# 1980年代 北太平洋 水産管理 方向

—「마라스코」의 所論을 中心으로—

# Trends in the Fisheries Management of the North Pacific for the 1980's

—Through Dr. Marasco's View—

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北太平洋漁場은 韓國에 隣接한 가장 가까운 遠洋漁場이며 世界最大의 好漁場으로서 現在의 200海浬經濟水域設定 趨勢에 따라 急激히 脚光을 받게 되었다. 이에 따라 本稿에서는 1980年代 北太平洋 水産資源에 對한 經濟的 側面에서 考察한다.

Anderson은 最近 海洋資源의 管理에 가장 顯著한 影響을 미치는 것은 200海浬 排他的 漁業規制線의 延長이다. 그러나 이 規制線의 延長 自體만으로 資源의 管理問題가 解決되는 것은 아니고 그것은 단지 問題解決을 爲한 輪廓만을 提示한다.

"200海浬内의 排他的 漁業管理를 爲한 權威는 問題解決의 障害도 되지 않고 그렇다 해서 解決의 關鍵도 되지 못한다"고 하였다. 漁業保存과 管理에 關한 法規는 管理活動을 위한 새로운 段階를 提供한다. 모든 關聯者의 意見이 같을 것이나 단지 經濟學者와 社會學者만은 이 問題에 새로이 關聯하게 된다. Gulland는 海洋資源에 關한 管轄權을 延長함에 따른 影響을 3가지로 分類하였다. 즉, 첫째는 어느 한 나라의 排他的 利益을 圖謀케 하는 것이고, 둘째는 두 나라 以上이 이를 나눠쓰는 것이고, 세번째는 國別 領土權 밖에서 一部 또는 全部를 利用할 수 있는 것이다. 여기서 다음과 같은 事項을 考察하였다.

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(1) 各漁場에서의 漁業의 特徵과 趨勢

(2) 이들 海域의 重要漁業에 關한 問題點

(3) 1980年代 北太平洋에서의 漁業管理에 必要한 硏究方向

漁業管理를 爲한 國際的인 協力의 必要性이 強調되어져야 한다. 北東太平洋 및 東部 베ー링海의 魚類資源은 政策的으로 境界域을 區分할 수 없는 먼 距離를 洄游한다. 거의 모든 魚類資源은 여러 國家에 依해 漁獲된다. 고로 資源의 狀態를 硏究하기 爲해서는 그 漁業에 參與하는 모든 國家로부터의 漁獲量 및 努力量에 對한 統計가 要求된다. 北洋漁場에 成功的으로 進出하기 爲해서는 水産業과 關聯된 生態界, 經濟 및 社會的 作用에 對한 보다 廣範圍한 情報가 要請된다. 더우기 北太平洋 水産委員會(INPFC) 및 將次 構成될 北太平洋 海洋開發委員會(PICES)와 緊密한 協助關係가 이뤄져야 한다.

東北太平洋 및 東部베링海에는 豊富하고 多樣한 底魚類 및 shellfish가 함께 棲息하고 있다. 水産資源의 管轄權을 200 mile로 擴張한 美國의 最近의 管理措置는 管理에 對한 解決策을 改善시킬 수 있는 새로운 方案을 提示한다. 管理를 위한 이 새로운 方法을 導入하기 爲해서는 많은 科學的인 情報가 必要하다.

이러한 要請은 生物學的인 觀點에만 限定되지 않는다. 最近에는 經濟的이고 社會的인 制度를 理解하고 또 그들이 管理方案에 依해 決定된 影響을 어떻게 받을 것인가를 理解할 必要가 있다.

水産資源管理에 對한 Holistic arproach는 生態界 Model 및 이들의 經濟的 및 社會的 要因과 結付에 對한 關心을 增加시키게 된다. 200 mile 時代에 對處한 現時點에서 北洋漁場에 슬기롭게 進出하려는 課題를 成功的으로 遂行하기 爲해서는 水産業과 關聯된 生態界, 經濟 및 社會的 作用에 對한 하다 廣範圍한 情報가 要請된다. 單位海域의 魚類集團과 關聯되는 成長, 生殖, 洄游 및 飽食者와 被食者의 關係作用에 對해 特別히 注目해야 하며, 이들 作用에 對한 環境도 調査되어야 한다. 操業船의 樣相, 物價와 費用을 決定하는 힘, 社會 或은 地域經濟의 다른 分野와 水産業과의 結付 및 關聯된 社會制度의 量的 說明이 經濟 및 社會的 調査의 초점이 되어야 한다. 이러한 充分한 調査가 先行된 後에 北洋에 進出하는 것이 容易하고 妥當하다.

