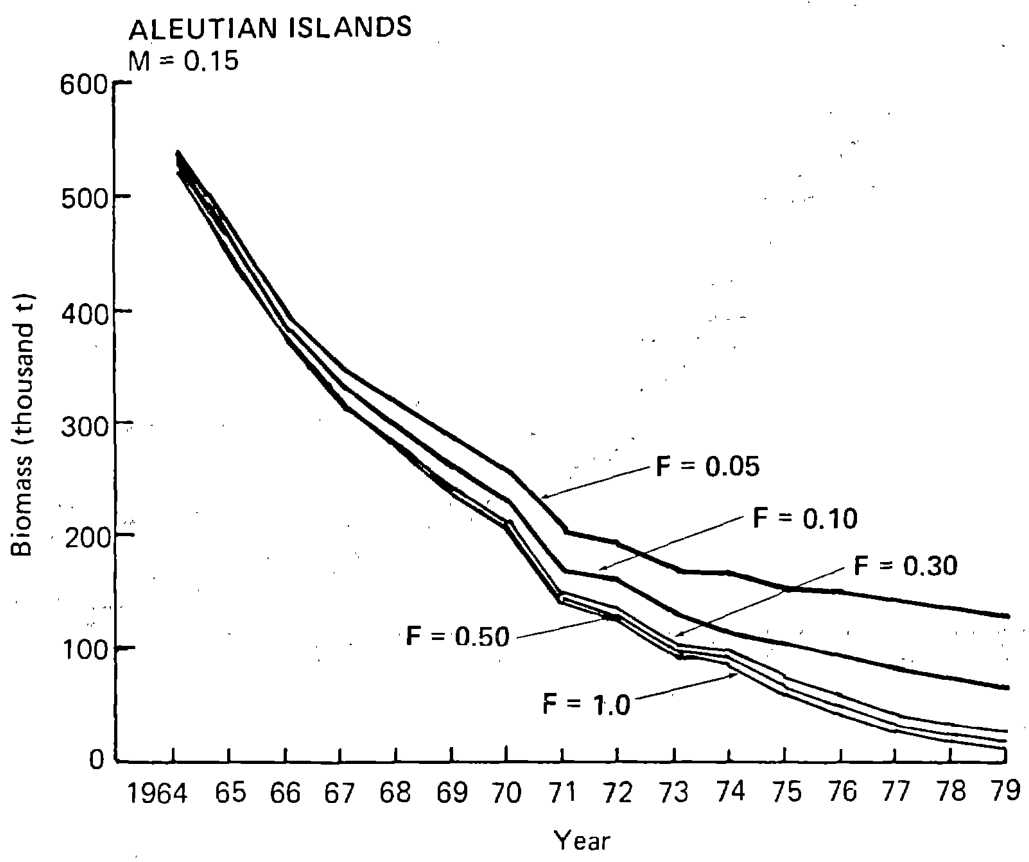

Figure 7. Virtual-population-analysis estimates of biomass by year for Pacific ocean perch in the Aleutian Islands region using a range of initial F-values from 0.05 to 1.0.

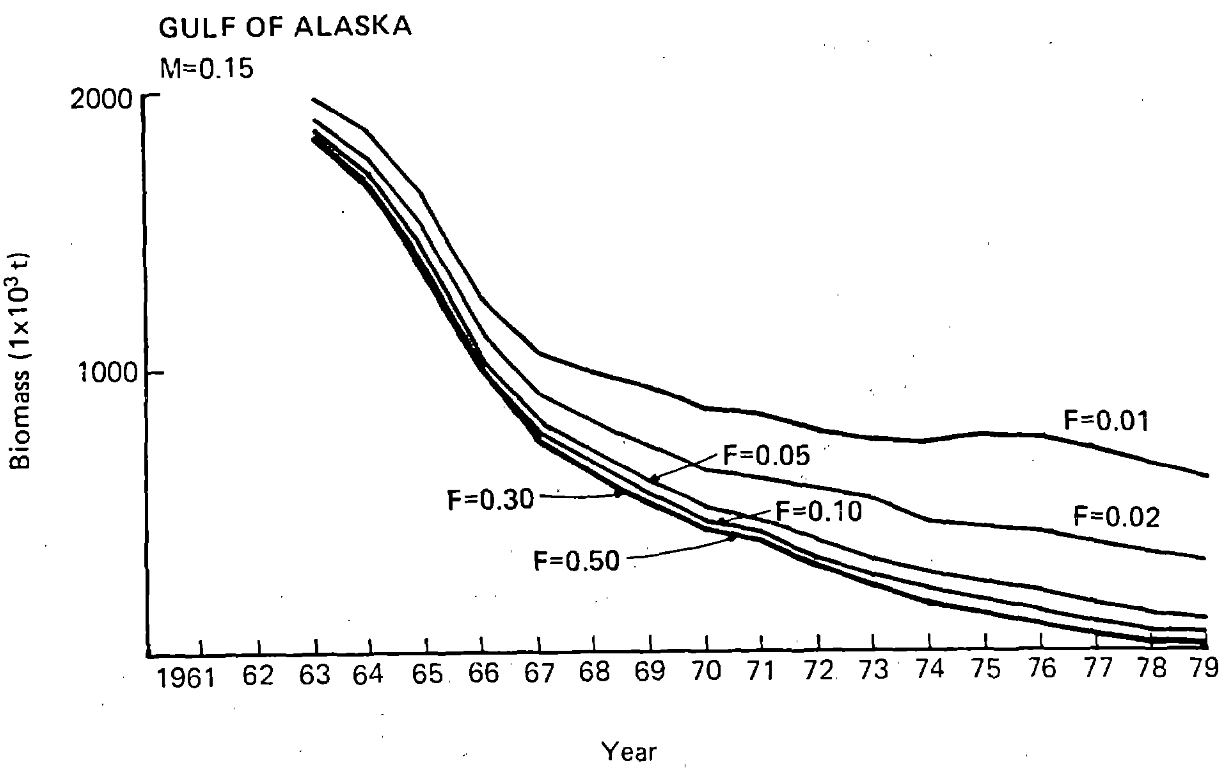

Figure 8. Virtual-population-analysis estimates of biomass by year for Pacific ocean perch in the Gulf of Alaska region using a range of initial F-values from 0.01 to 0.50.

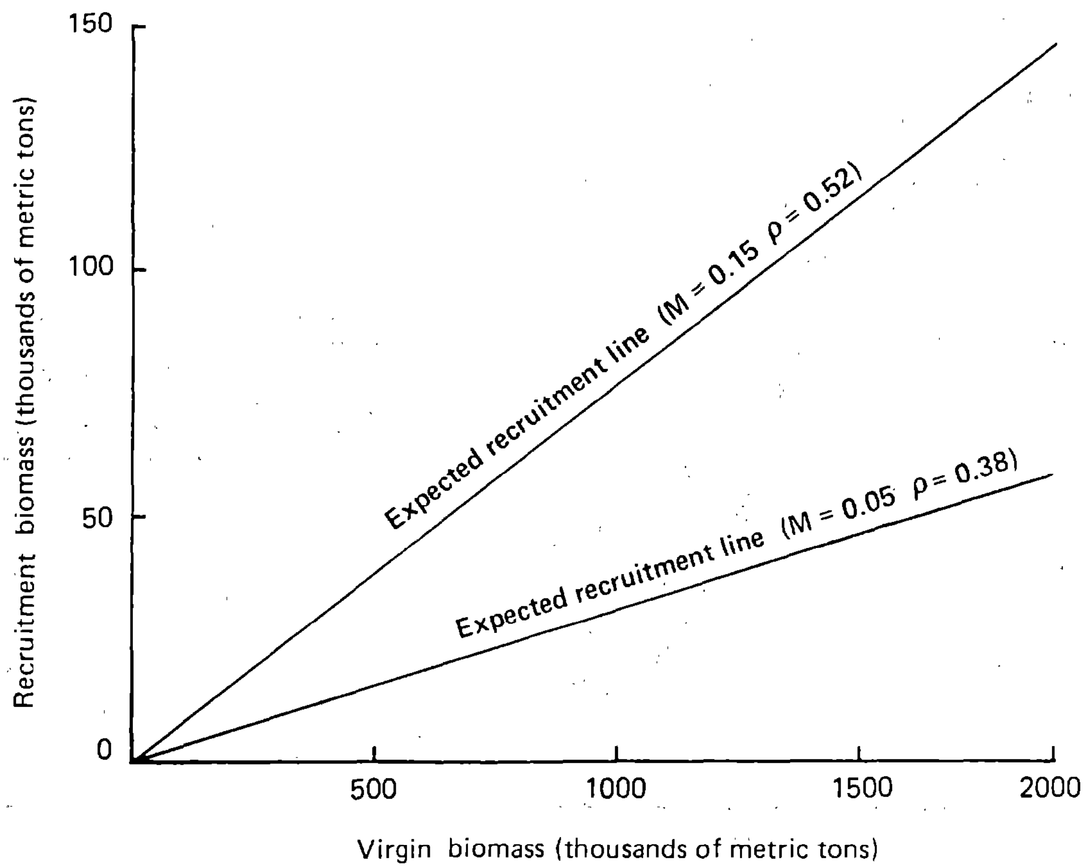

Figure 9. Expected recruitment lines describing the constant recruitment level required to sustain a given virgin biomass, for M=0.05 with p=0.38 and M=0.15 with p=0.52.

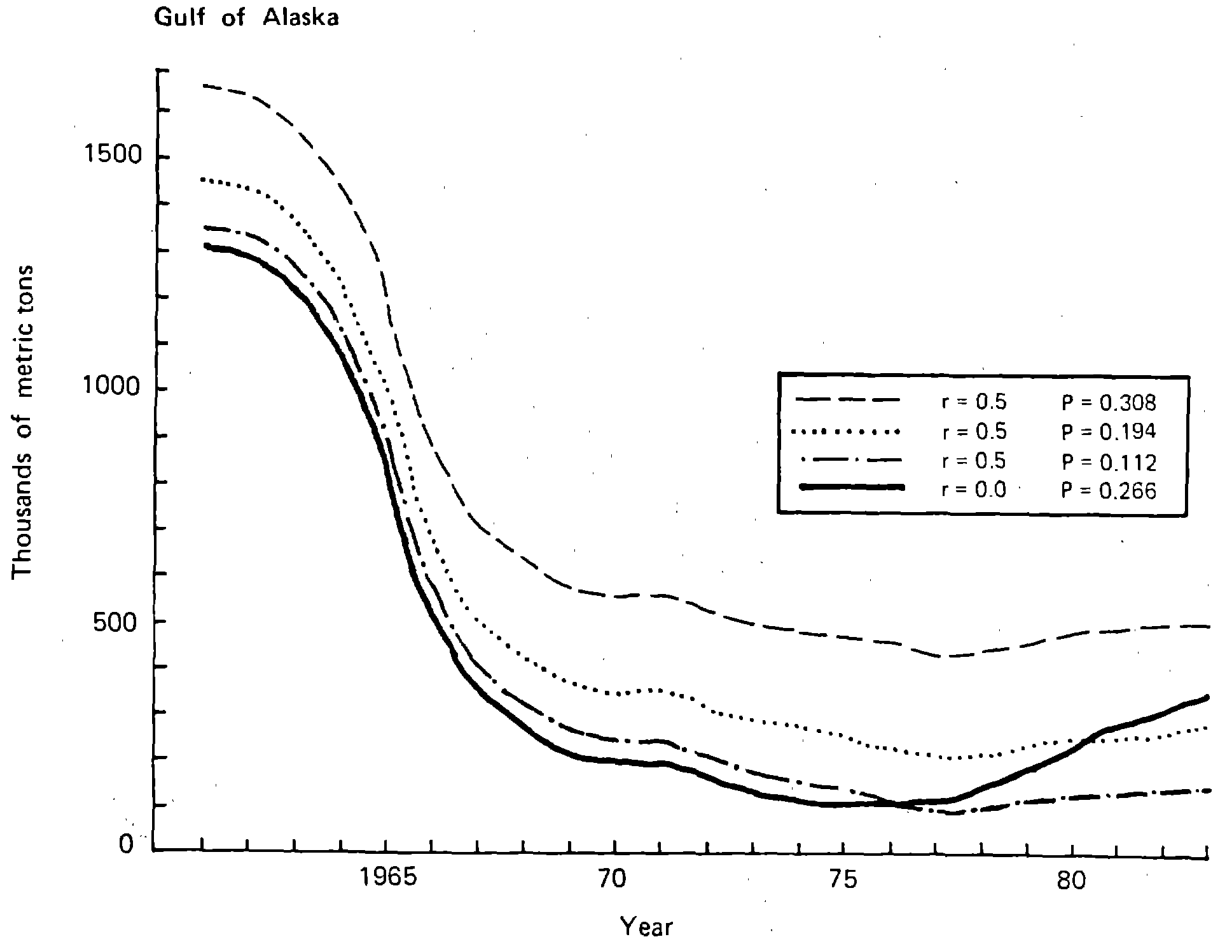

Figure 10. For Pacific ocean perch in the Gulf of Alaska, estimated population biomass (assuming M=0.05 and p=0.38) over time for SRA fits P 50.25 with r=0.0, and P 0.1, 0.2, and 0.3 with r=0.5.

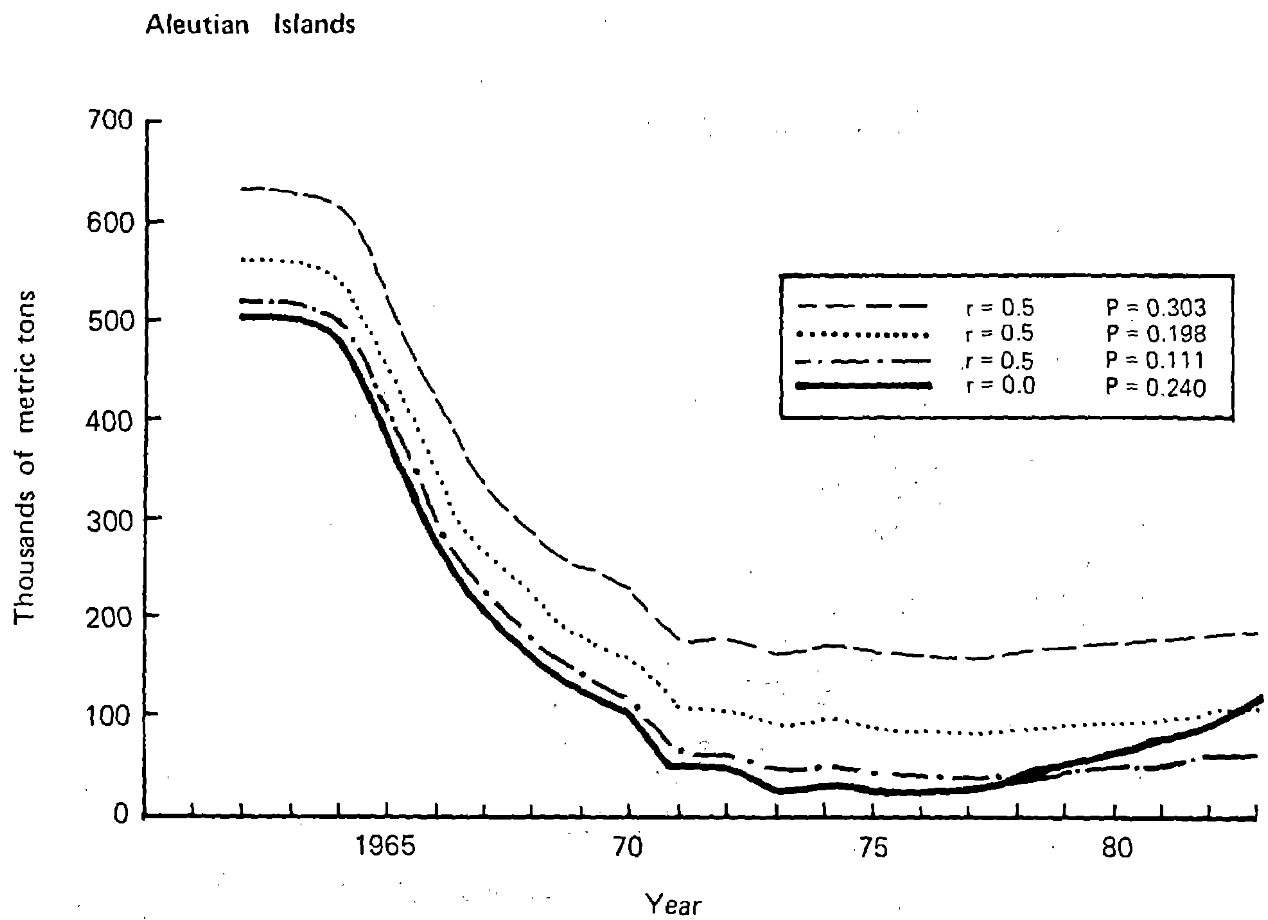

Figure 11. For Pacific ocean perch in the Aleutian Islands, estimated population biomass (assuming M=0.05 and p=0.38) over time for SRA fits P 0.25 with r=0.0, and P 0.1, 0.2, and 0.3 with r=0.5.

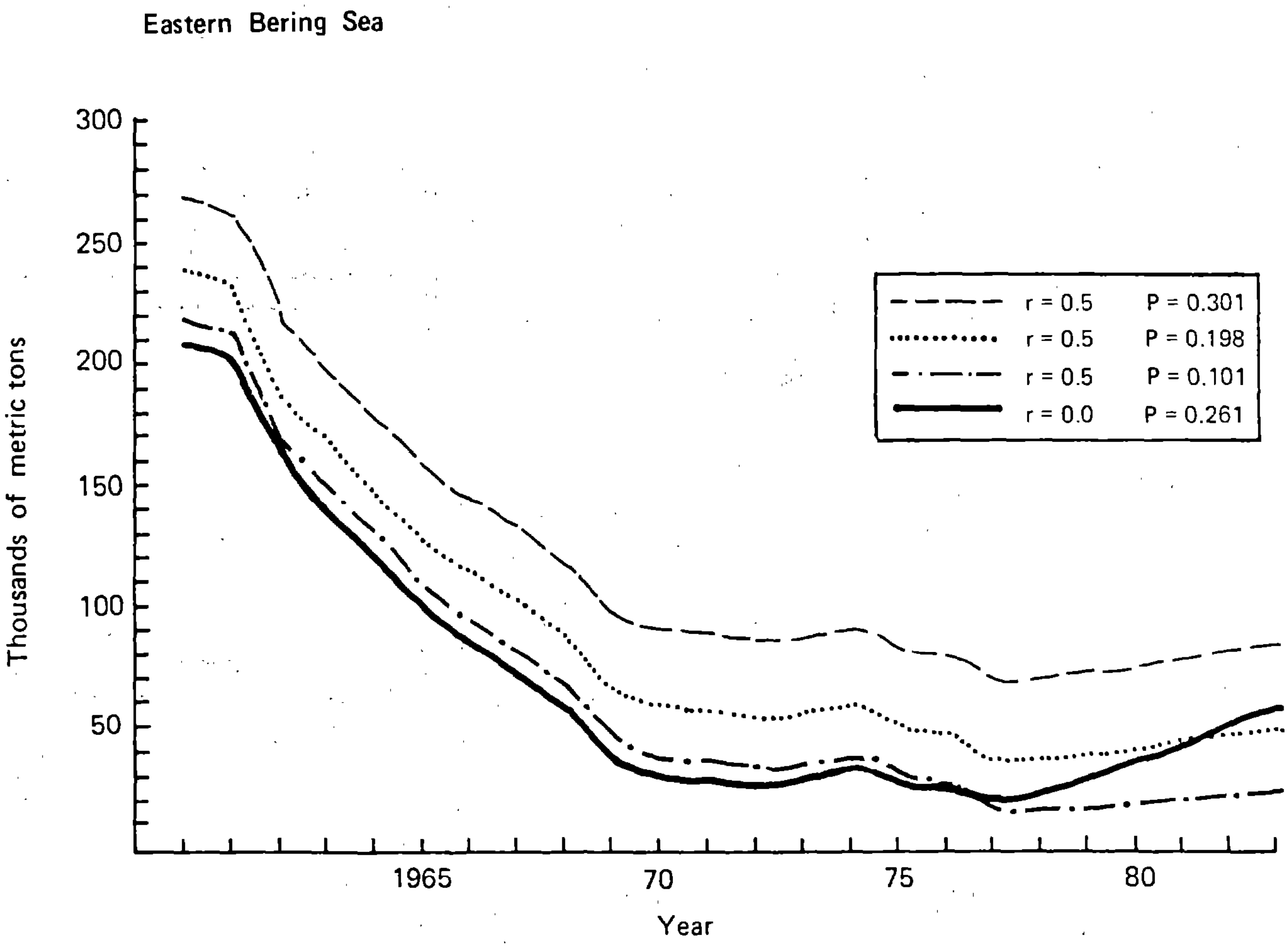

Figure 12. For Pacific ocean perch in the Eastern Bering Sea, estimated population biomass (assuming M=0.05 and p=0.38) over time for SRA fits P 0.25 with r=0.0, and P 0.1, 0.2, and 0.3 with r=0.5.

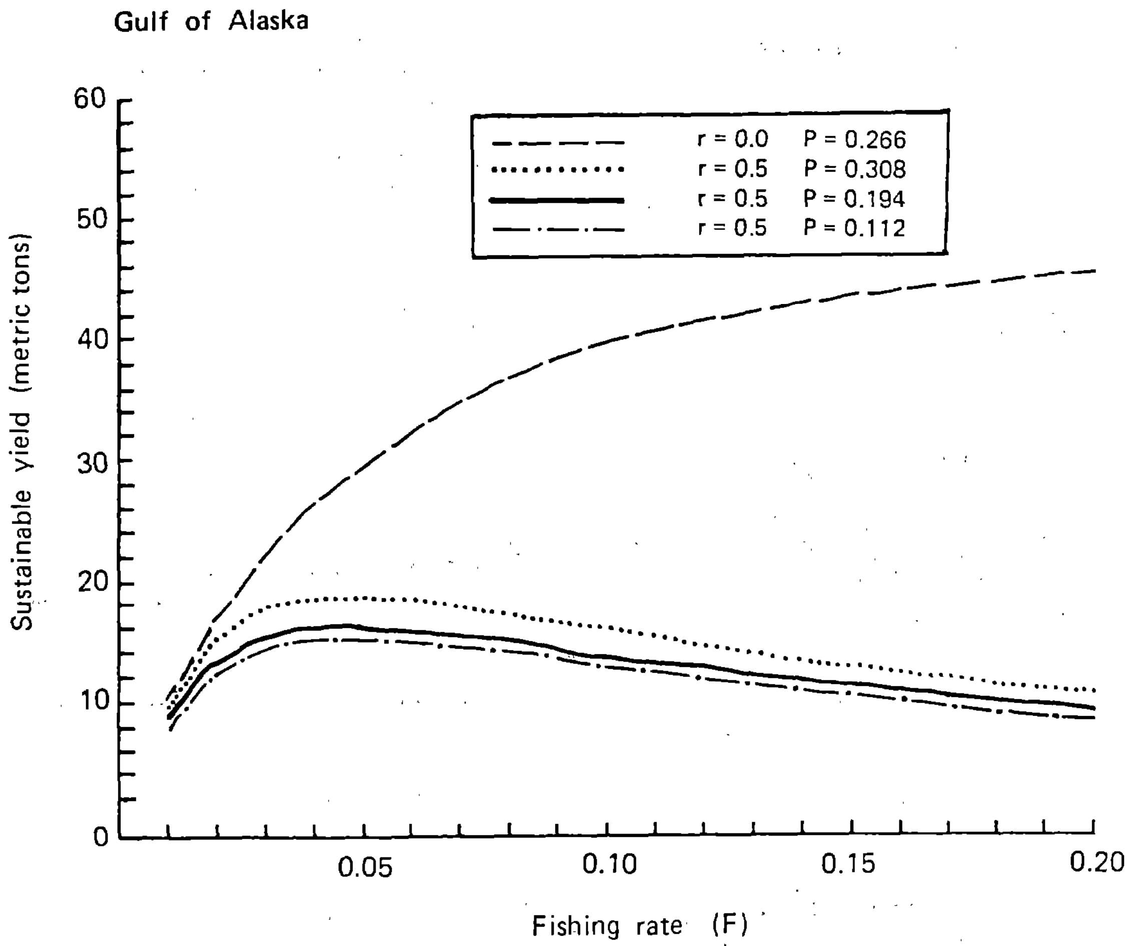

Figure 13. For Pacific ocean perch in the Gulf of Alaska, estimated sustainable yield (assuming M=0.0S and P=0.38) for a given fixed instantaneous fishing mortality rate F, calculated for SRA fits P 0.25 with r=0.0, and P 0.1, 0.2, and 0.3, with r=0.5.

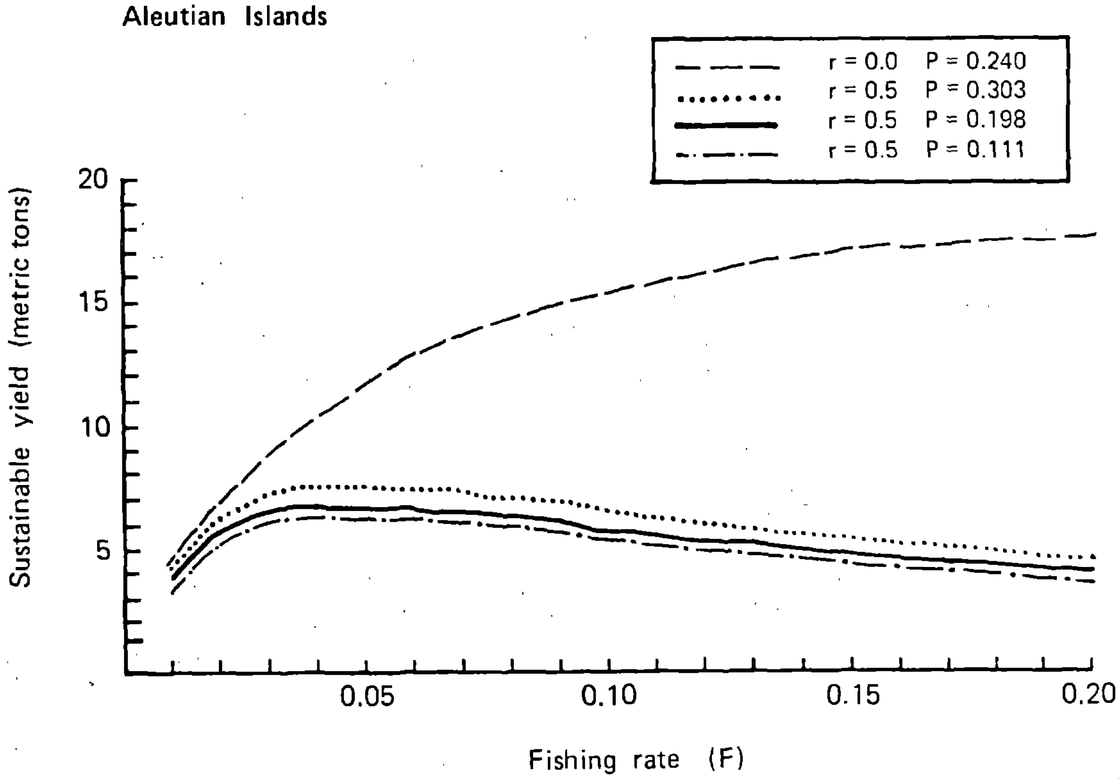

Figure 14. For Pacific ocean perch in the Aleutian Islands, estimated sustainable yield (assuming M=0.05 and p=0.38) for a given fixed instantaneous fishing mortality rate F, calculated for SRA fits P 0.25 with r=0.0, and P 0.1, 0.2, and 0.3, with r=0.5.

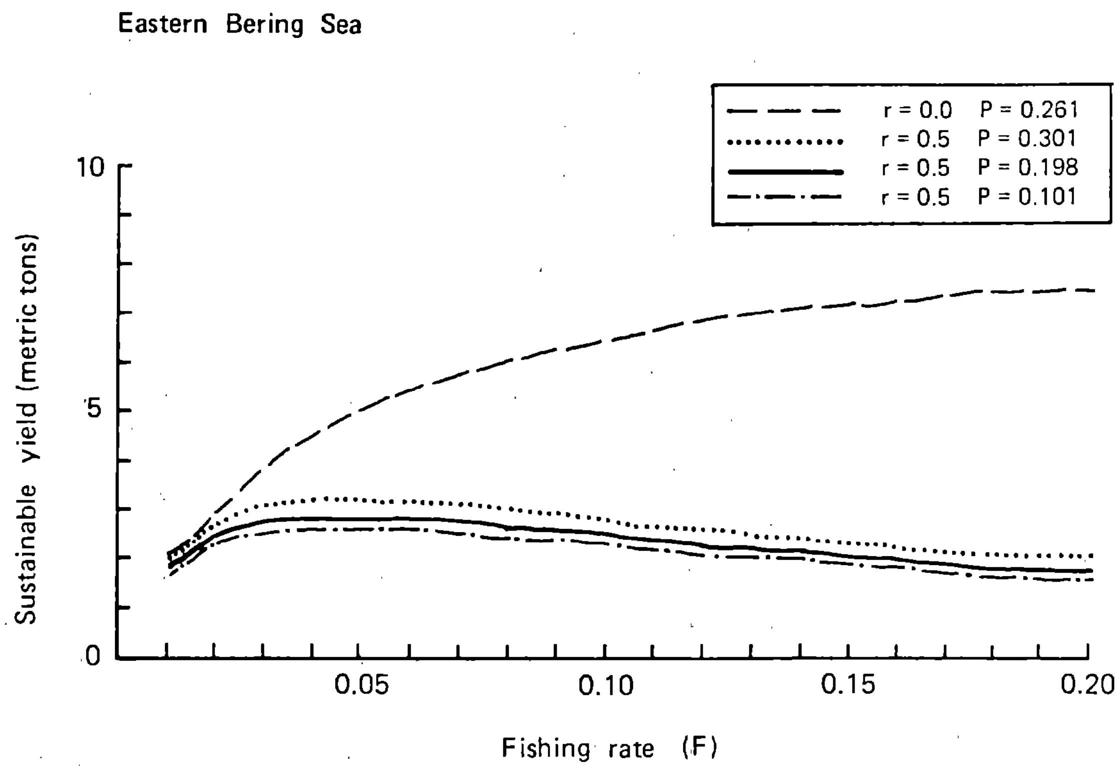

Figure 15. For Pacific ocean perch in the Eastern Bering Sea, estimated sustainable yield (assuming M=0.05 and p=0.38) for a given fixed instantaneous fishing mortality rate F, calculated for SRA fits P 0.25 with r=0.0, and P 0.1, 0.2, and 0.3, with r=0.5.

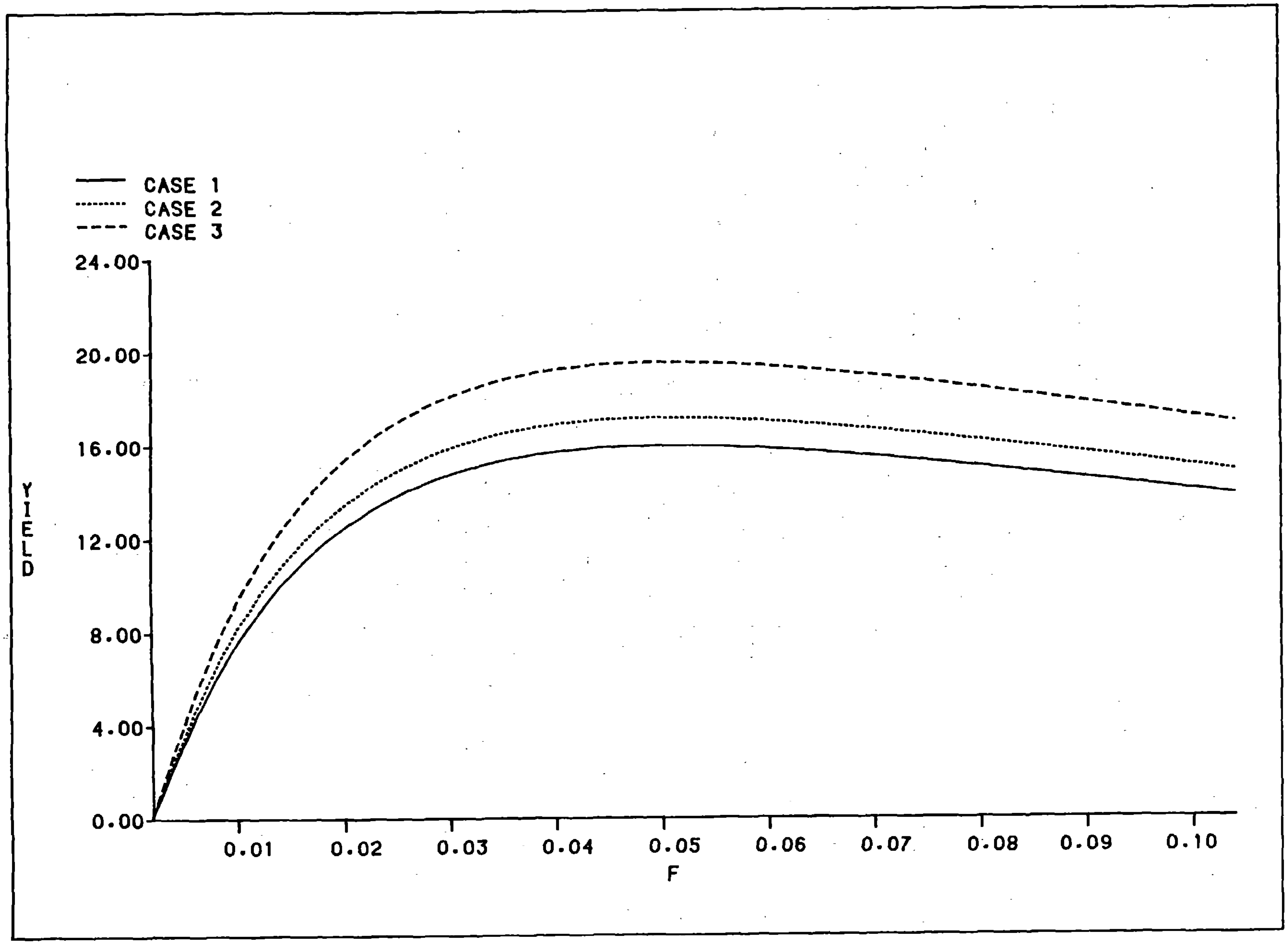

Figure 16. Equilibrium yield (1,000 t) as a function of F for the Gulf of Alaska region, 3 cases.

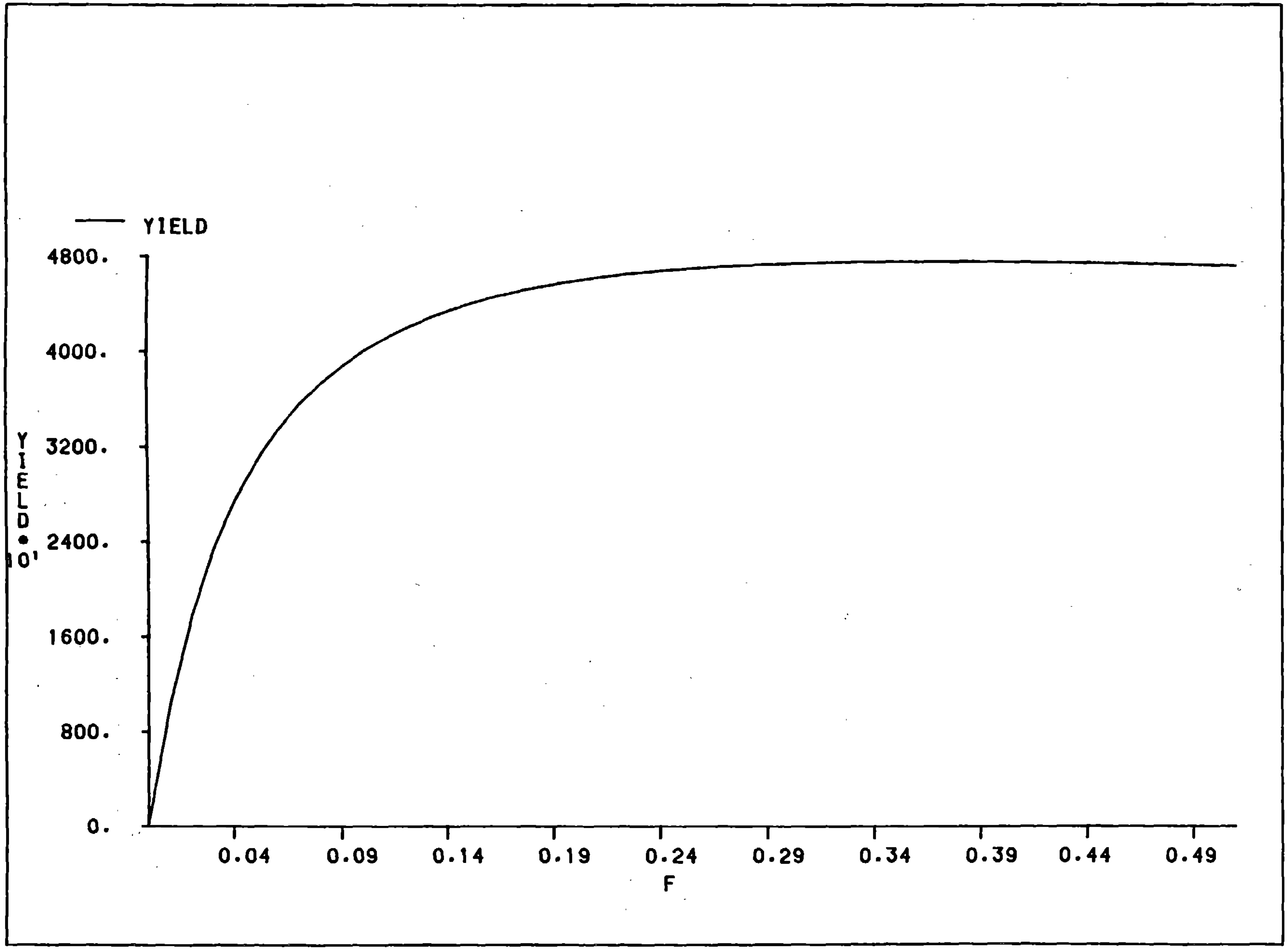

Figure 17. Equilibrium yield (t) as a function of F for the Gulf of Alaska region, case 4.

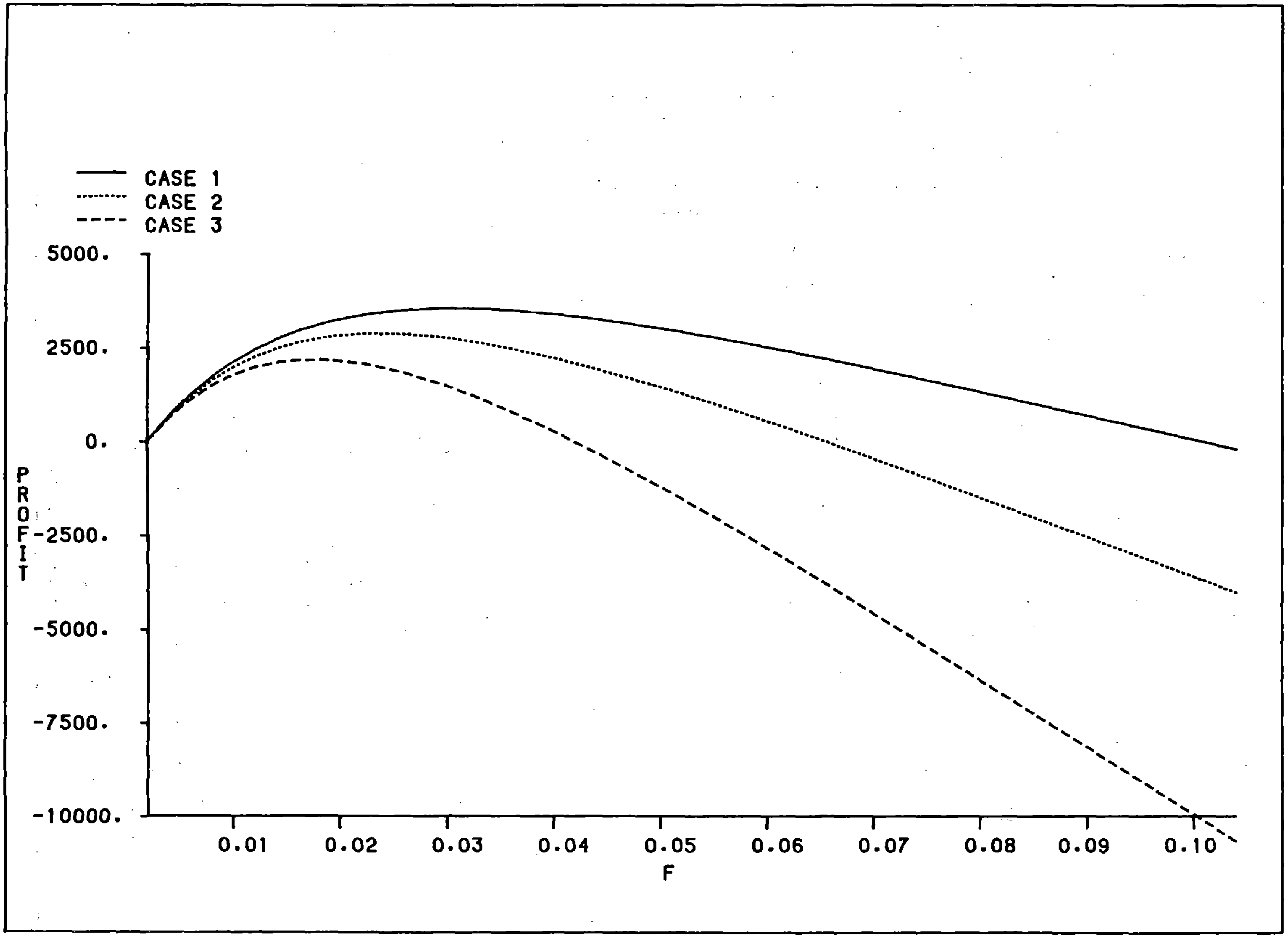

Figure 18. Equilibrium profit ($1,000) as a function of F for the Gulf of Alaska region, 3 cases.

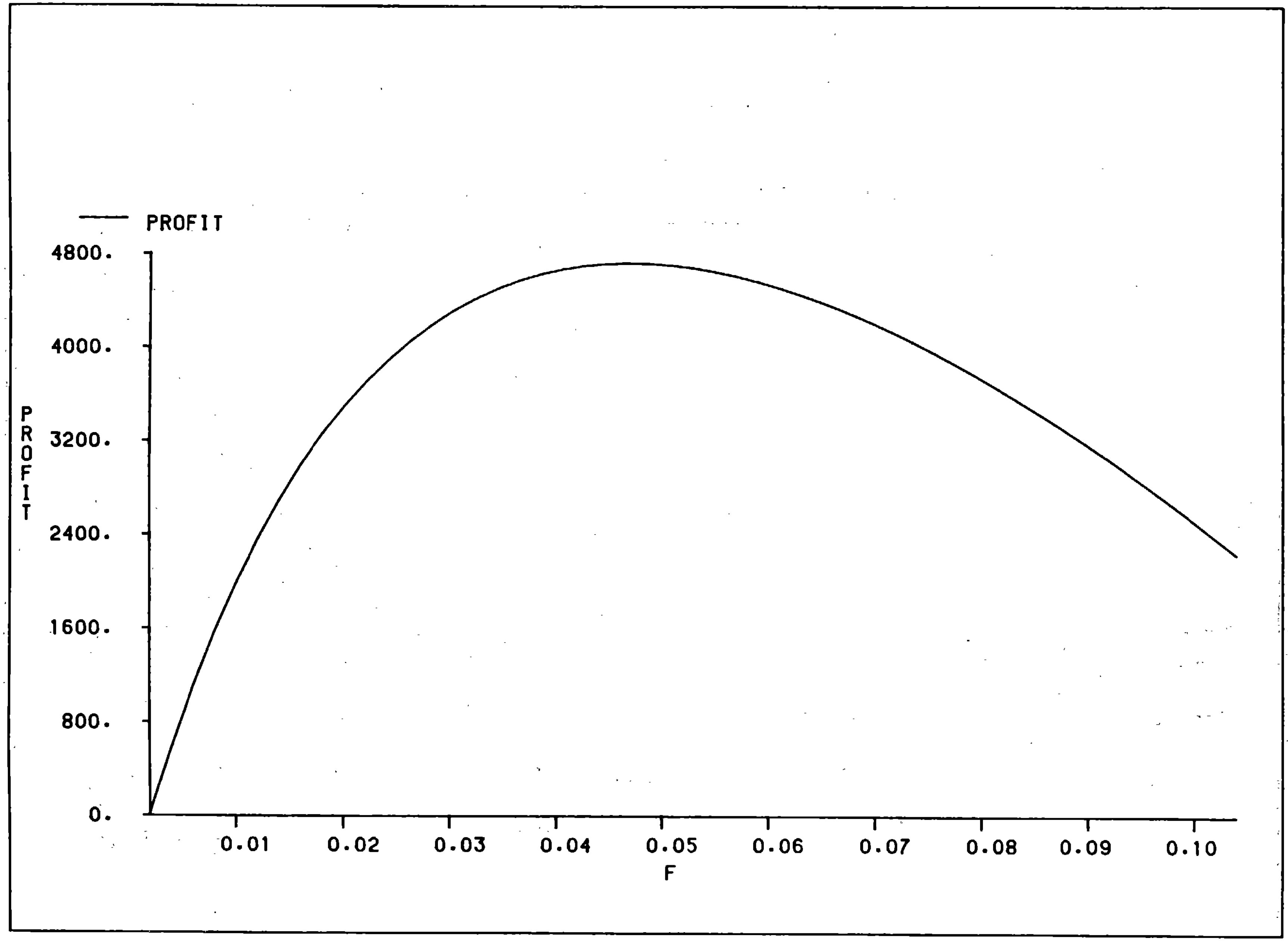

Figure 19. Equilibrium profit ($1,000) as a function of F for the Gulf of Alaska region, case 4.

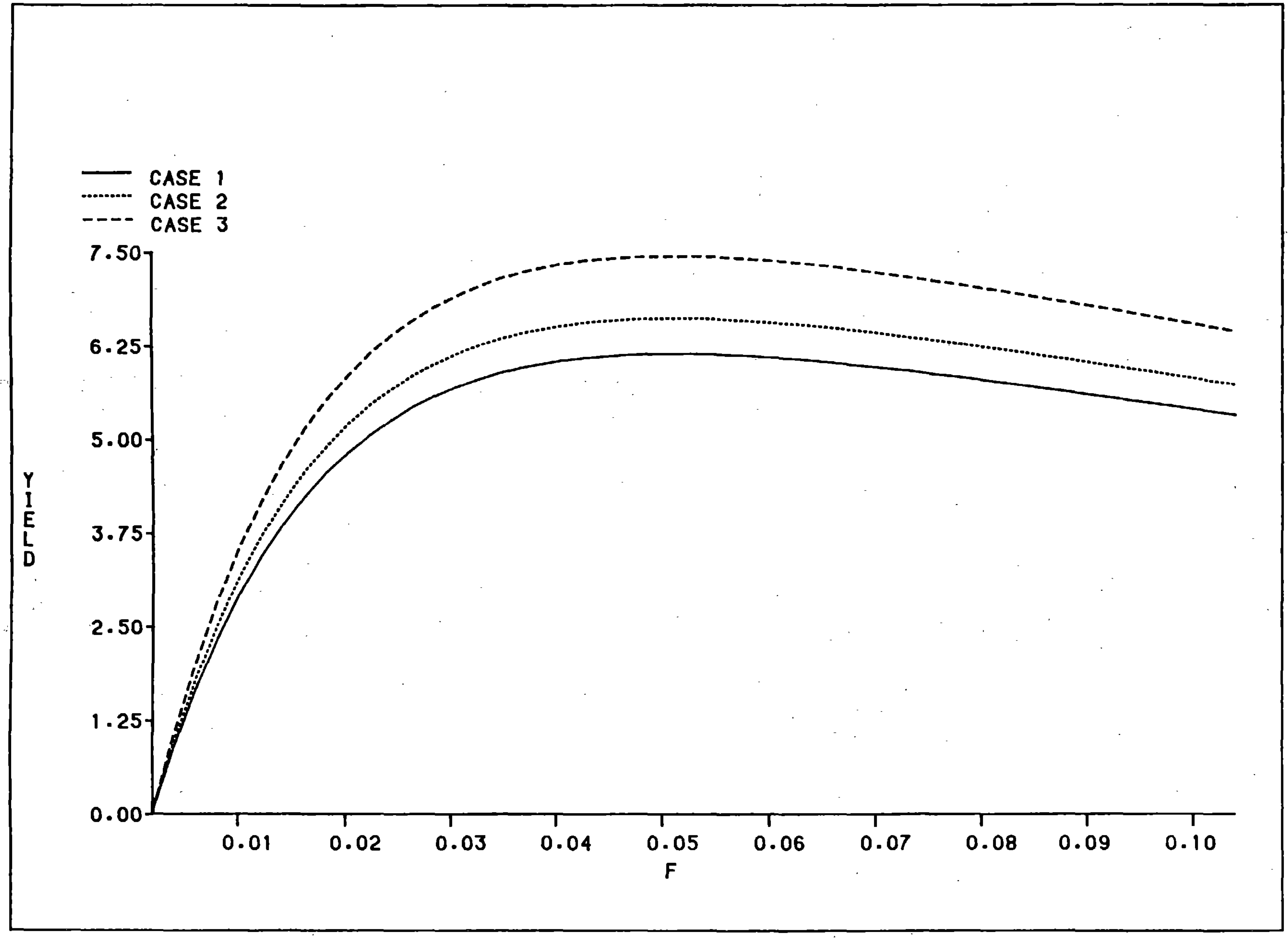

Figure 20. Equilibrium yield (1,000 t) as a function of F for the Aleutian Islands region, 3 cases.