## Ⅰ. Introduction

The most significant event affecting management of ocean fisheries in recent years has been the extension of fisheries jurisdiction to 200 miles. In itself, extension does not solve any management problems; but it does provide a framework within which solutions may be easier to find. It has been suggested that exclusive fishery management authority in the 200-mile zone is not necessarily a bane nor a blessing(Anderson, 1977, p.57). Another author(Alverson, 1977, p.738), states that "The Fishery Conservation and Management Act in a sense provides a new stage upon which the actors can act out their play. Most

※ 註 : 本稿는 國立水産振興院 創設 60周年 紀念行事時 招請되었던 美國 北西水産센타의 資源部長 Dr. Marasco의 發表論文을 우선 紹介한다. 完全한 論文은 追後에 發表될 것이나 本稿가 앞으로 韓國水産業의 새로운 次元에서 北洋漁業의 活路를 開拓하는 先驅가 되어지기를 바라는 마음 간절하다.

of the actors will be the same, except that economists and sociologists will now be assigned to the cast; the major difference lies in the new script". Gulland(1980, p. 374) states that the effect of extended jurisdiction over oceanic fisheries is to divide resources into three classes those that are the exclusive interest of one country; those that are shared by more than one country; and those that can be; taken partly or wholly outside of national jurisdiction.

Extension of jurisdiction over marine fisheries resources off the west coast of the United States has resulted in a change in which nations use the resources, reduction in the quantities harvested, and an expansion in domestic catches. The eastern Bering Seas the only area of the three major geographical fishing areas of the west coast of the United States, the other two being the Gulf of Alaska and Washington-Oregon-California coast, where there has been an increase in the number of nation's fishing. Prior to passage of the Magnuson Fishery Conservation and Management Act(MFCMA) Japan, Republic of Korea, U.S.S.R., and Taiwan had established fisheries in the area. These nations were joined by Poland and West Germany in 1980. Conversely, in the Gulf of Alaska(GOA) and Washington-Oregon-California(WOC) areas the number of nations fishing decreased. The number of nations engaged in the WOC fishery fell from 6 to 1 between 1976 and 1980. Over the same time period, the number of nations active in the GOA area decreased from 4 to 3. Accompanying the change in the nations fishing each of these areas has been a reduction in catches. Between 1976 and 1980, groundfish catches decreased approximately 258, 14, and 207 thousand metric tons in the eastern Bering Sea, GOA, and WOC, respectively.

The post-MFCMA period has seen the emergence of joint ventures between United States fishermen and foreign processors. The first of these arrangements was entered into by domestic fishermen and the U.S.S.R. in 1978 and involved the harvesting of Pacific whiting in the WOC area. The number of joint ventures expanded to 8 in 1981, encompassing all three fishing areas. These arrangements have played a major role in expanding the involvement of U.S. fishermen in eastern Bering Sea, GOA, and WOC groundfish fisheries. For example, the 1980 U.S. catch, including the joint venture catch, in the eastern Bering Sea was about 41,000 metric tons(mt), while the 1976 catch was only 400 mt.

Historically, the management of fish populations has focused on the conservation of fish stocks. Beginning in the 1960's there was increased recognition of the importance of economics. While international bodies and national governments have long recognized the importance of economic factors, very few marine fisheries management measures have led to improved economic performance. If anything, the reverse has been true. In many cases management measures taken to maintain a healthy fish stock have been at the price of imposing economic inefficiency. The MFCMA stresses the importance of considering economic and social factors in fisheries management. Under the new management regime managers are mandated to manage fisheries to meet the consumptive and nonconsumptive demands of users in addition to protecting fishery resources from actions that render restoration of resources impossible given the current technological and economic environment. To meet this responsibility managers must have information on the functioning of a complex system called a fishery. Managers, in their search for this information, will turn to fisheries scientists. In order to be responsive, scientists will need an understanding of how a system composed of physical, biological, economic, and social components operates. In most cases, this information is not available. This paper discusses and outlines: ① the characteristics and trends of fisheries in each geographic area, ② the major problems which are associated with important fisheries in these areas, and ③ the direction research should take during the decade of the 1980's to meet the needs of managers of fisheries off the west coast of the United States.