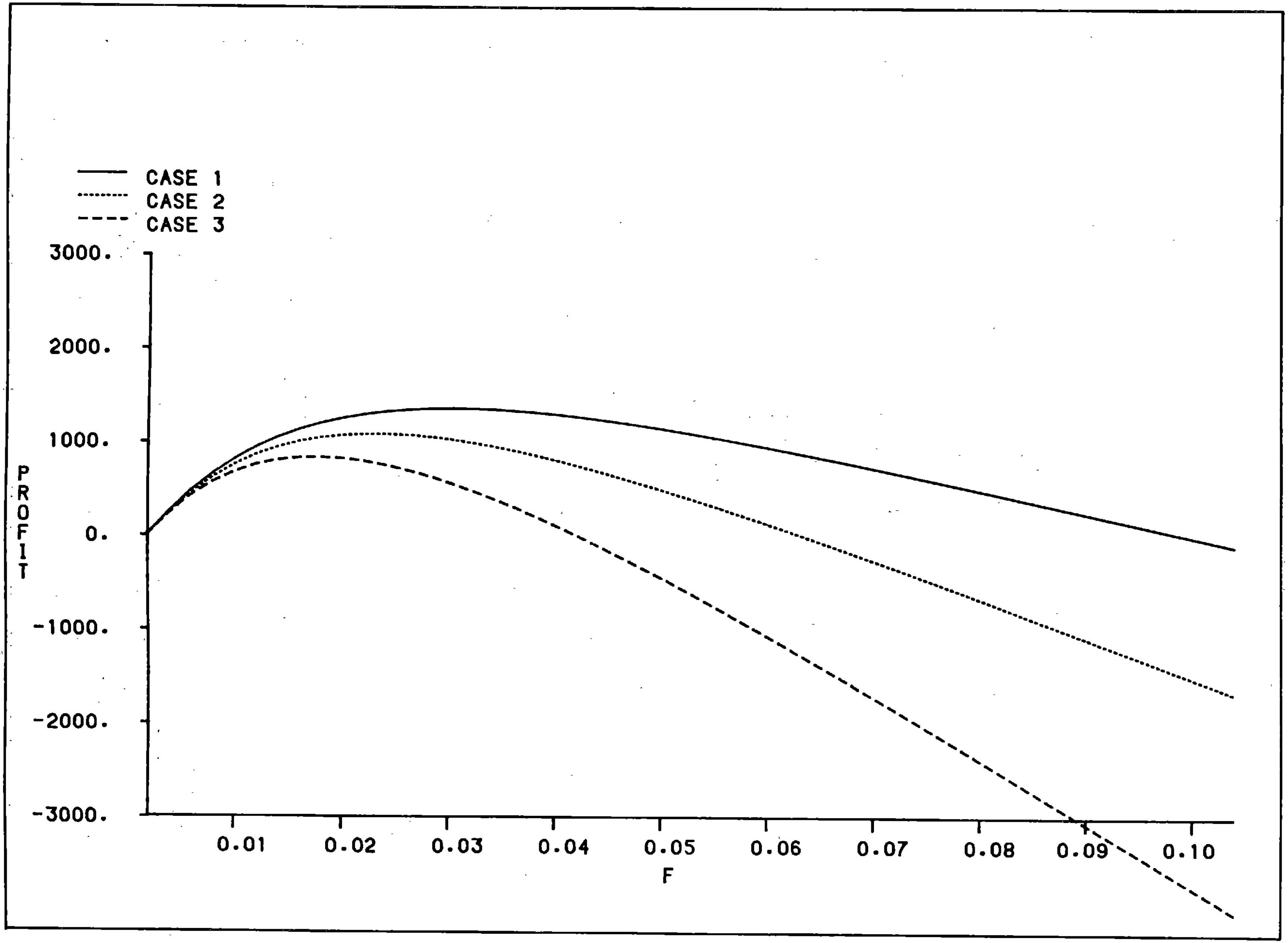

Figure 21. Equilibrium profit ($1,000) as a function of F for the Aleutian Islands region, 3 cases.

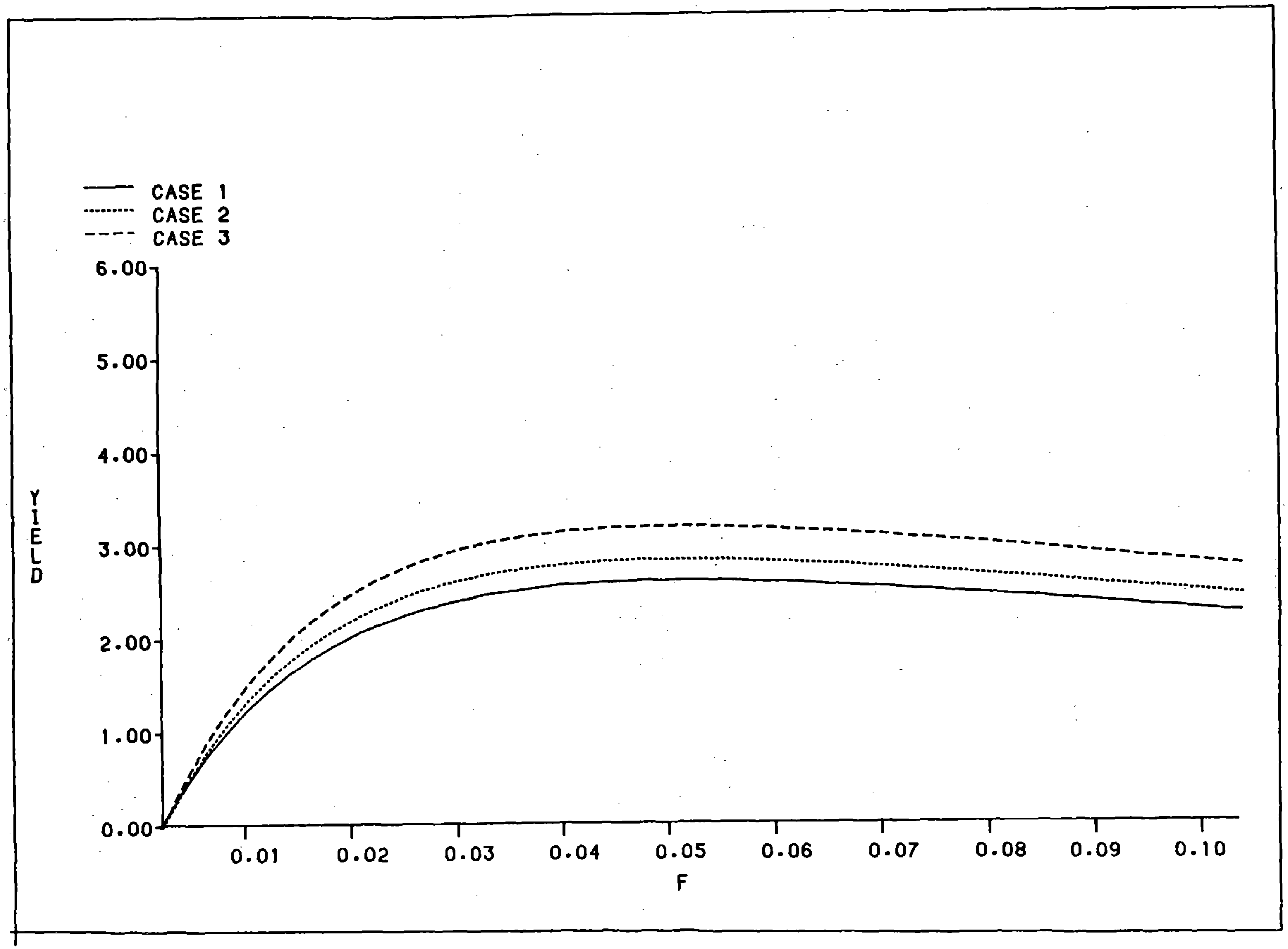

Figure 22. Equilibrium yield (1,000 t) as a function of F for the eastern Bering Sea region, 3 cases.

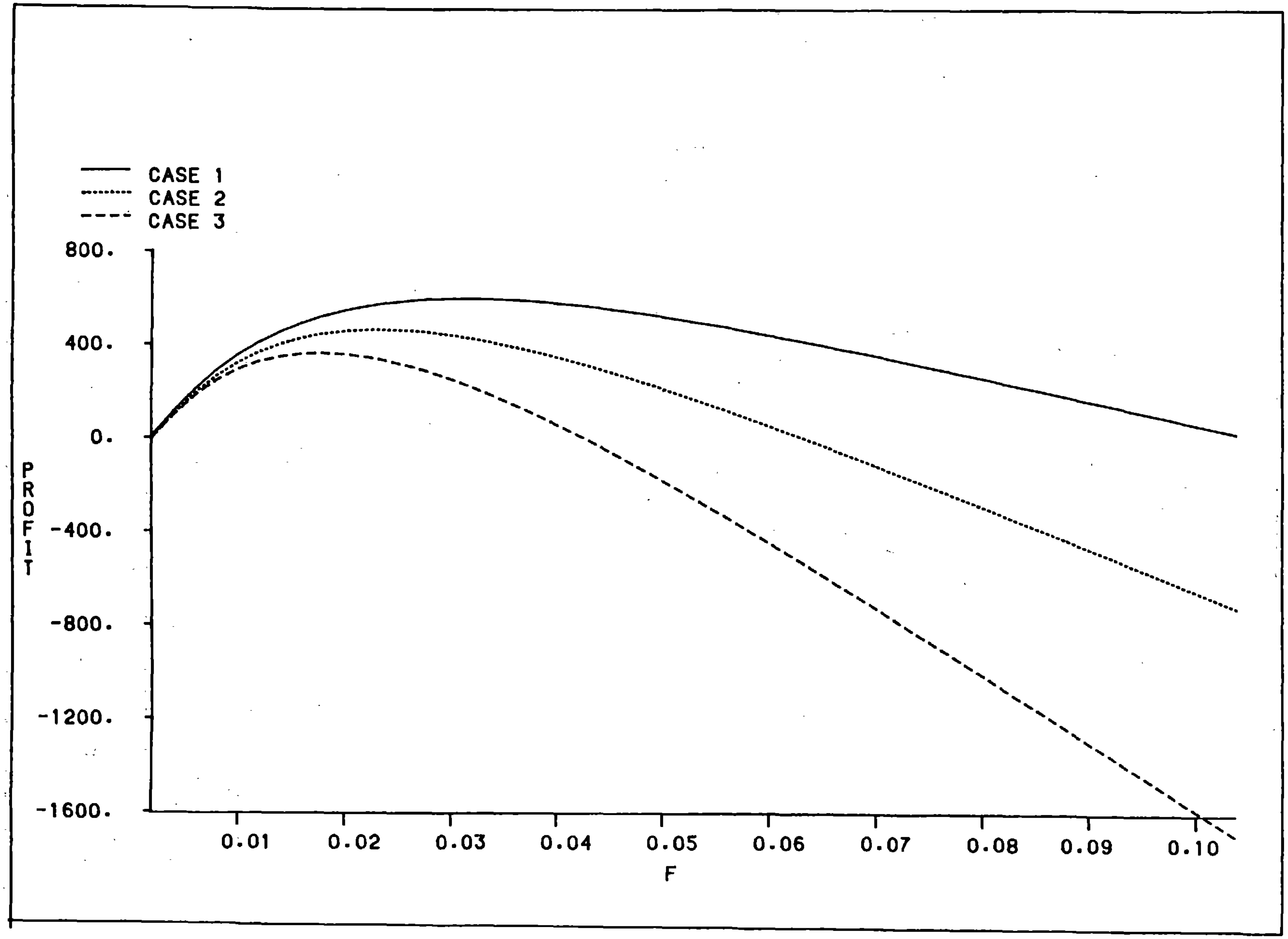

Figure 23. Equilibrium profit ($1,000) as a function of F for the eastern Bering Sea region, 3 cases.

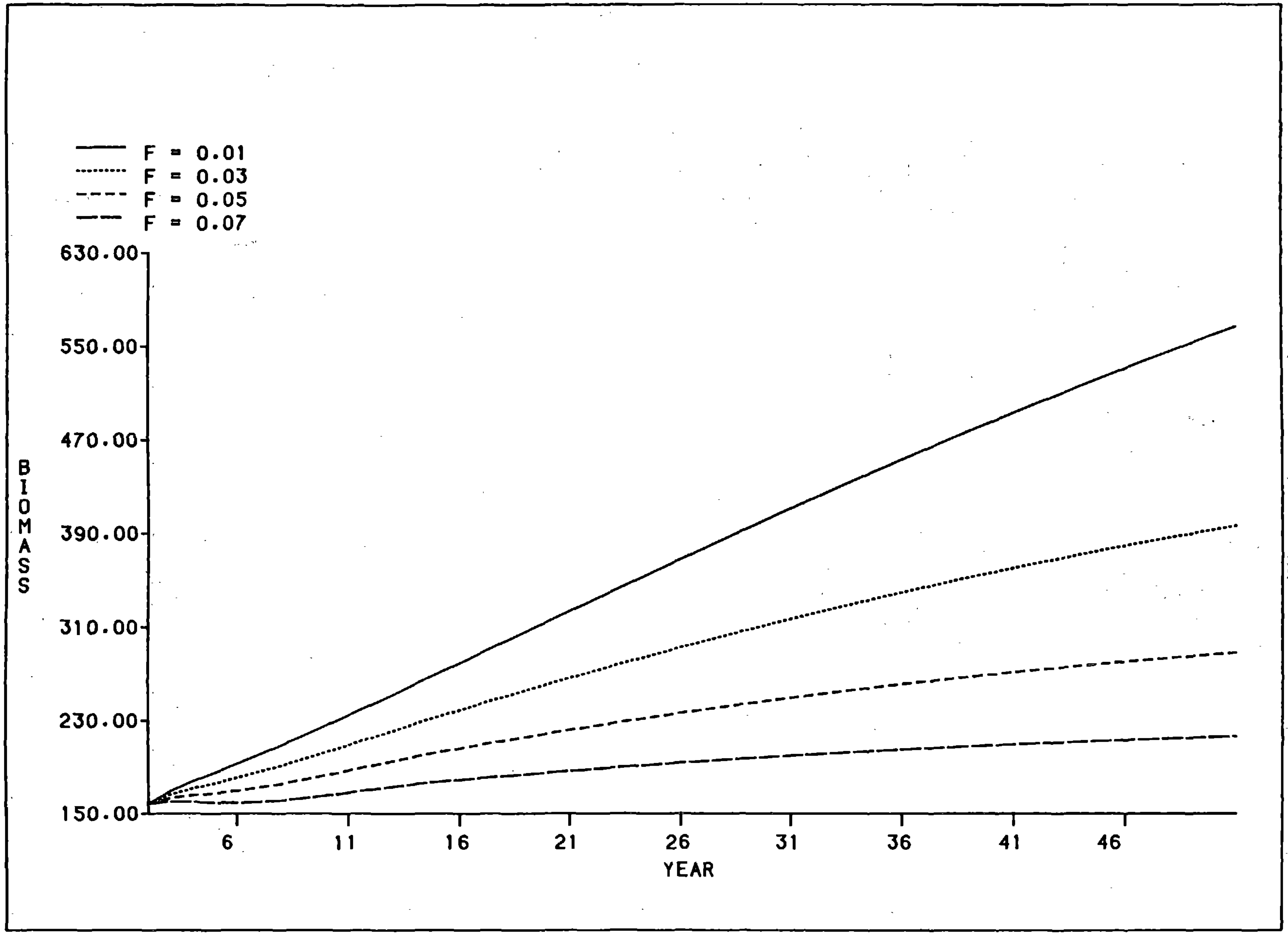

Figure 24. Biomass (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 1.

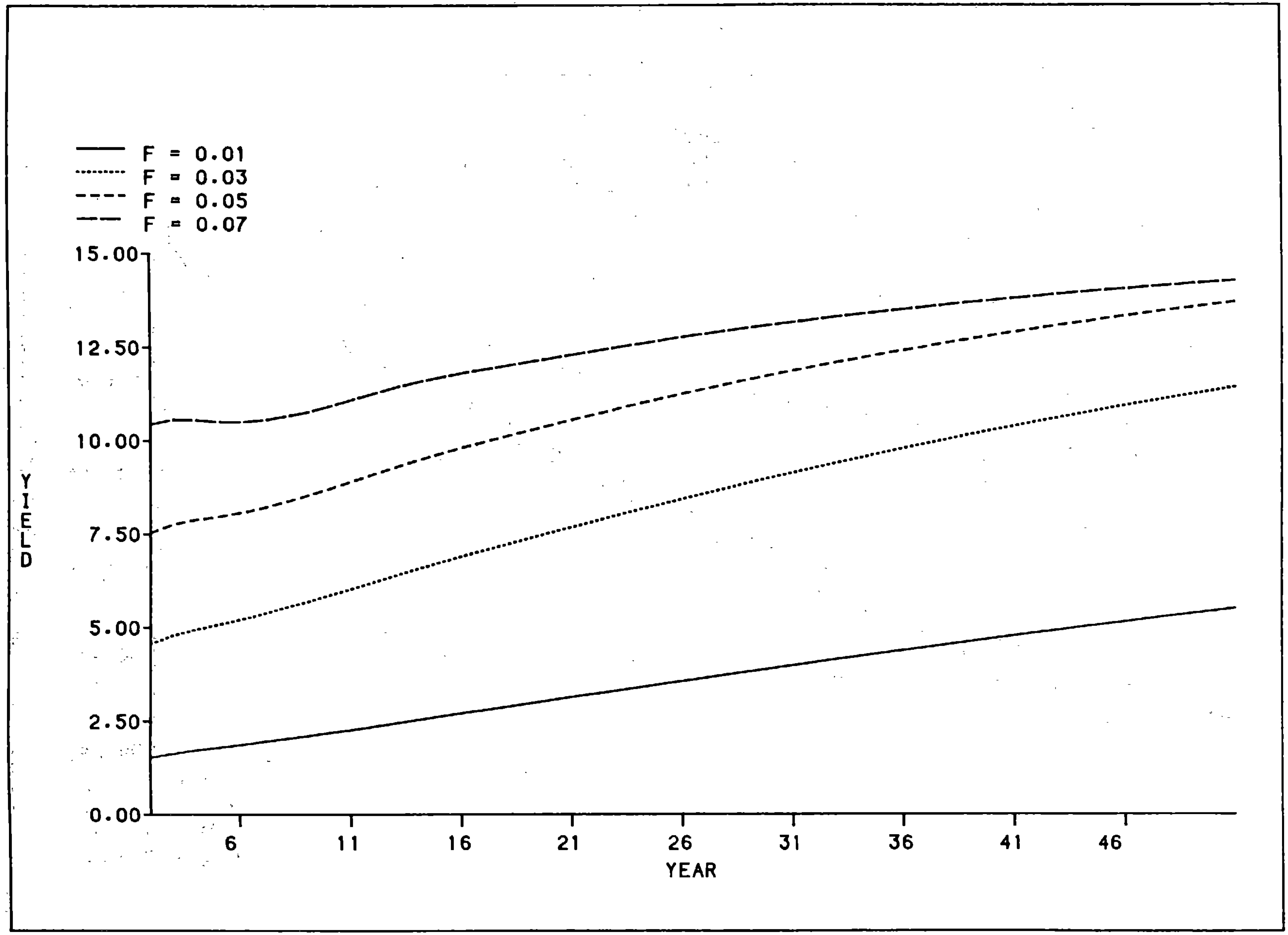

Figure 25. Yield (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 1.

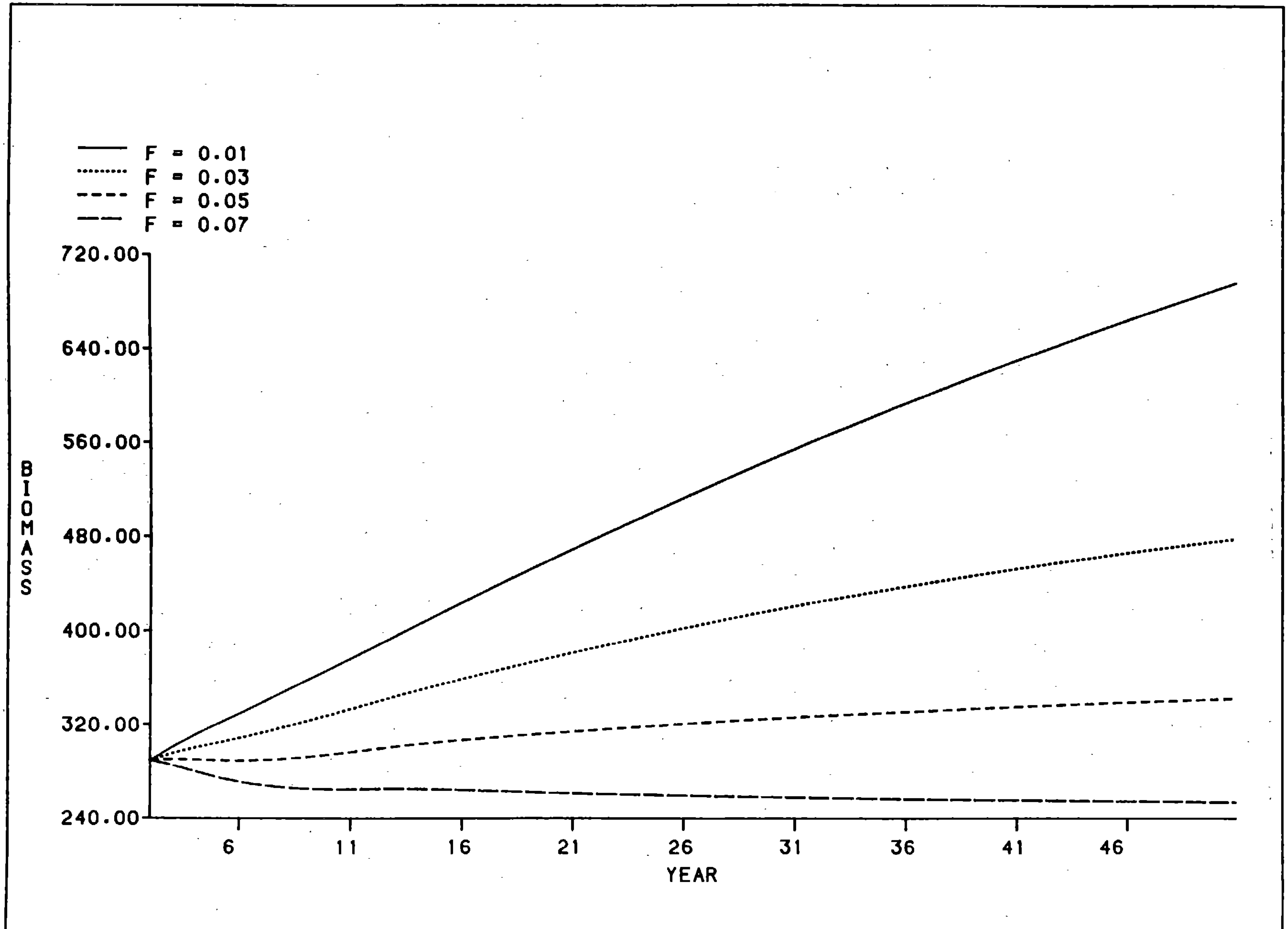

Figure 26. Biomass (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 2.

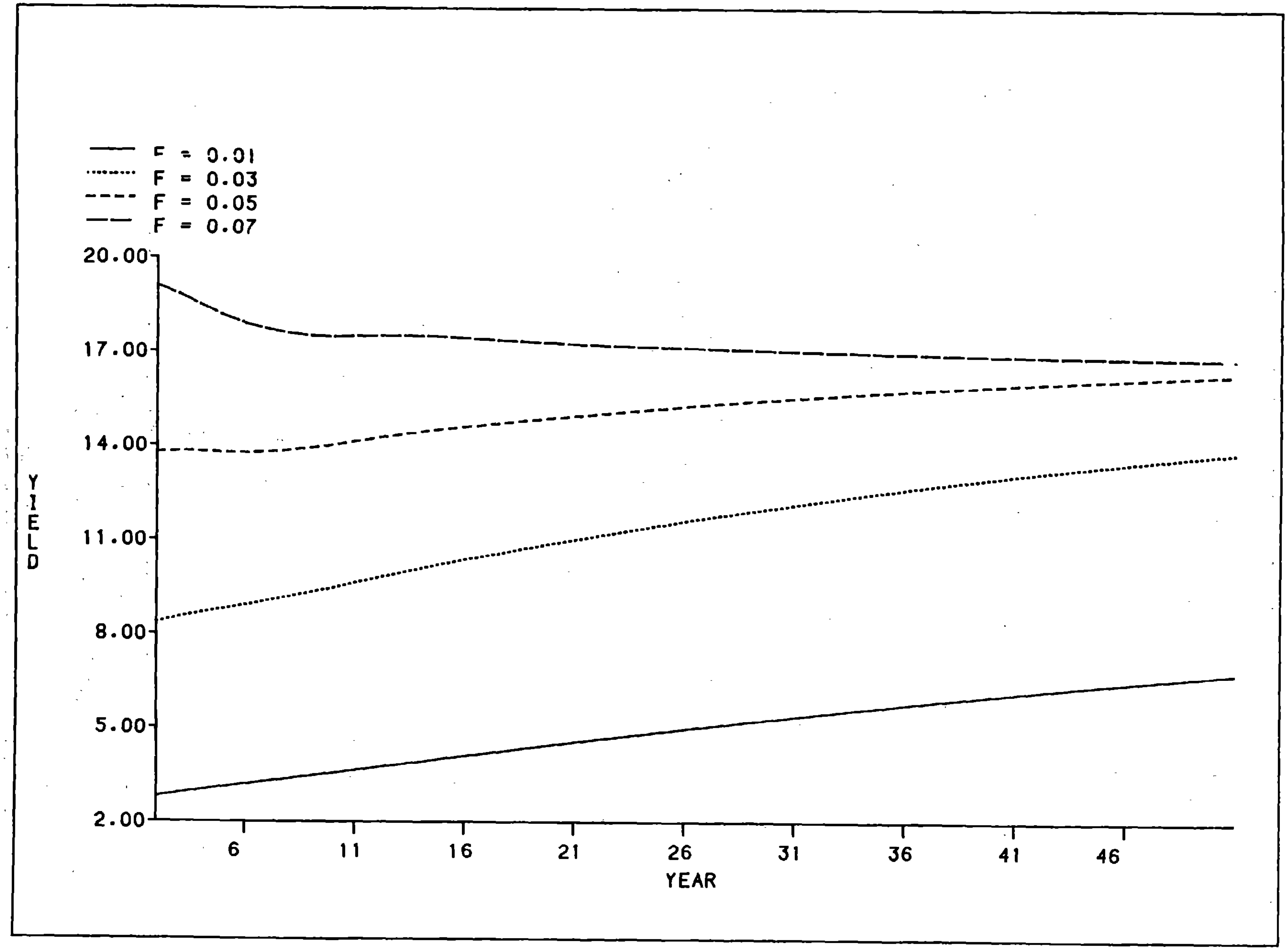

Figure 27. Yield (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 2.

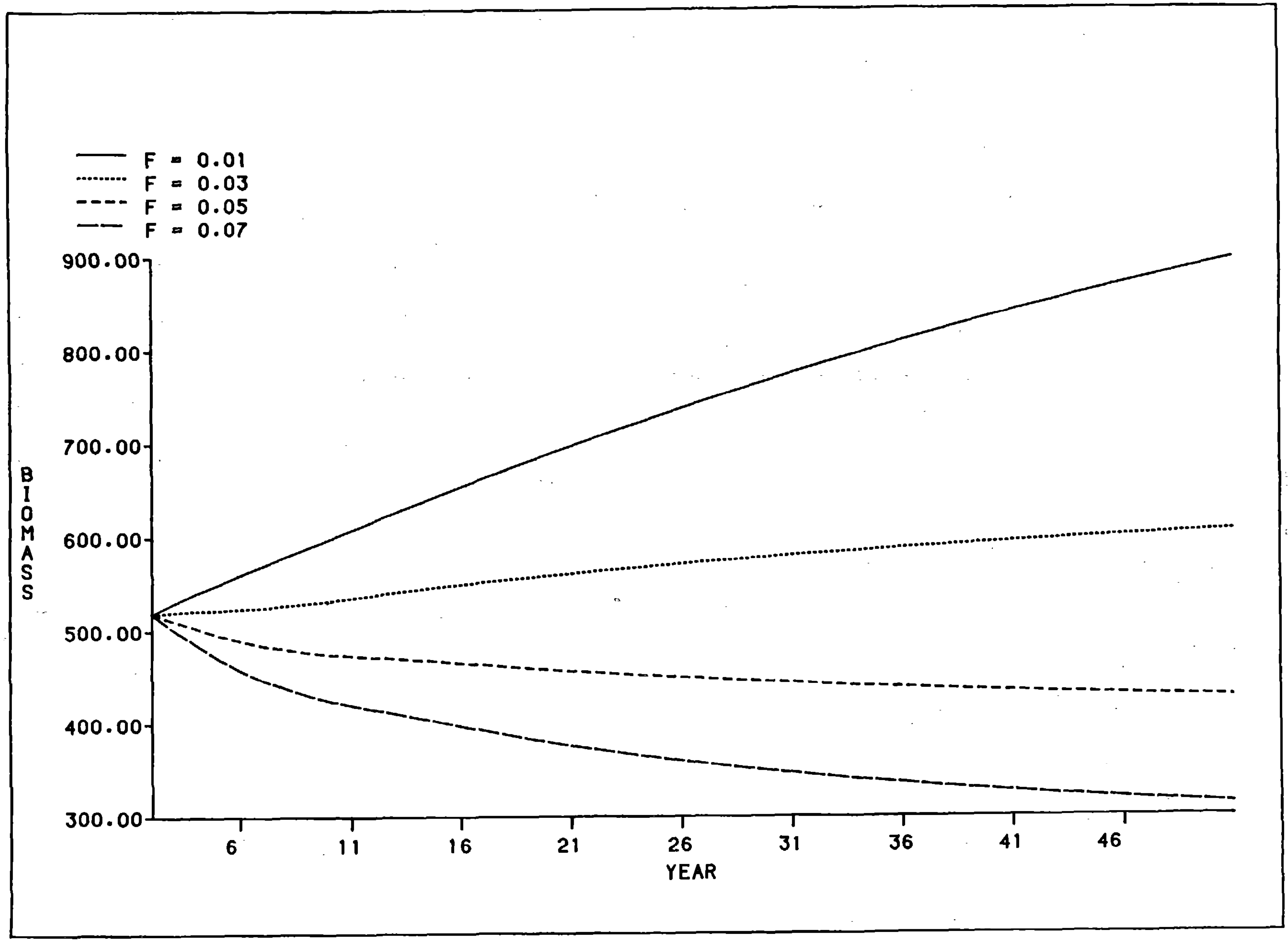

Figure 28. Biomass (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 3.

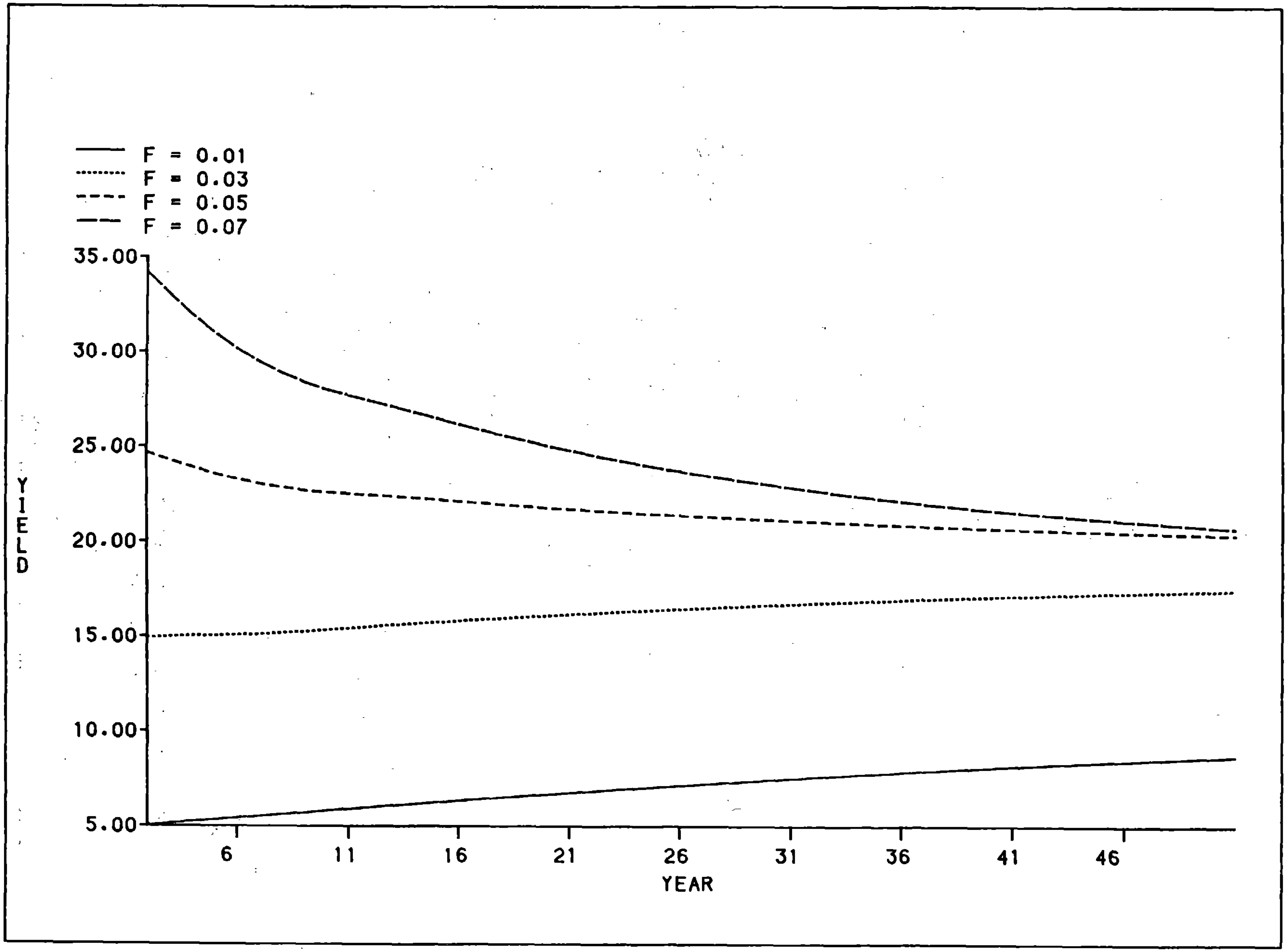

Figure 29. Yield (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 3.

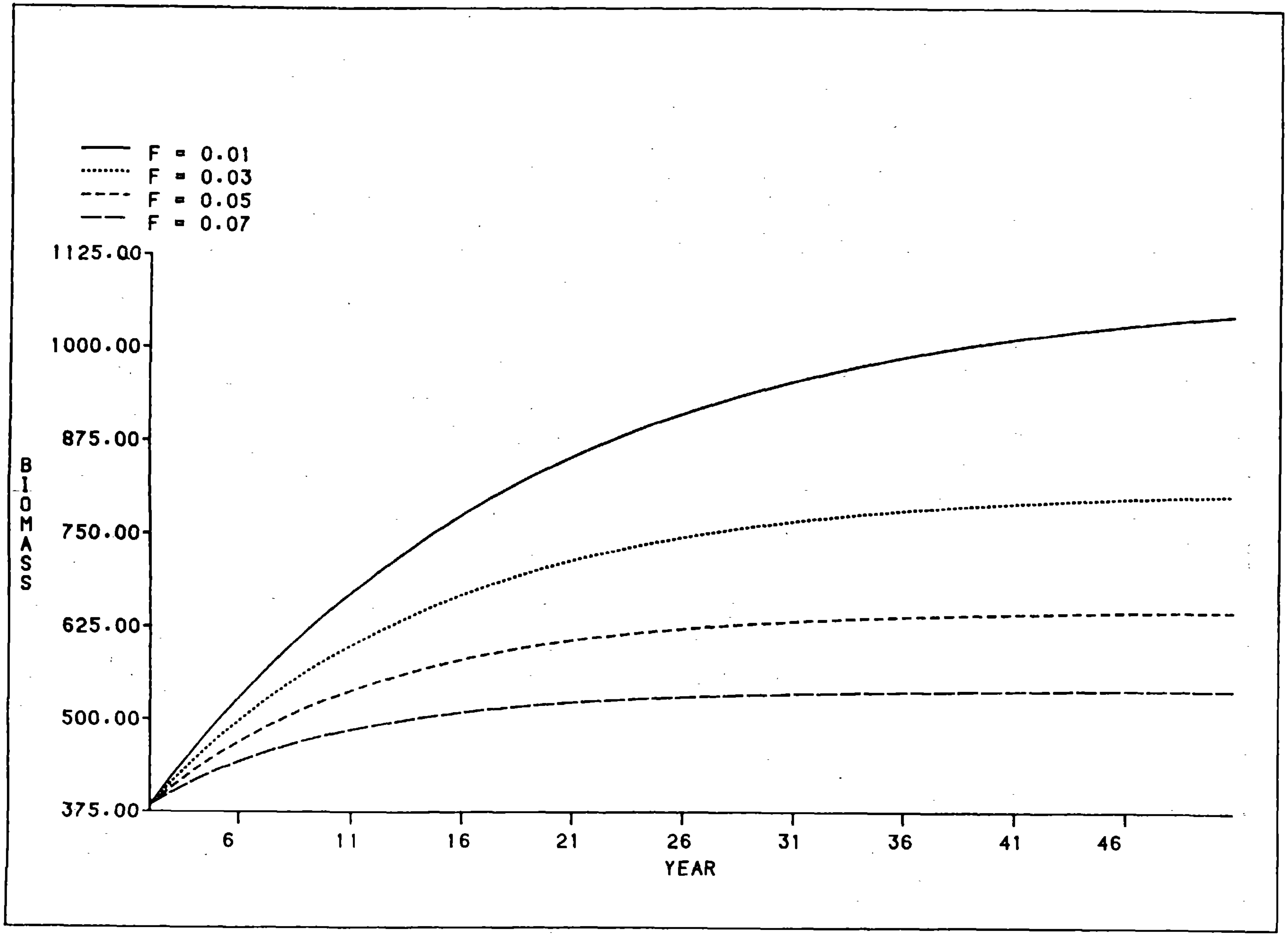

Figure 30. Biomass (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 4.

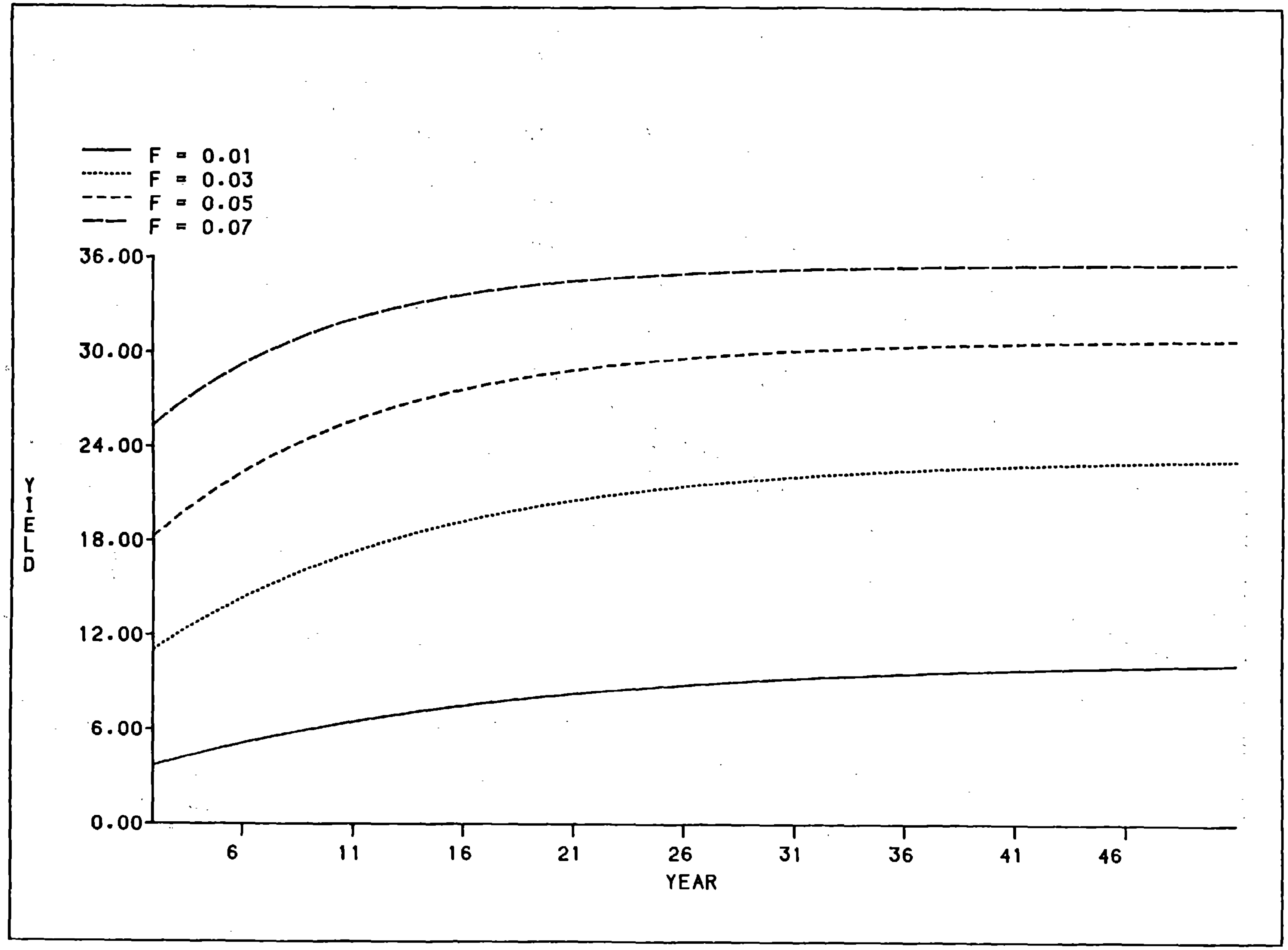

Figure 31. Yield (1,000 t) time paths of 4 F's for the Gulf of Alaska region, case 4.

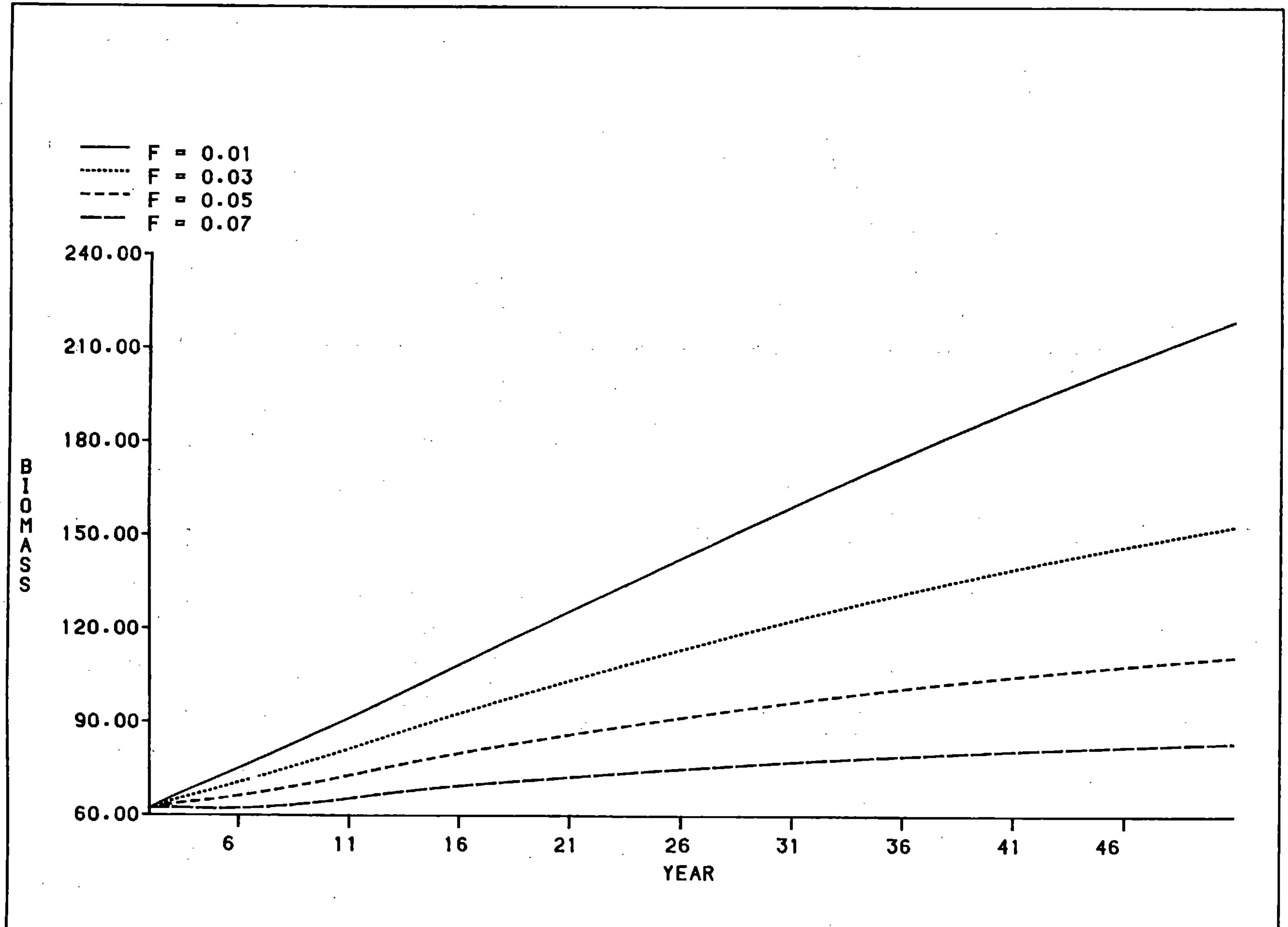

Figure 32. Biomass (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 1.

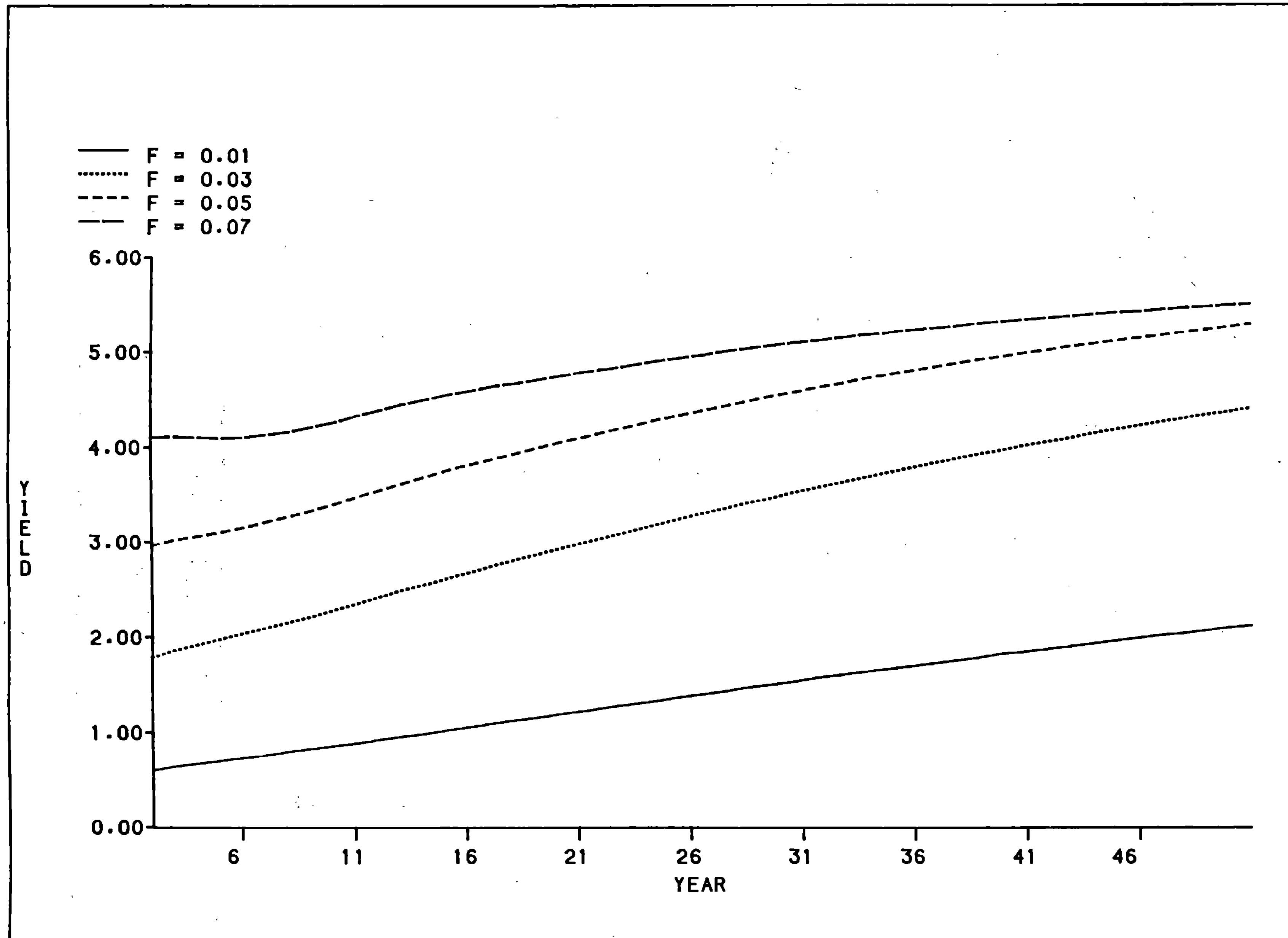

Figure 33. Yield (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 1.

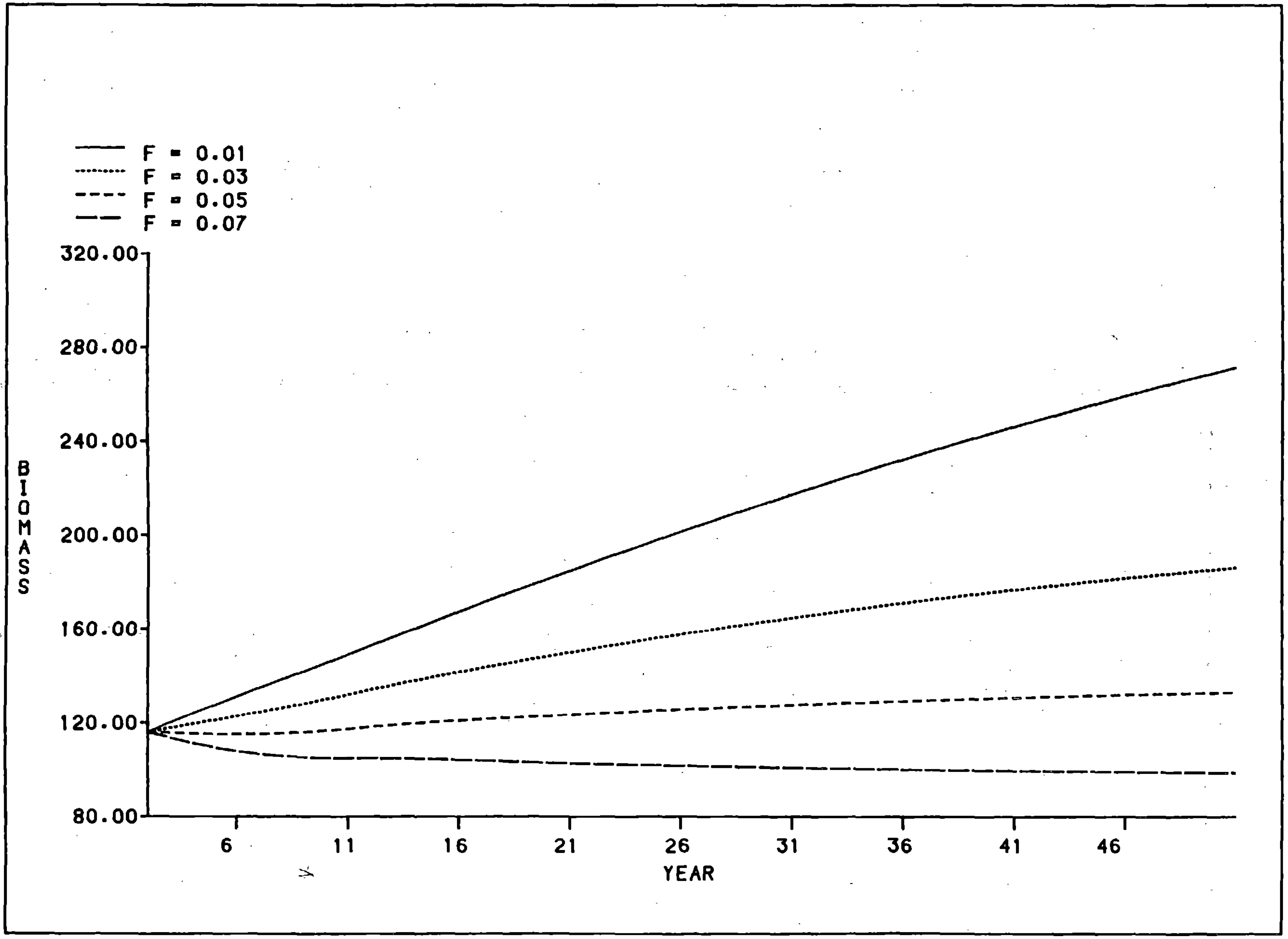

Figure 34. Biomass (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 2.

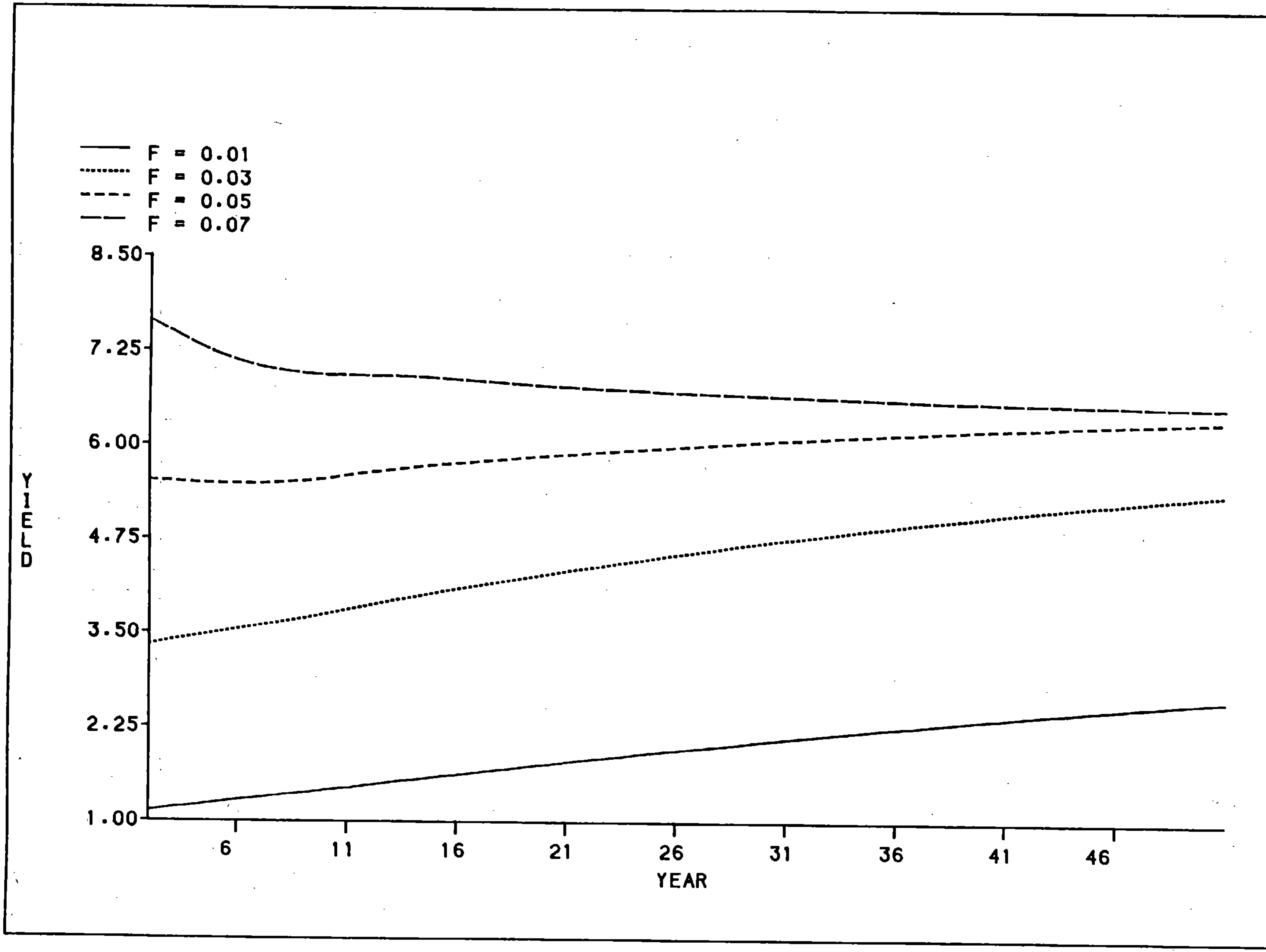

Figure 35. Yield (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 2.

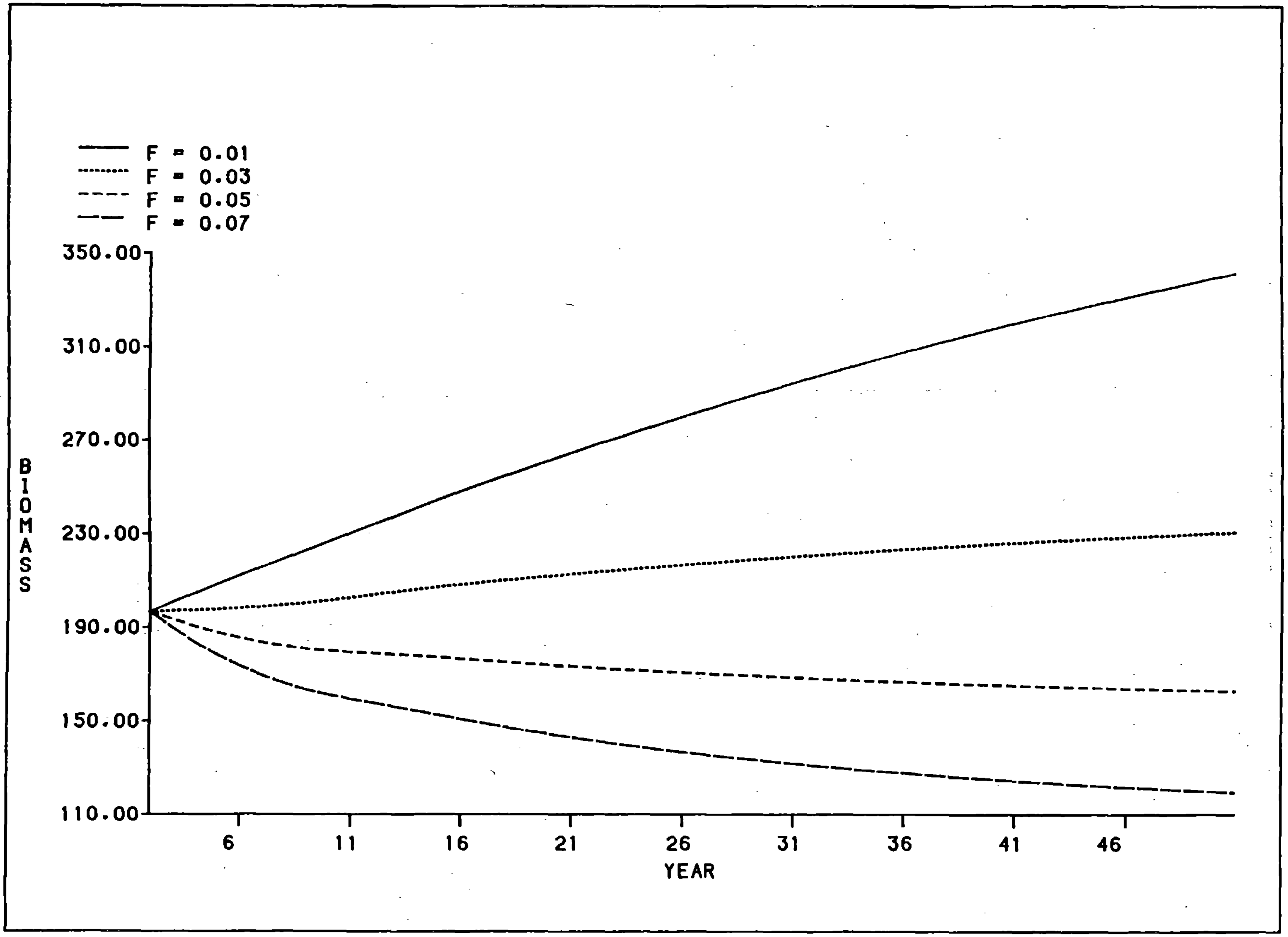

Figure 36. Biomass (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 3.

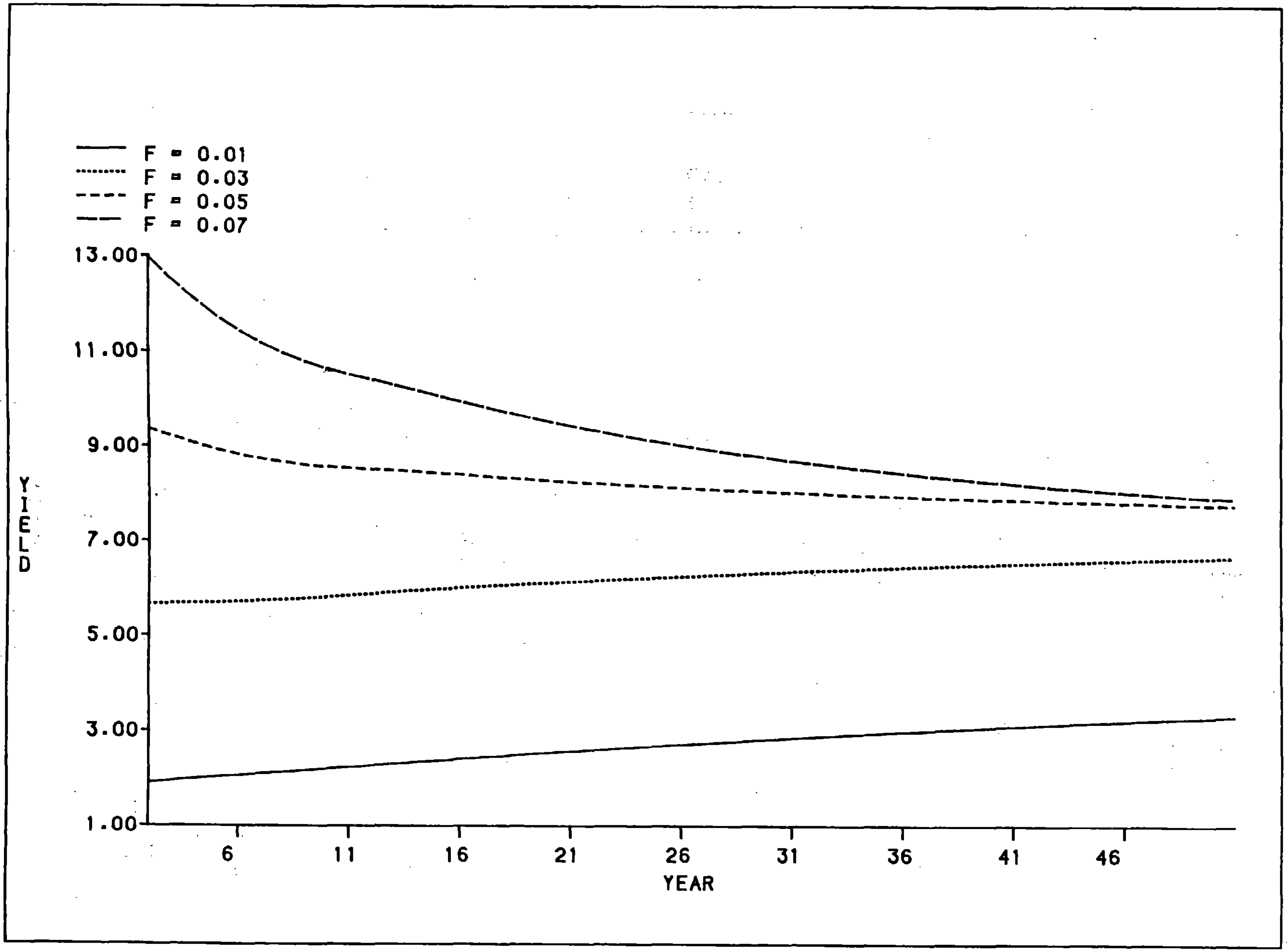

Figure 37. Yield (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 3.

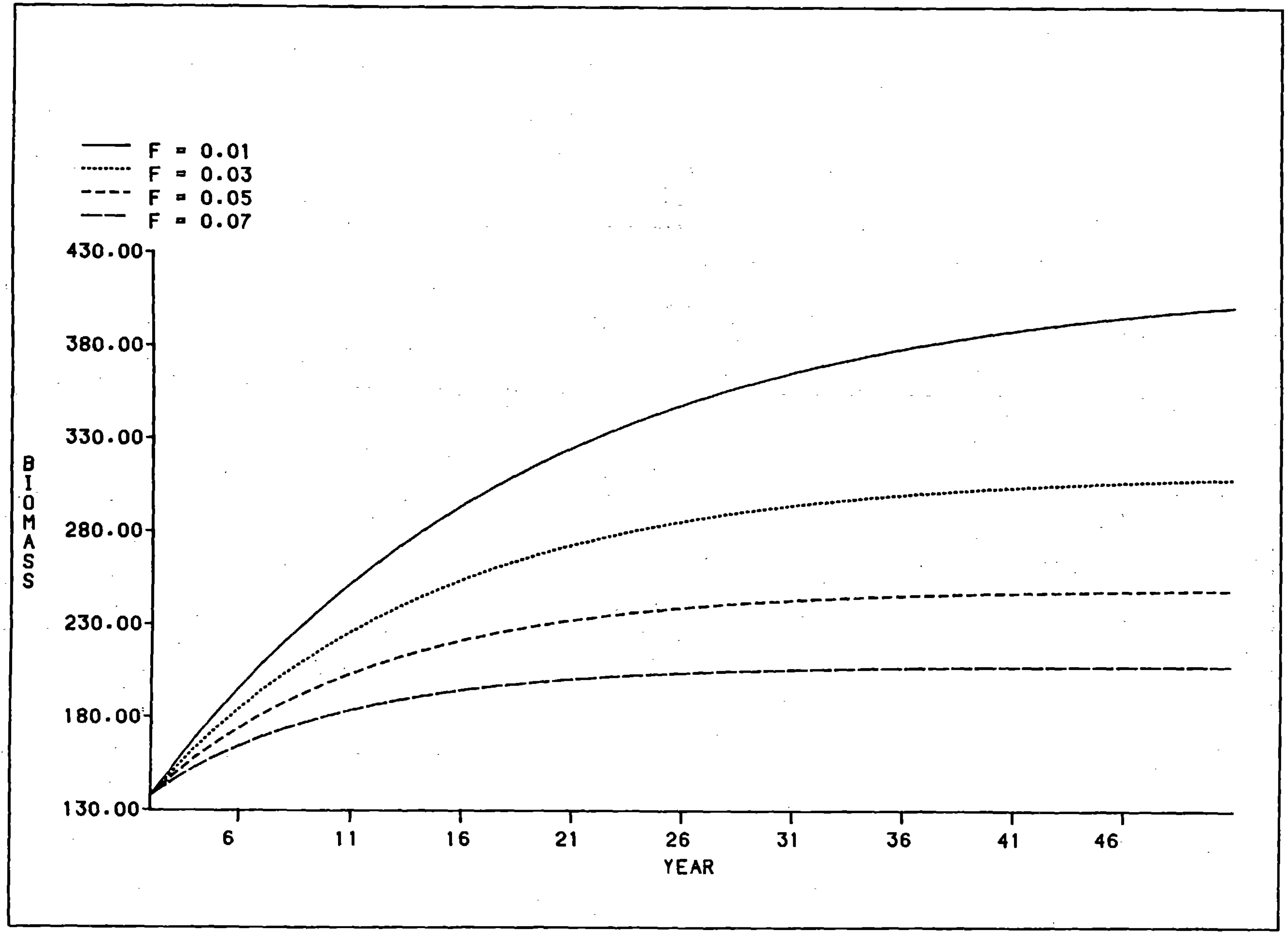

Figure 38. Biomass (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 4.

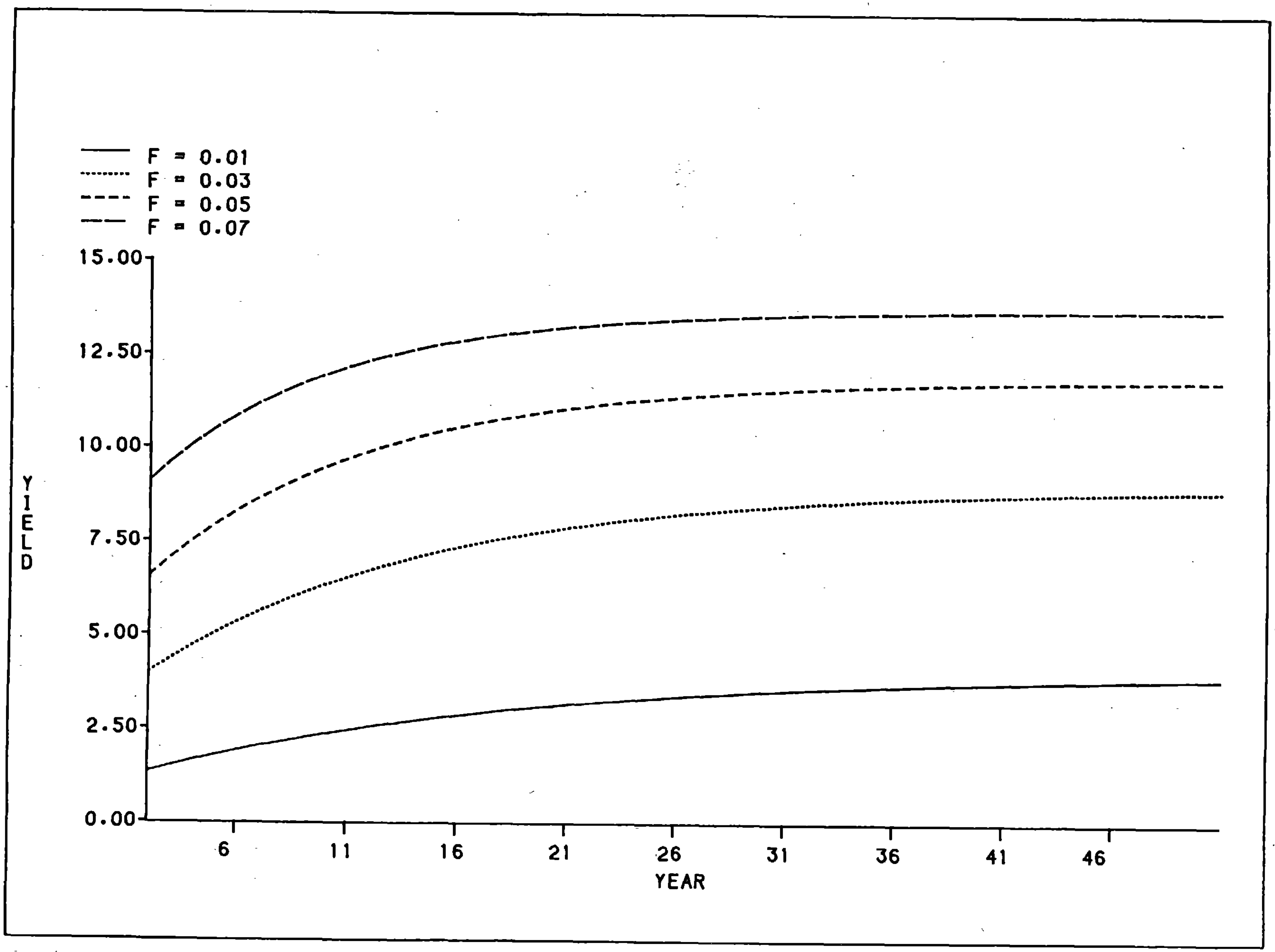

Figure 39. Yield (1,000 t) time paths of 4 F's for the Aleutian Islands region, case 4.

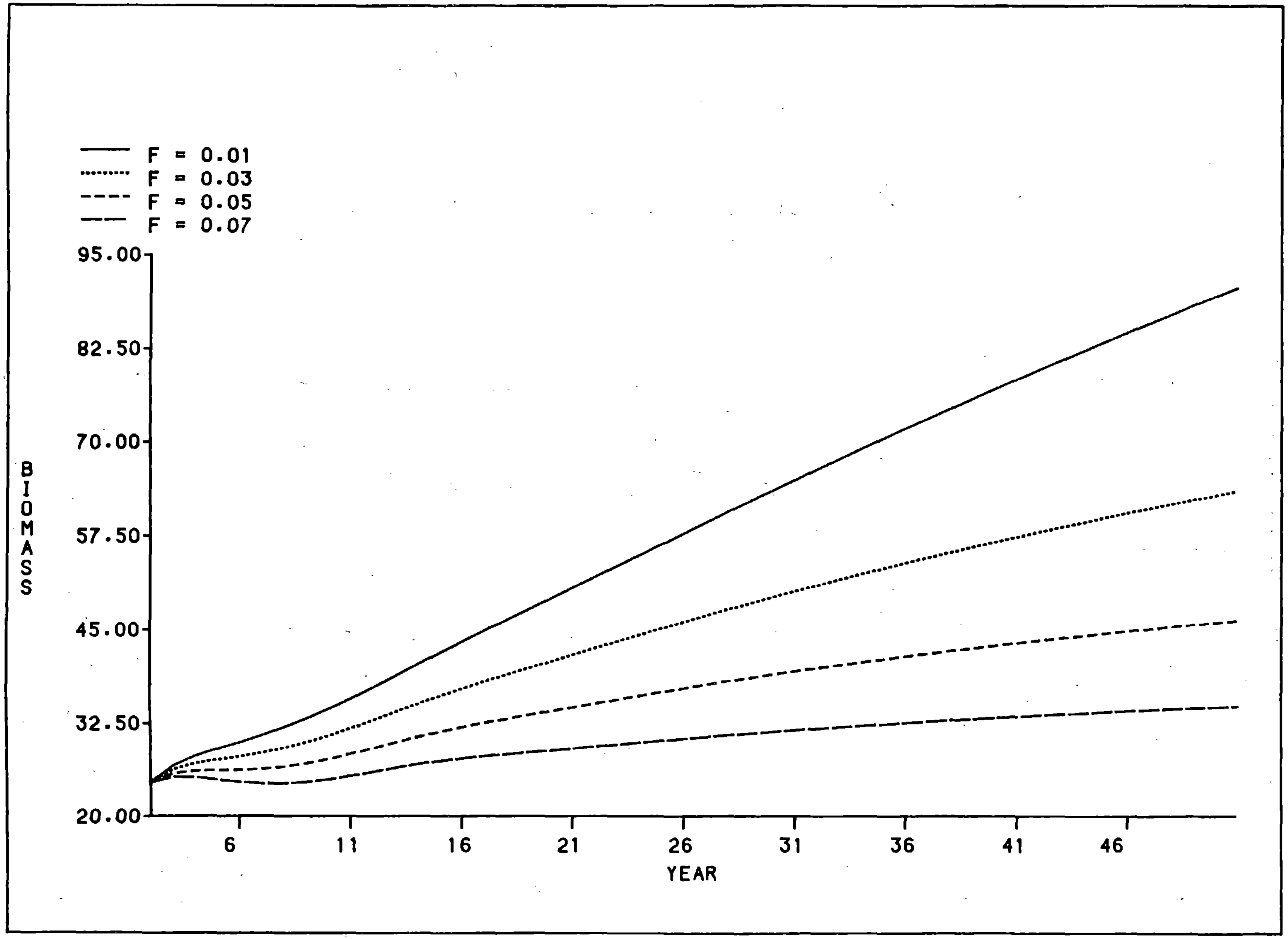

Figure 40. Biomass (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 1.

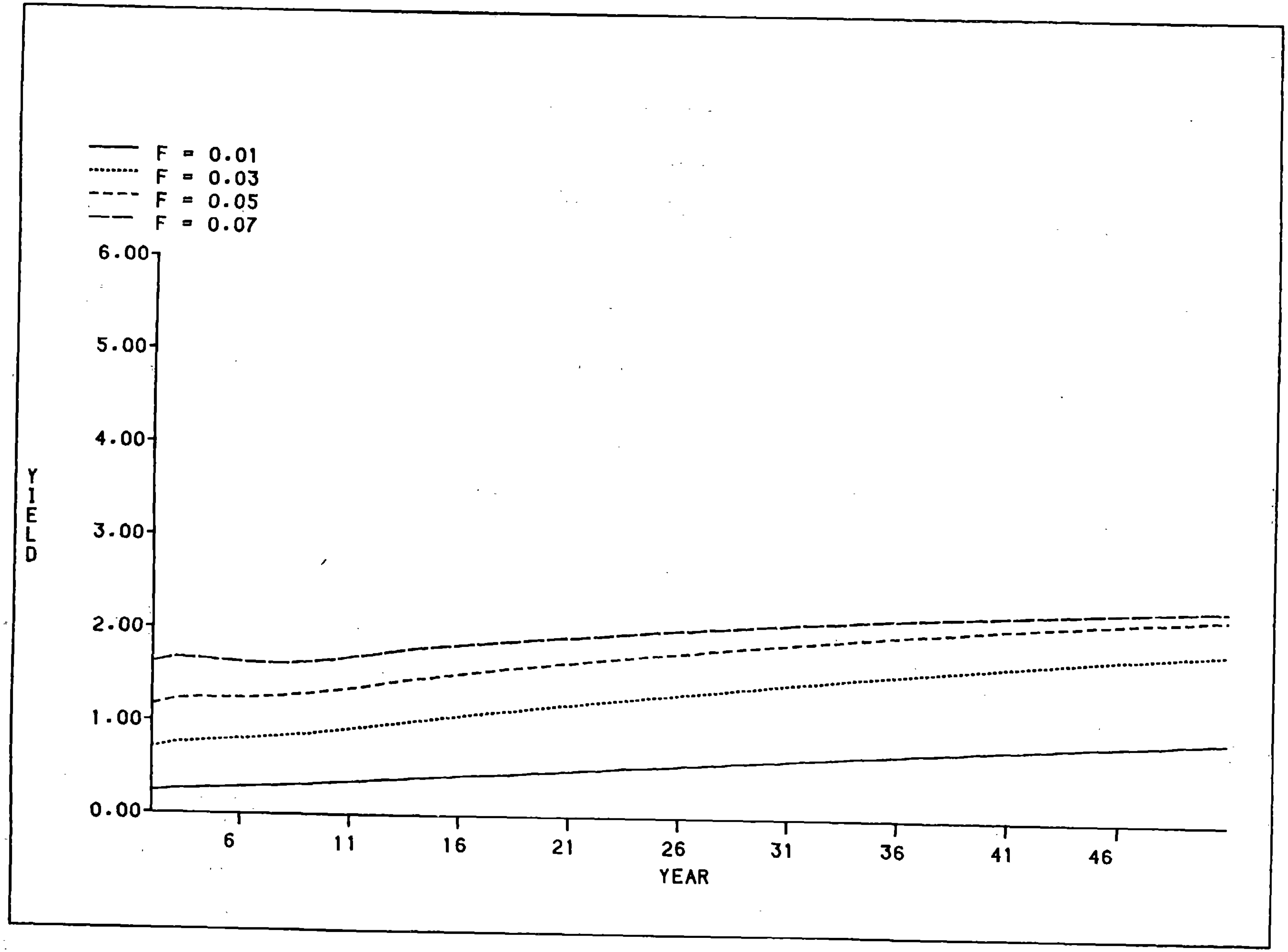

Figure 41. Yield (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 1.

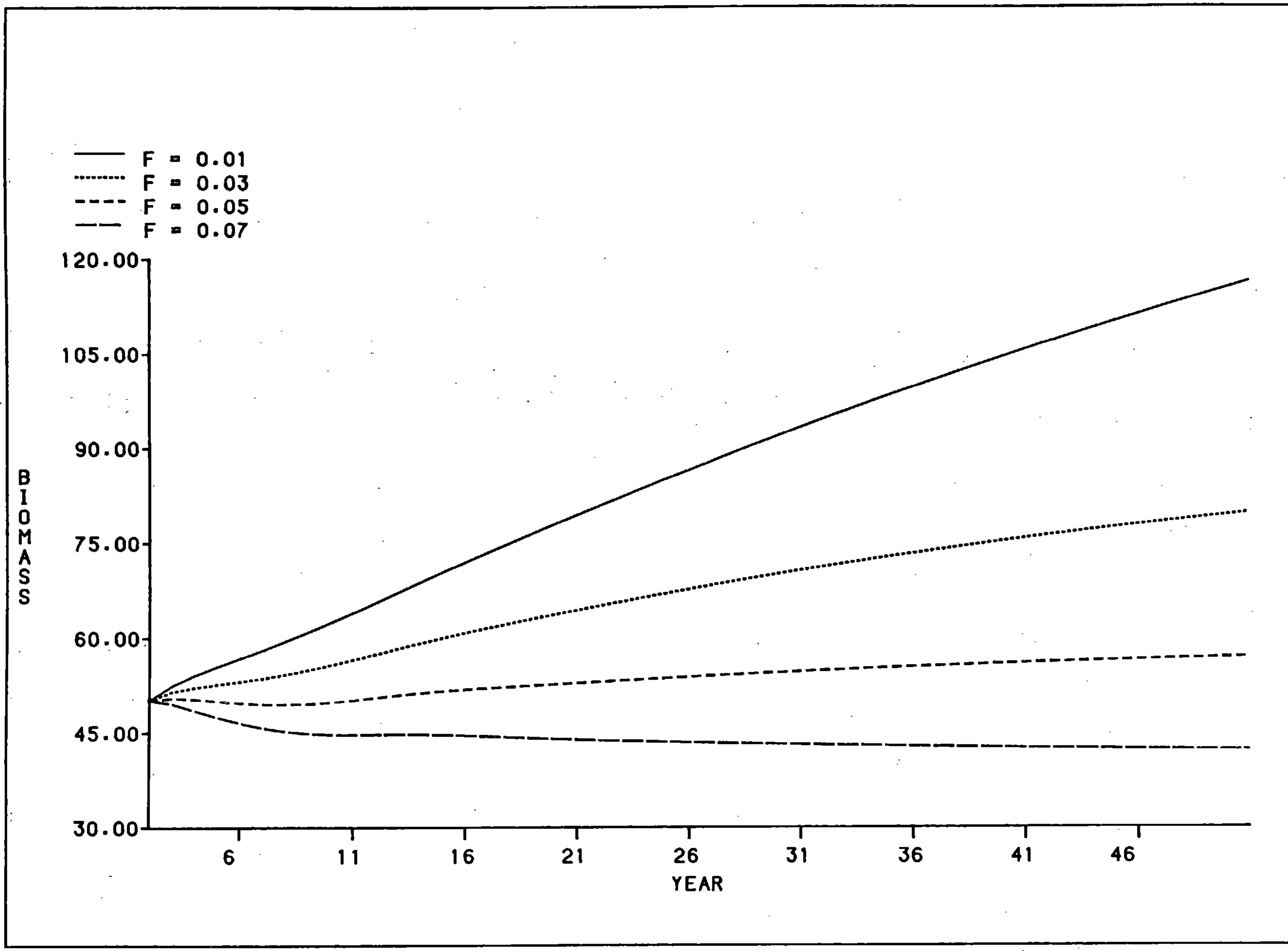

Figure 42. Biomass (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 2.

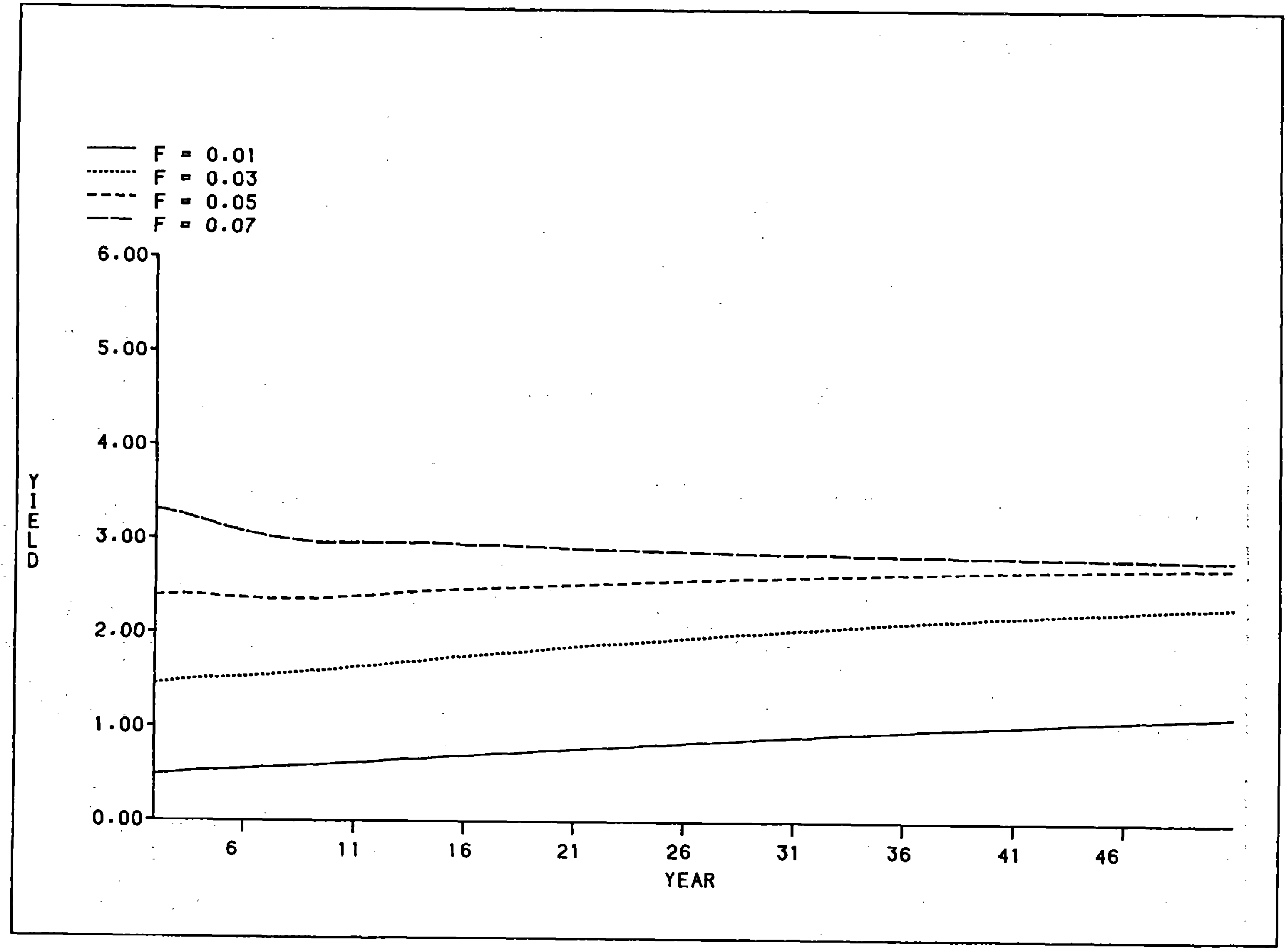

Figure 43. Yield (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 2.

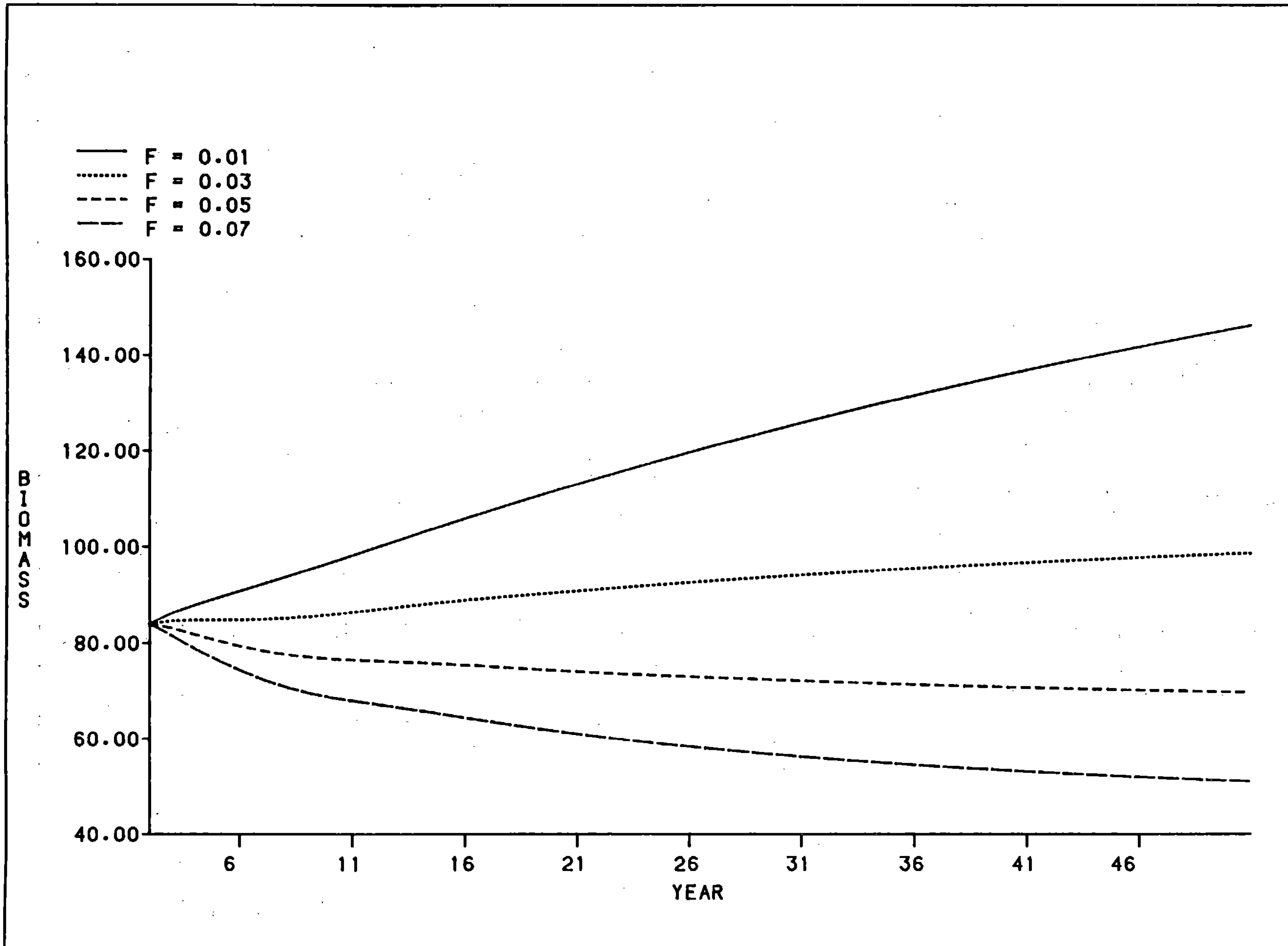

Figure 44. Biomass (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 3.

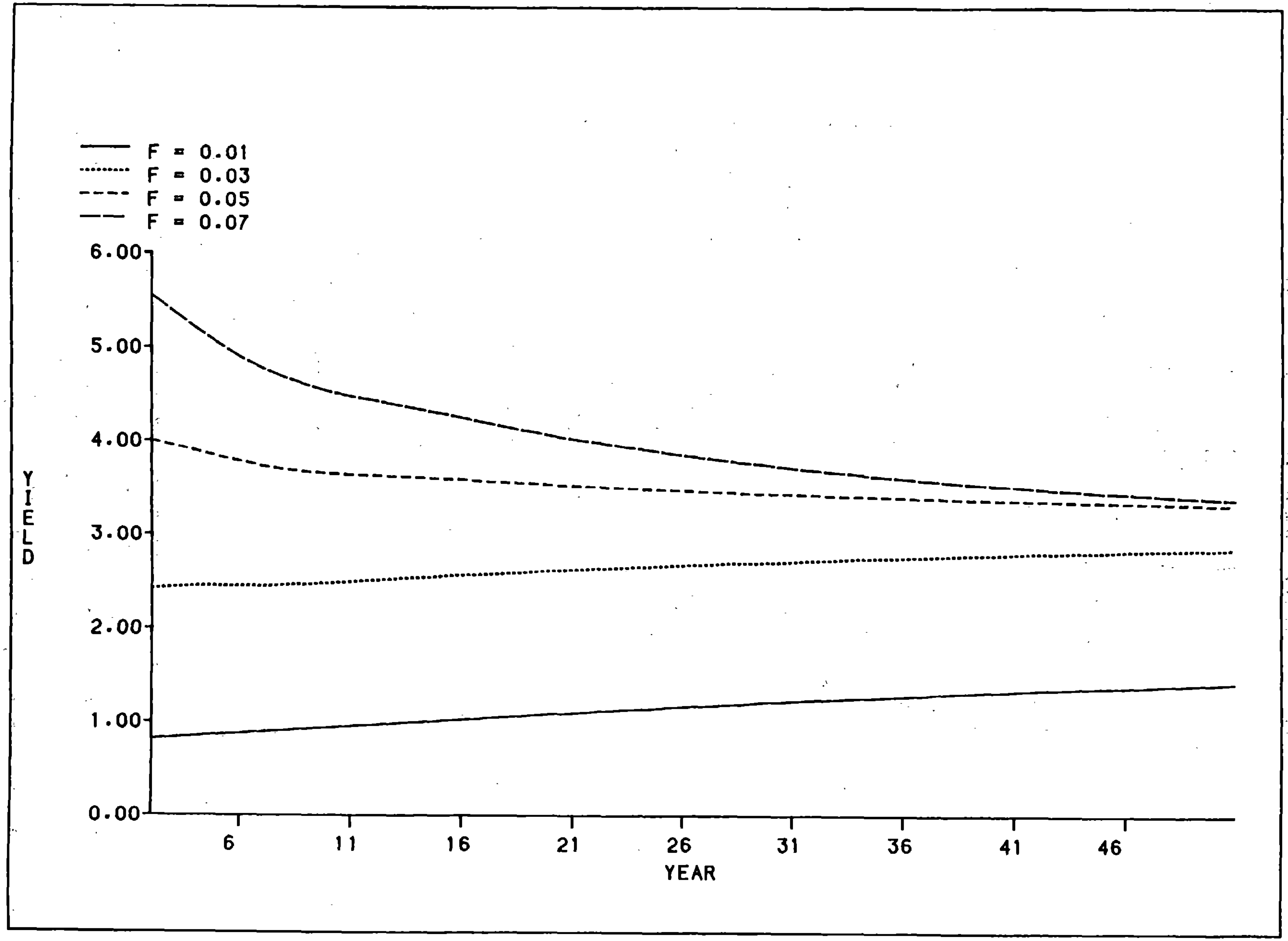

Figure 45. Yield (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 3

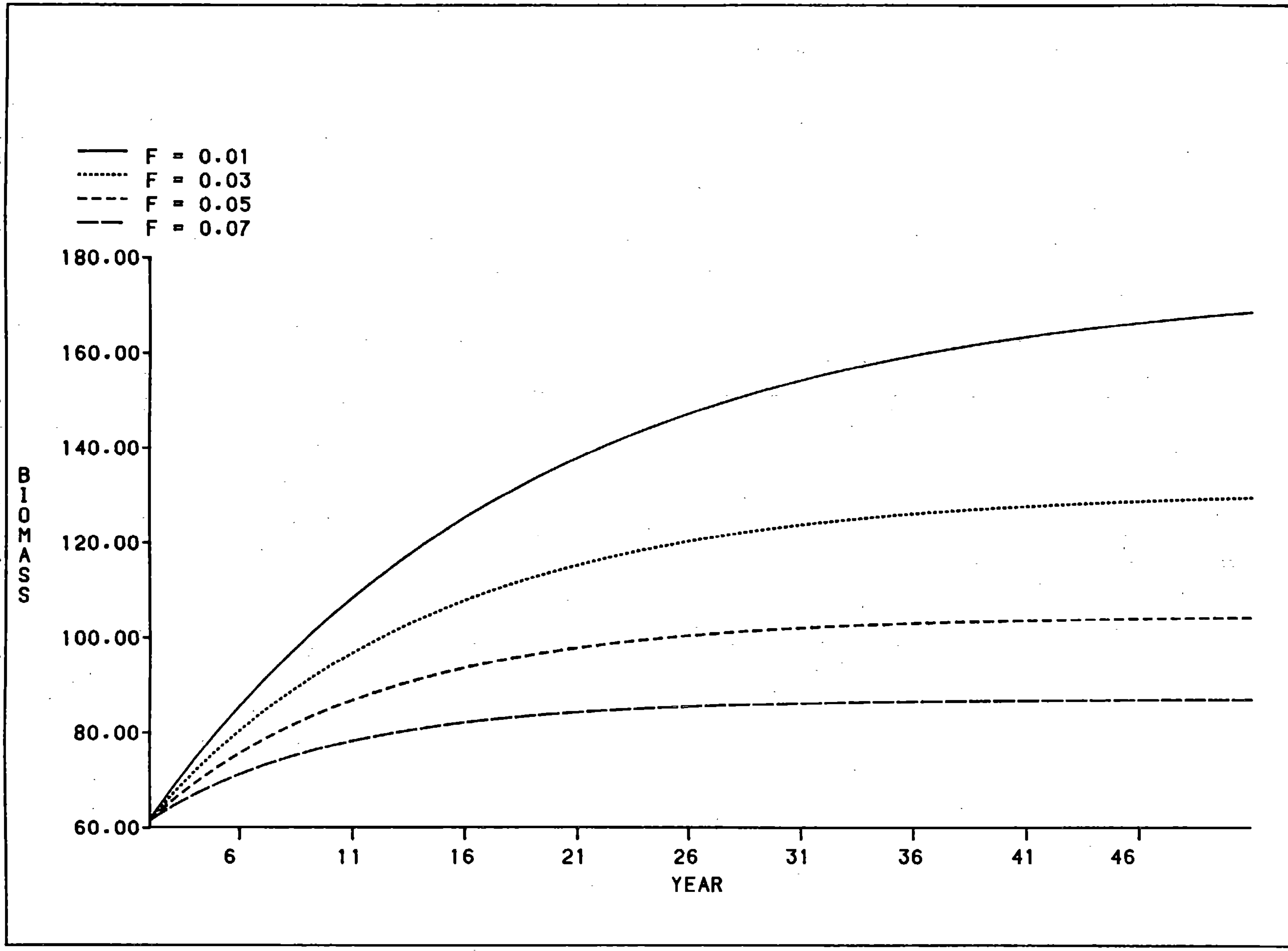

Figure 46. Biomass (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 4

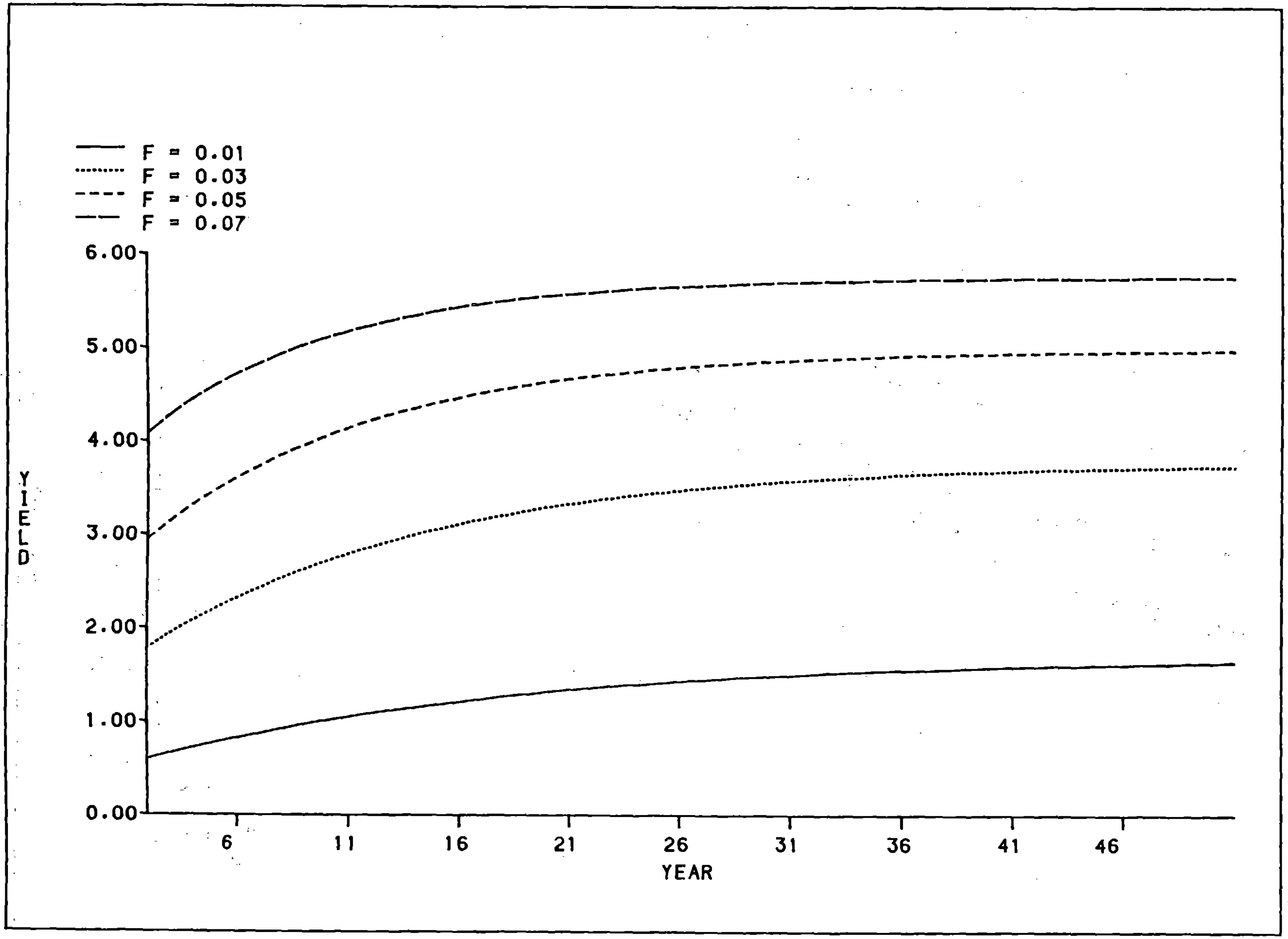

Figure 47. Yield (1,000 t) time paths of 4 F's for the eastern Bering Sea region, case 4.

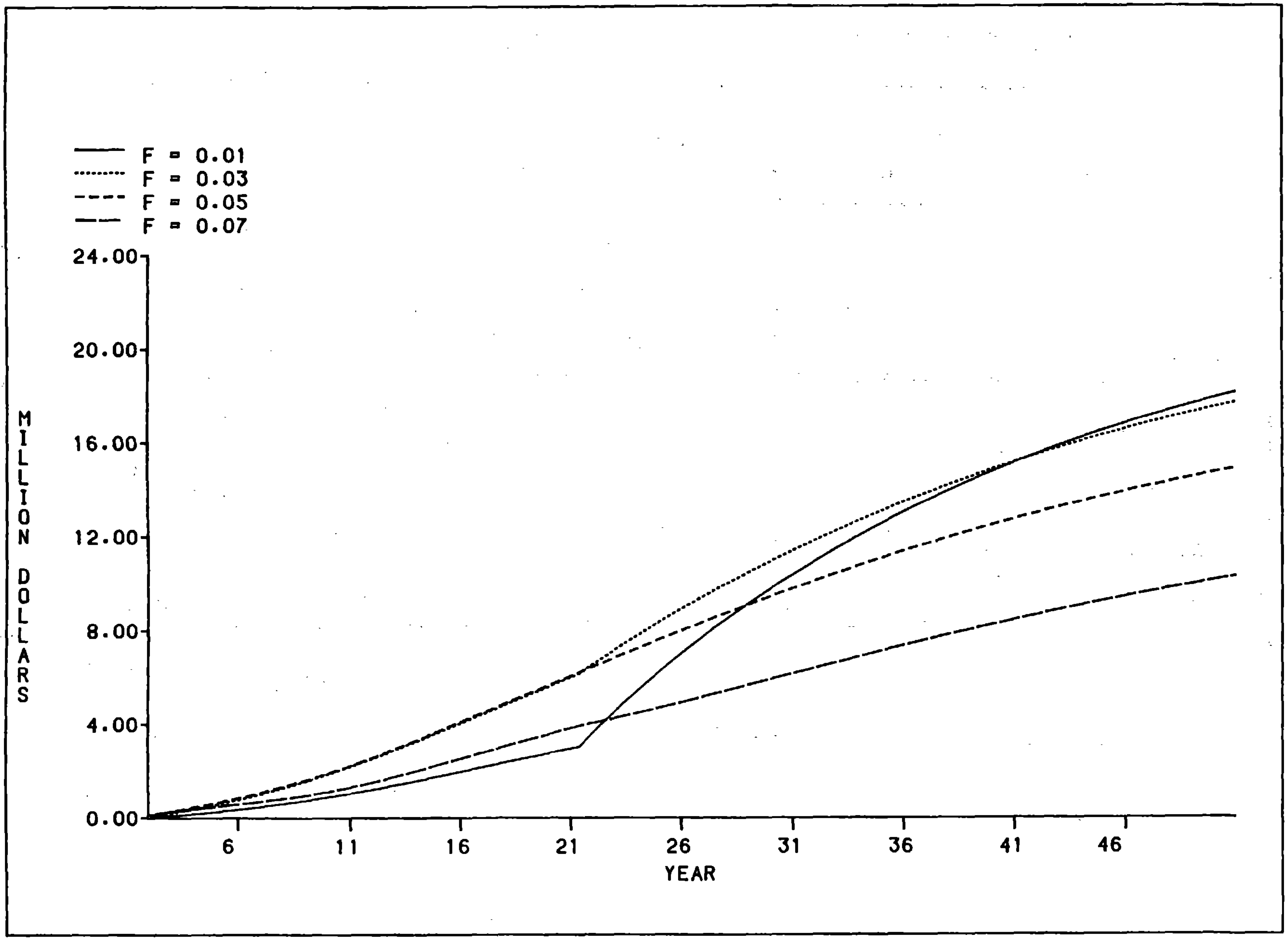

Figure 48. Cumulative discounted profit time paths of 4 F's for the Gulf of Alaska region, case 1.

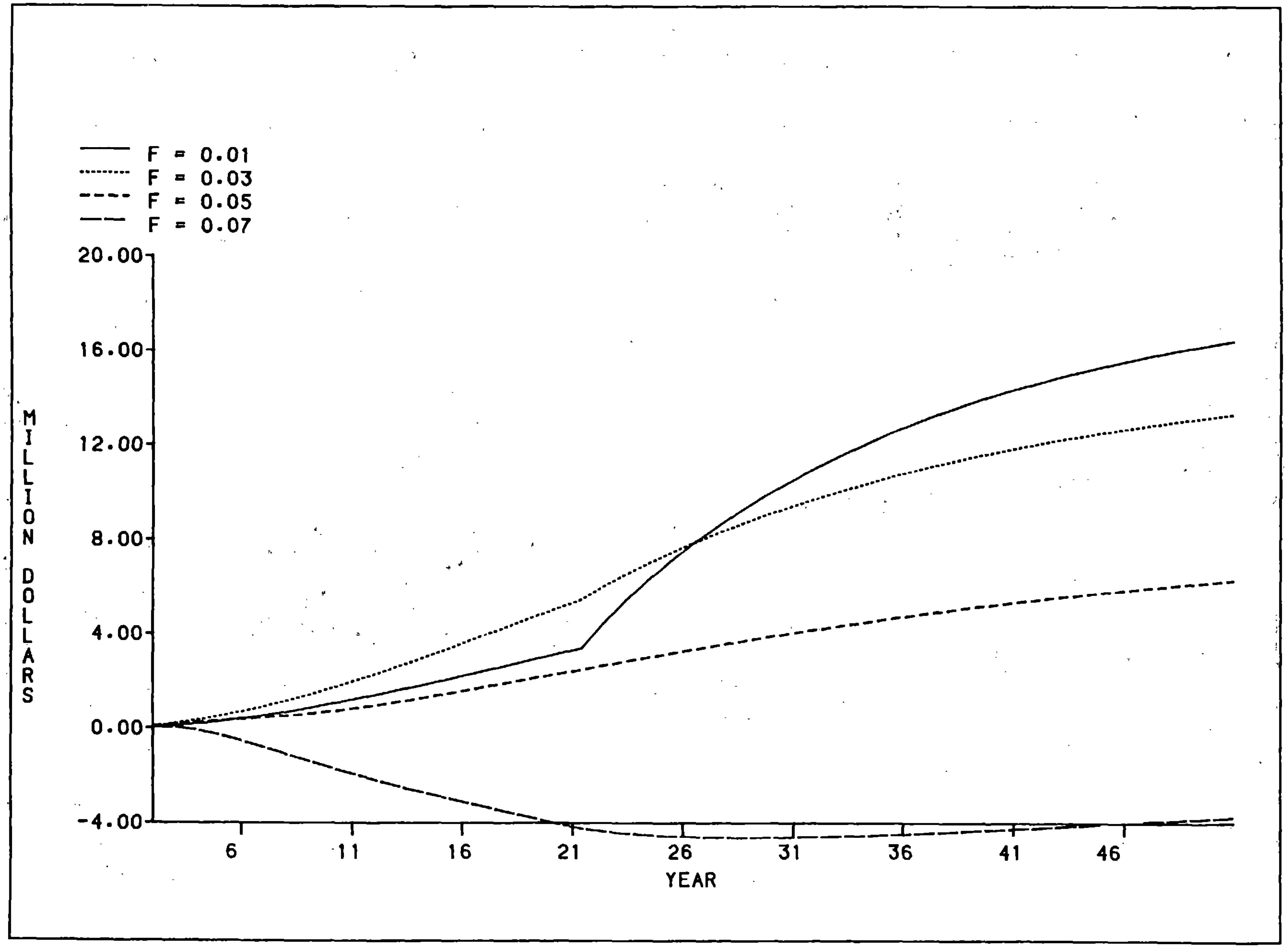

Figure 49. Cumulative discounted profit time paths of 4 F's for the Gulf of Alaska region, case 2.

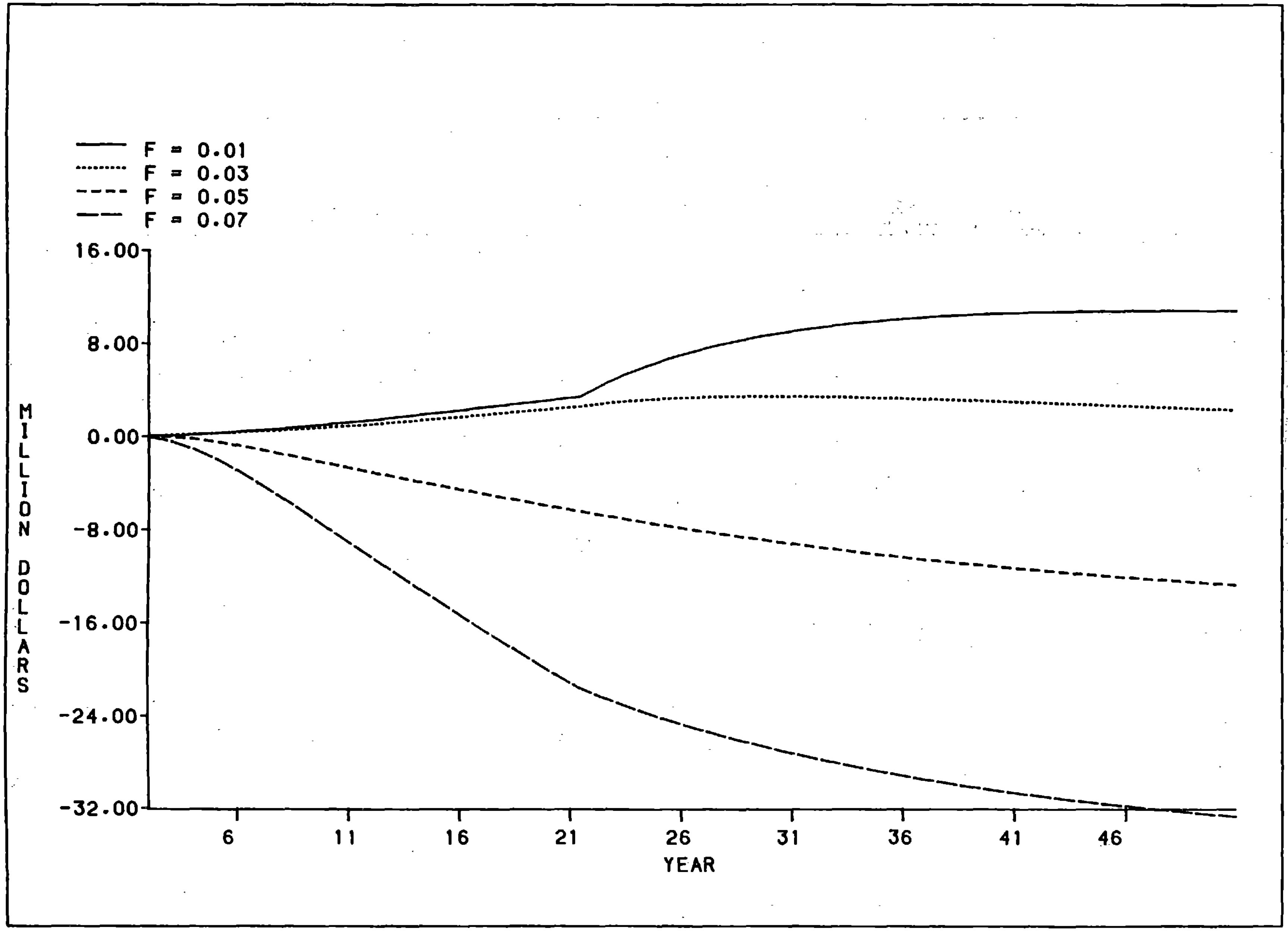

Figure 50. Cumulative discounted profit time paths of 4 F's for the Gulf of Alaska region, case 3.

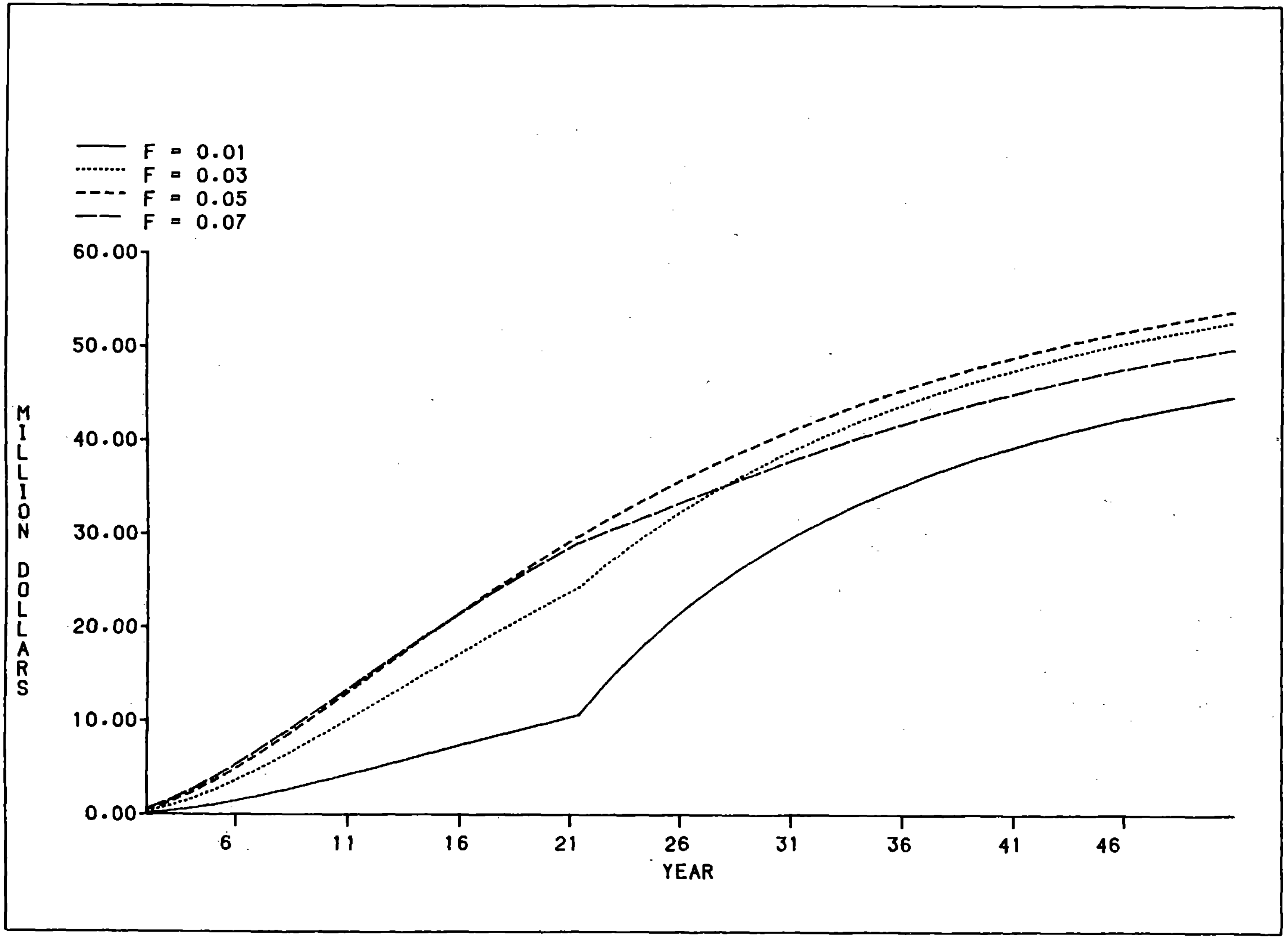

Figure 51. Cumulative discounted profit time paths of 4 F's for the Gulf of Alaska region, case 4.

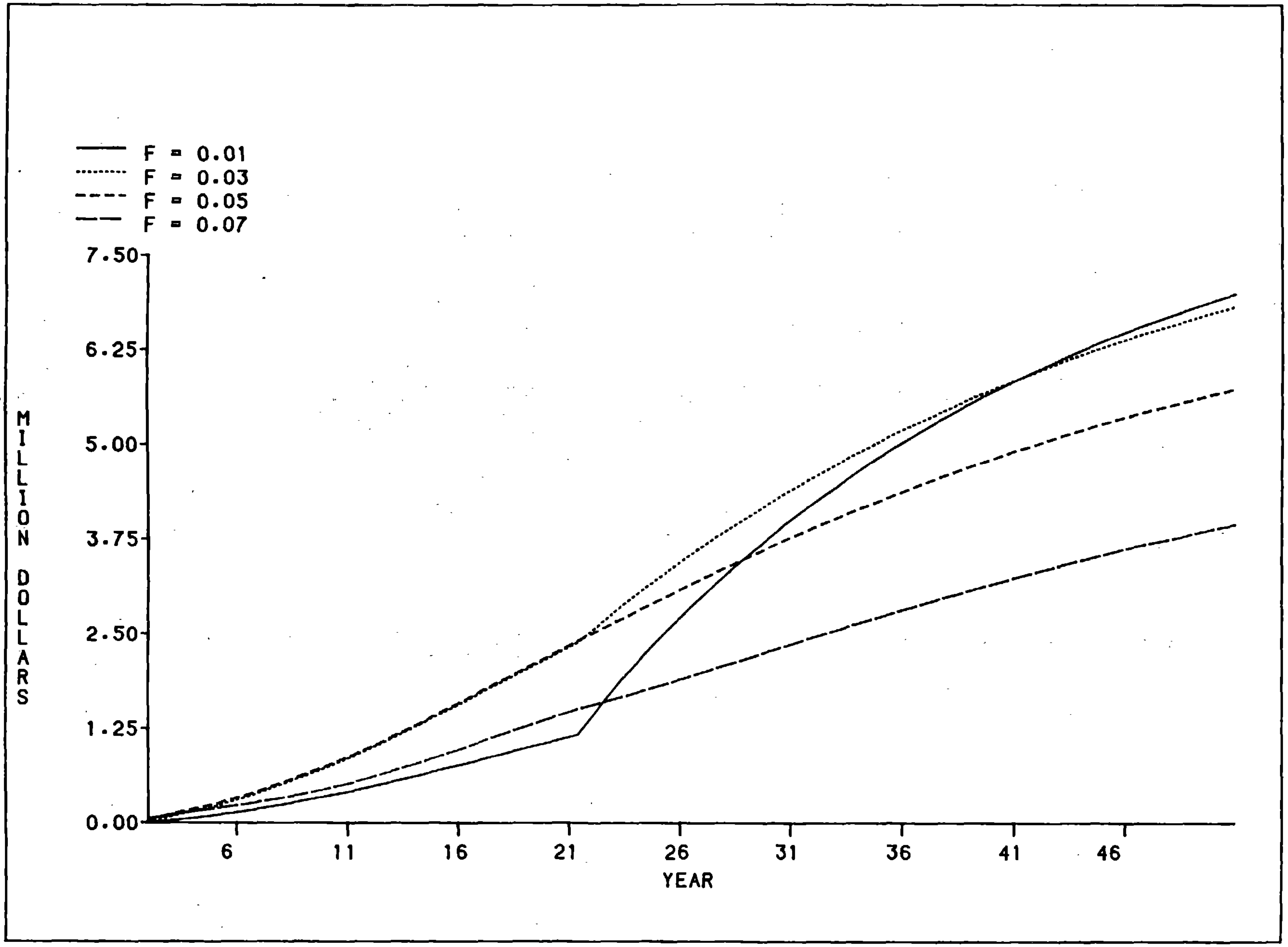

Figure 52. Cumulative discounted profit time paths of 4 F's for the Aleutian Islands region, case 1.

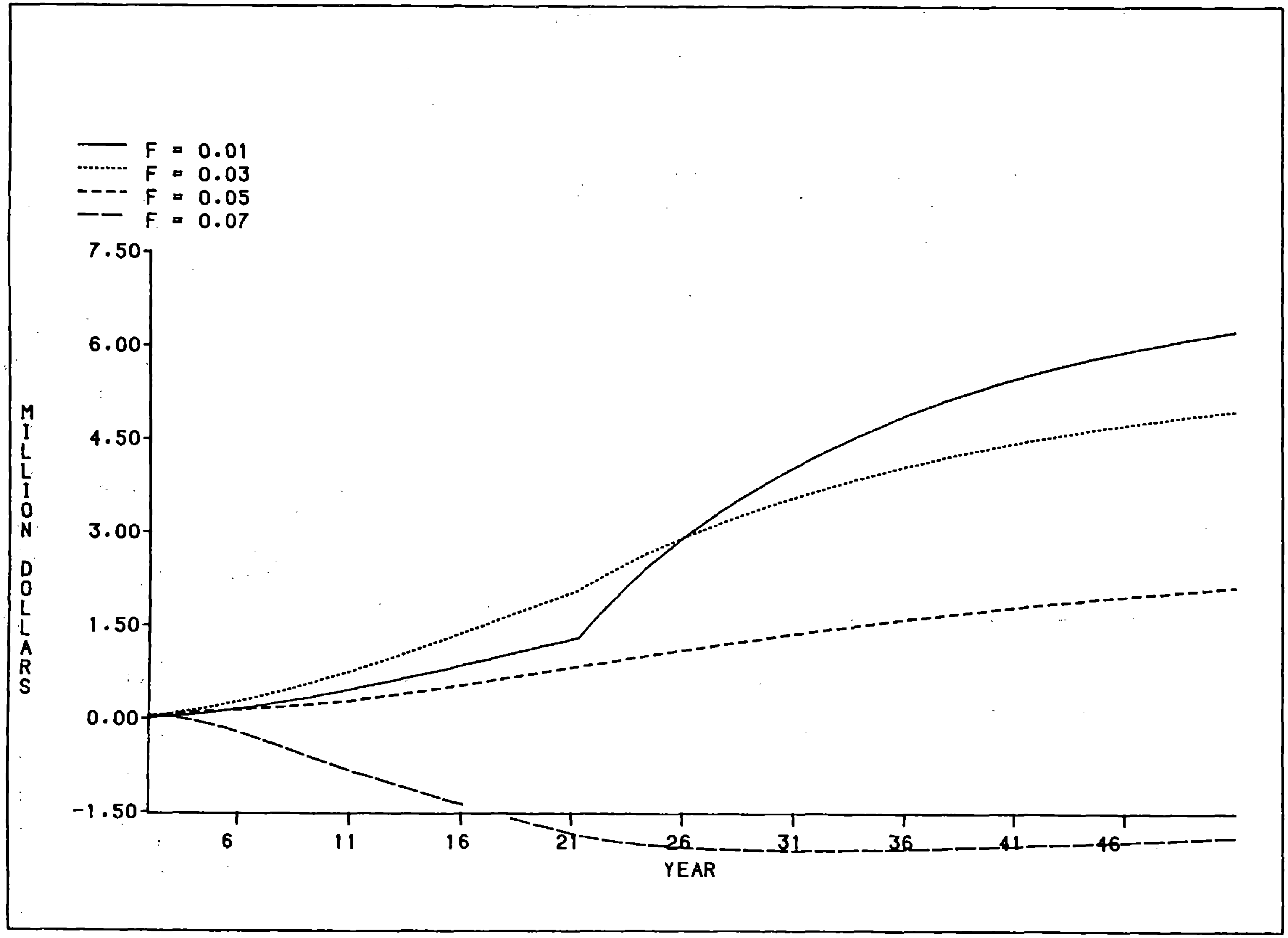

Figure 53. Cumulative discounted profit time paths of 4 F's for the Aleutian Islands region, case 2.

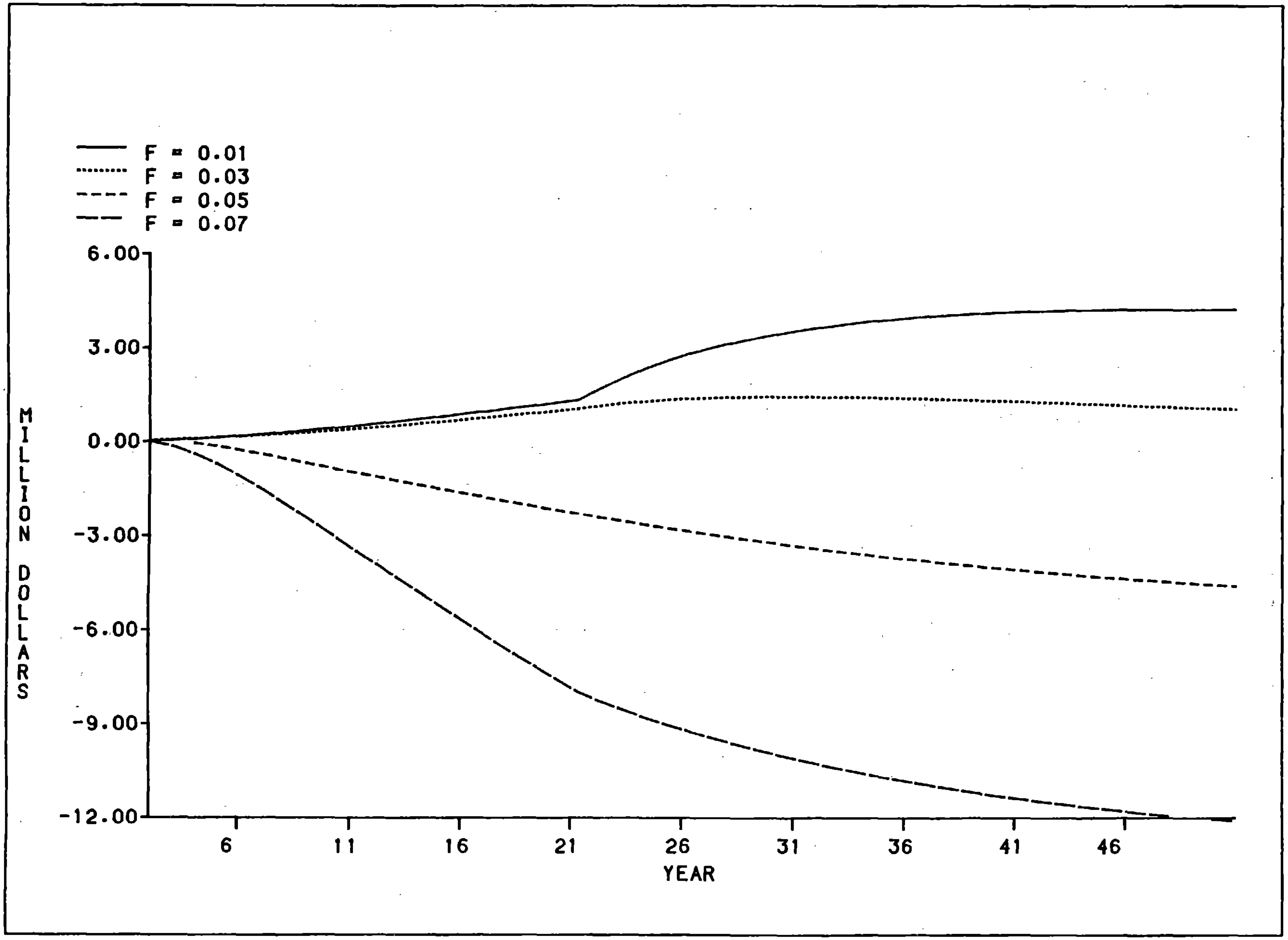

Figure 54. Cumulative discounted profit time paths of 4 F's for the Aleutian Islands region, case 3.

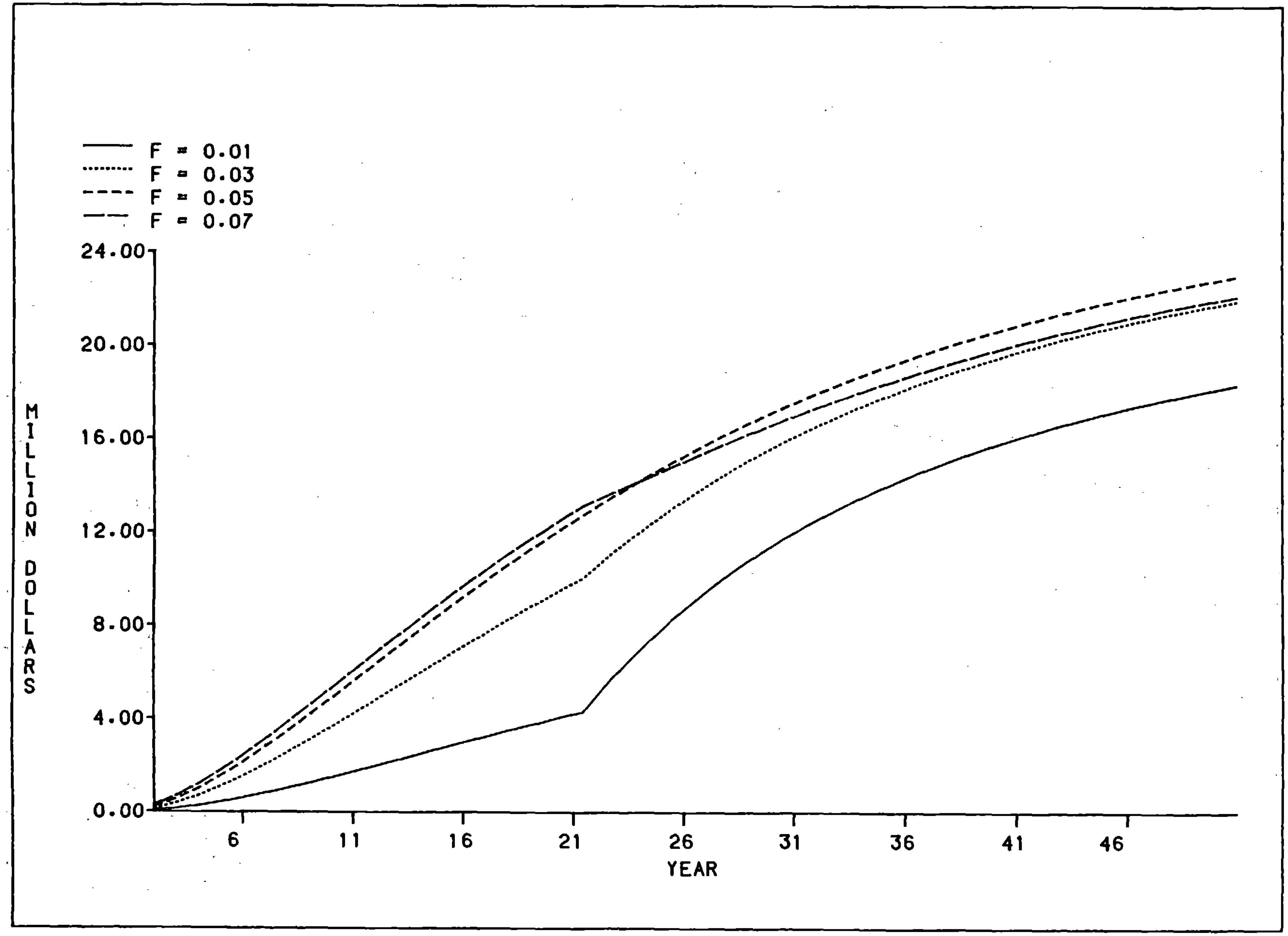

Figure 55. Cumulative discounted profit time paths of 4 F's for the Aleutian Islands region, case 4.

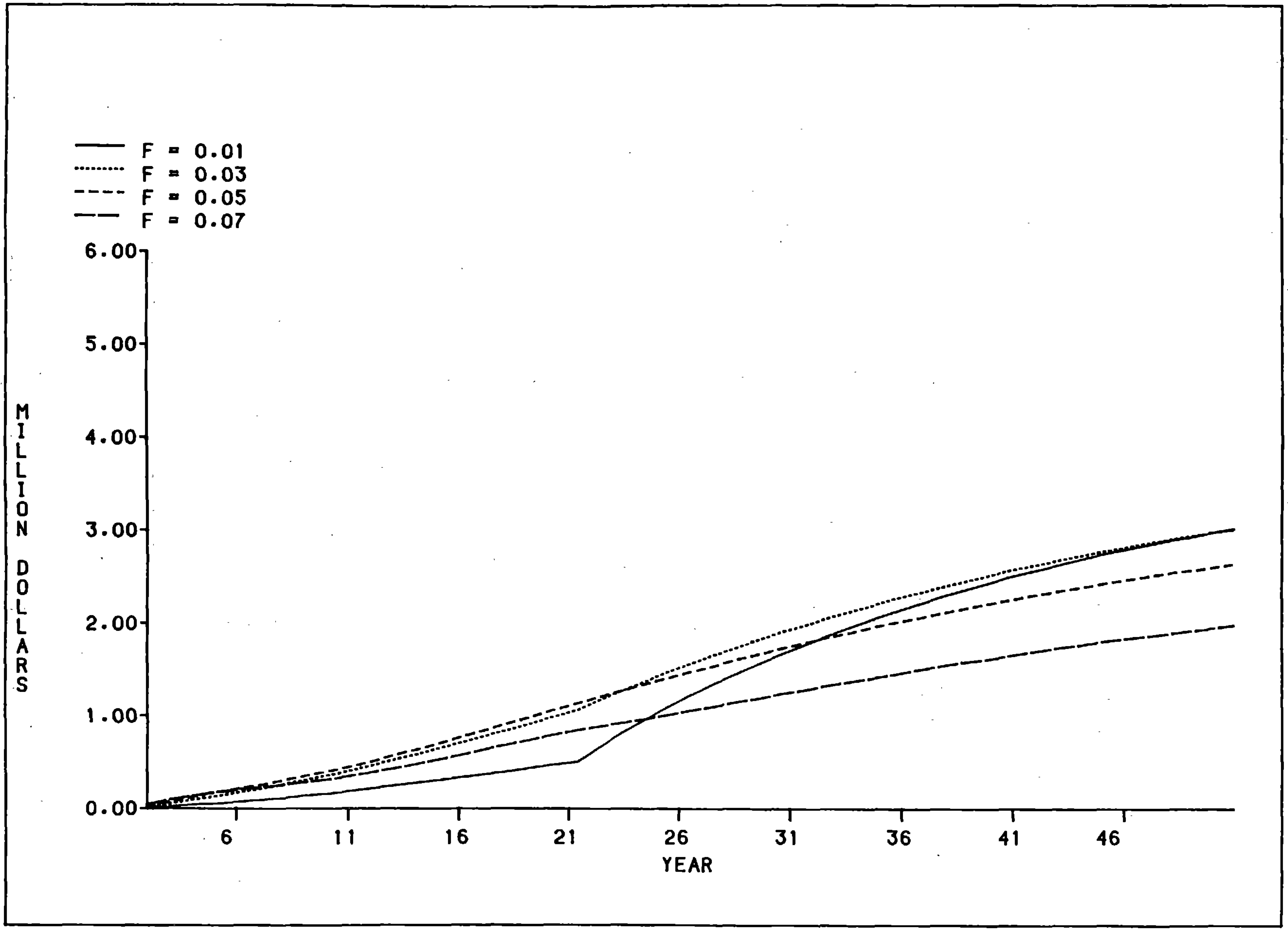

Figure 56. Cumulative discounted profit time paths of 4 F's for the eastern Bering Sea region, case 1.

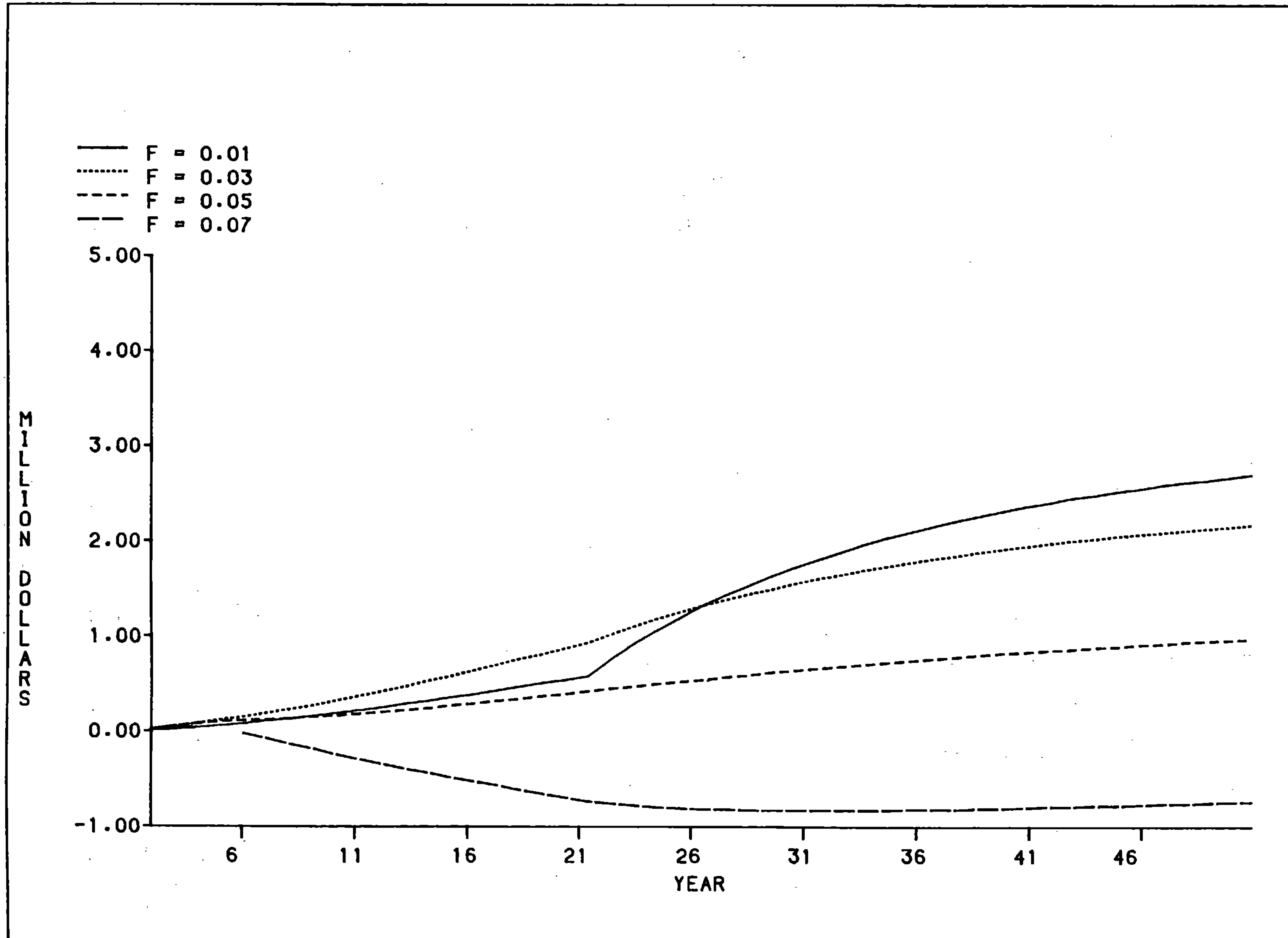

Figure 57. Cumulative discounted profit time paths of 4 F's for the eastern Bering Sea region, case 2.

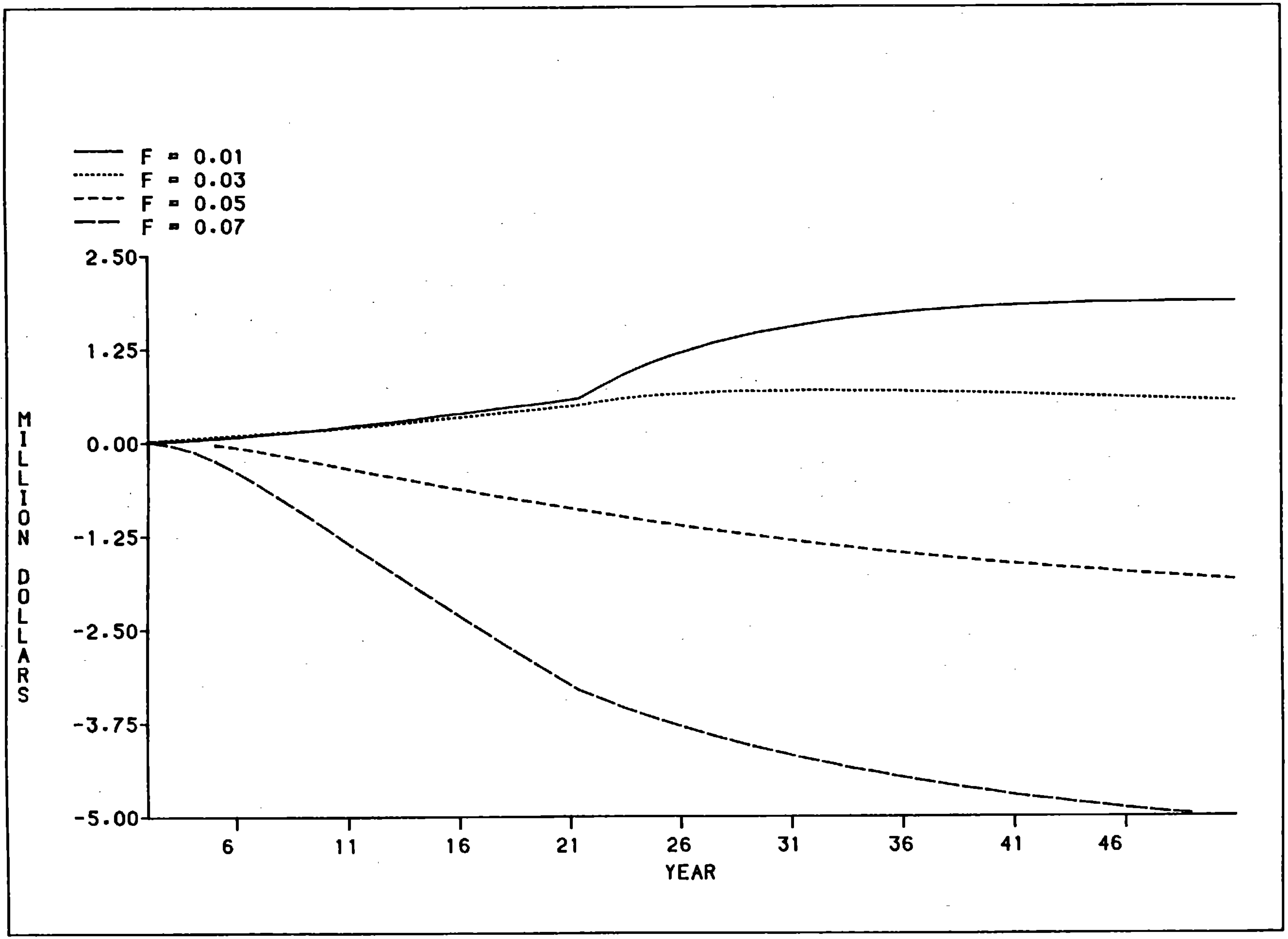

Figure 58. Cumulative discounted profit time paths of 4 F's for the eastern Bering Sea region, case 3.

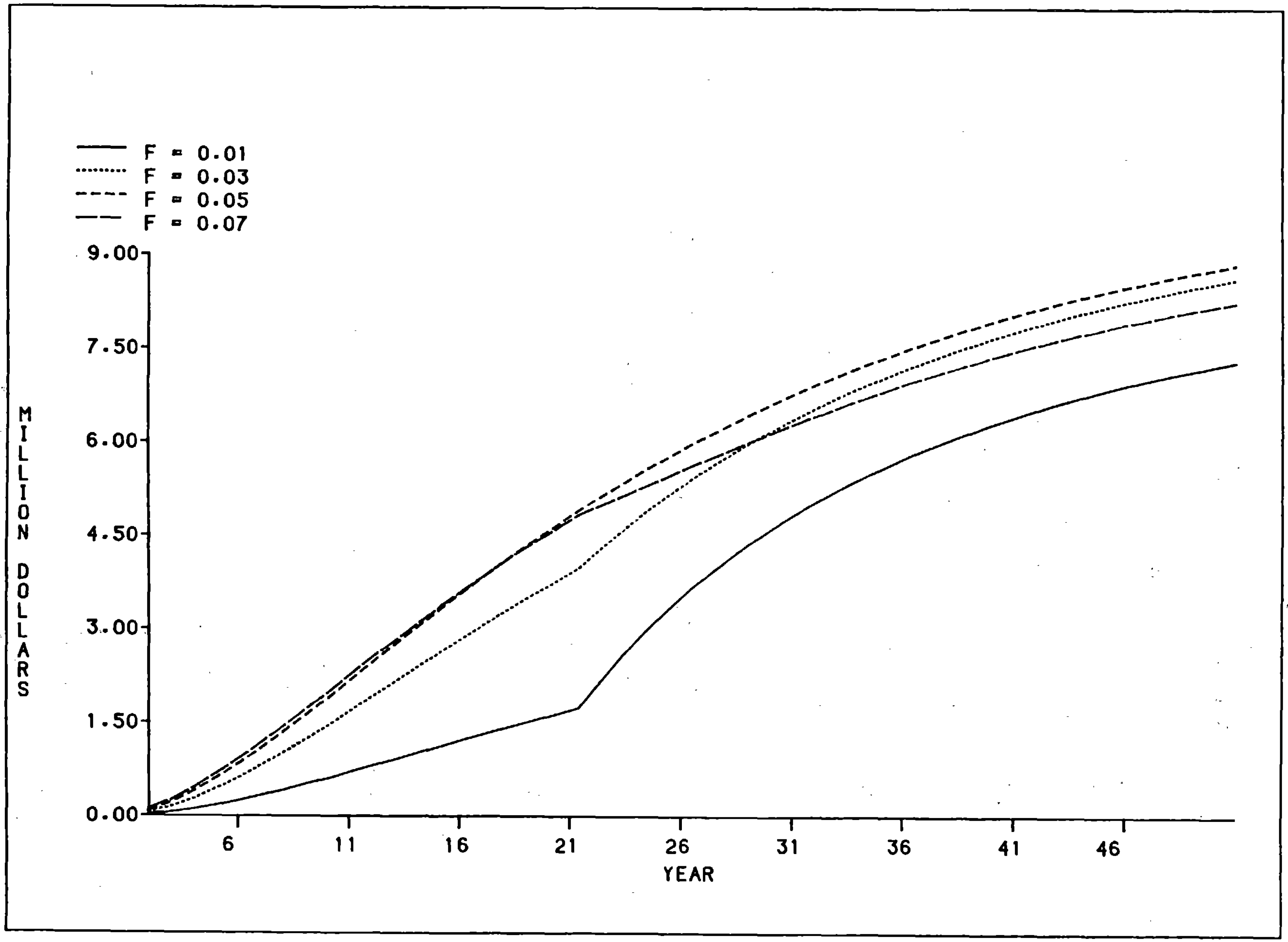

Figure 59. Cumulative discounted profit time paths of 4 F's for the eastern Bering Sea region, case 4.

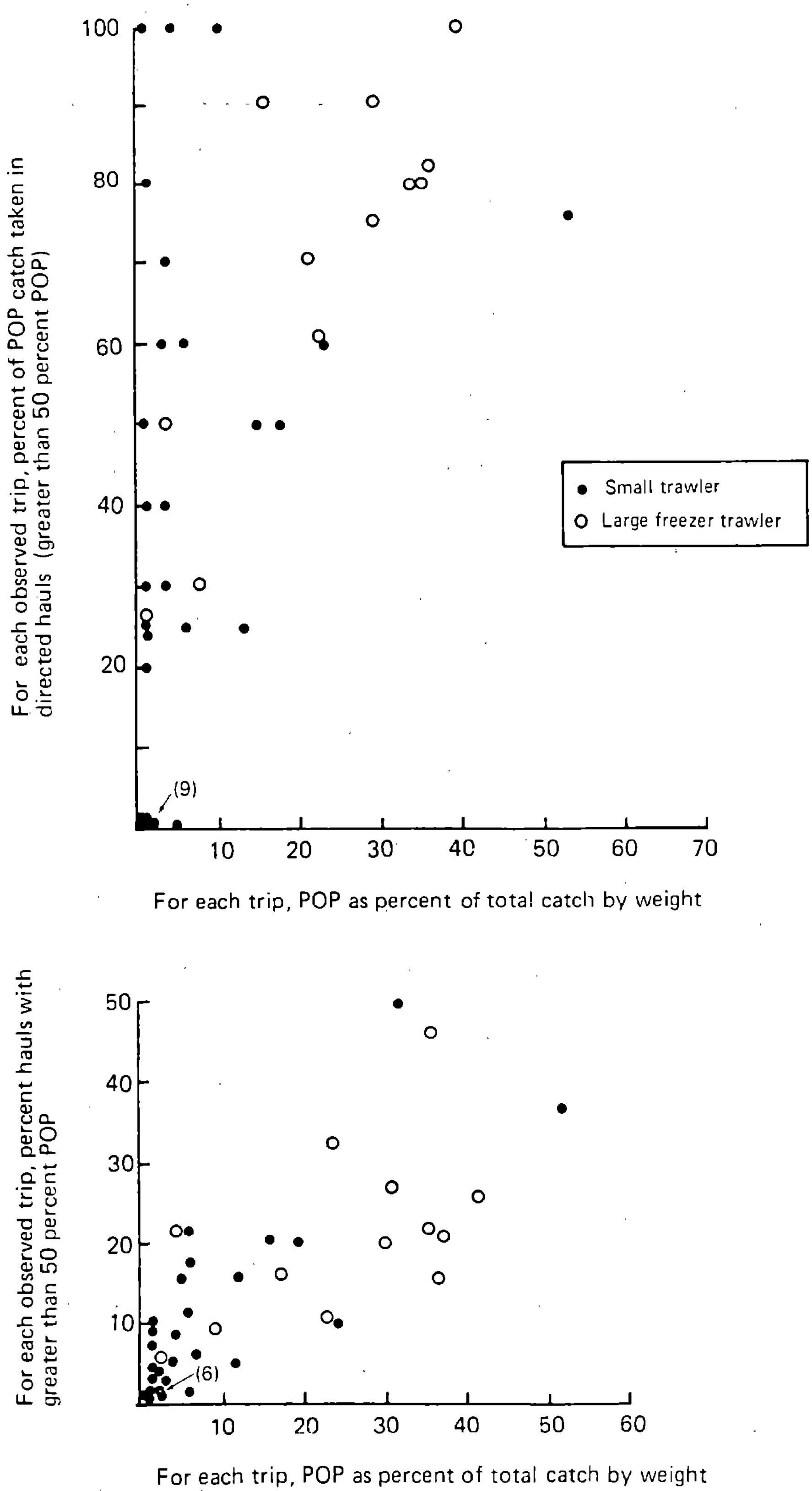

Figure 60. Percentage, by weight, of the Pacific ocean perch (POP) catch taken in trawl hauls which contained greater than 50% POP and percentage, by number, of all hauls which contained greater than 50% POP are, for each vessel, plotted against the percentage of POP in the total catch. For most of the large freezer trawlers and some of the small trawlers, nearly all of the POP catch is taken in hauls greater than 50% POP. Likewise, for most large freezer trawlers, a relatively high percentage of hauls contain greater than 50% POP.