## Ⅱ. Characteristics and Trends

### 1. Eastern Bering Sea

The eastern Bering Sea supports about 300 species of fishes, with the majority being found on or near the bottom(Wilimovsky, 1974). The groundfish resource of this area is considered to be one of the world's largest(Bakkala, et al., 1979). During the peak period of foreign fishing, 1971-74, annual catches ranged from 2.0 to 2.3 million metric tons. Commercial production by all nations from the eastern Bering Sea, during 1980, represented in excess of 80 percent of the groundfish catch for the entire region from the Bering Sea to California. Groundfish species of importance included the flounders, rockfish, sablefish, cod, pollock, and Atka mackerel. Salmon, herring, capelin and other smelts are among the pelagic species of either current or potential commercial importance. Shellfish of commercial significance include shrimp, king, and Tanner(snow) crabs.

The earliest fisheries in the eastern Bering Sea were native fisheries for subsistence. Fishing occurred in near-shore waters with salmon, halibut, herring, and several kinds of groundfish being the important species. Remnants of salmon fishing sea have been found in old village sites at Cape Denbigh in Norton Sound that date back to 400 B.C. (ADF & G, 1972). Subsistence fisheries continue to be important in western Alaska.

The first domestic commercial venture for bottomfish occurred in 1864 when a single schooner fished for Pacific cod(Cobb, 1927). However, the cod fishery did not commence on an annual basis until 1882(NPFMC, 1979). This fishery continued until the 1950's, when economic conditions caused the fishery to cease(Alverson, et al., 1964). The first significant commercial harvest of salmon also began in the 1800's(Freeburn, 1976). Unlike the bottomfish fishery, the salmon fishery has been continuously active.

Of the nations participating in the groundfish of the eastern Bering Sea, Japan has the longest history of fishing in the region. After the exploratory efforts of two trawlers in 1930, the Japanese returned in 1933 with a mothership-catcher boat operation(Forrester, et al., 1978). Target species of the fishery included walleye pollock and flounders(Bakkala, et al., 1979). It was during this same time period that Japanese fishermen began intercepting Bristol Bay sockeye on the high seas(Shapiro, 1971). Excluding Canada's halibut fishing activities initiated in the mid-1950's, the second nation to participate in the groundfish fisheries was the U.S.S.R. in 1958. Following the Japanese and Soviets were the Koreans in 1967, Poles in 1973, and Taiwanese in 1974.

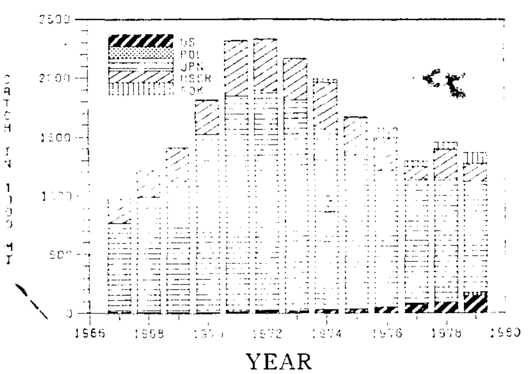


Fig 1. Annual catch of groundfish and shellfish by nation in the eastern Bering Sea, 1967-79. (US=United States, POL=Poland, JPN=Japan, USSR=Union of Soviet Socialist Republics, ROK=Republic of Korea.

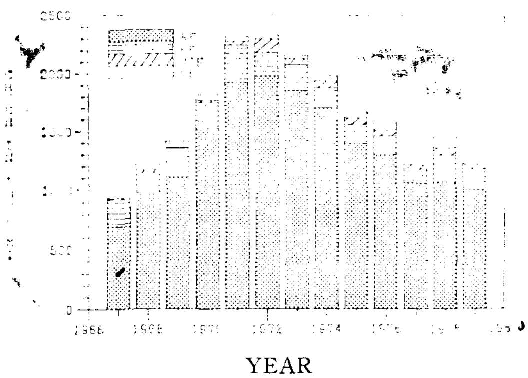


Fig 2. Annual catch by species group in the eastern Bering Sea, 1967-79. (RF=roundfish, FF=flatfish, OTF=other fish, SF=shellfish.)

Fig. 1 and 2 illustrate catch trends by nation and species groups for 1967 through 1979. Fig. 1 shows that after reaching a peak in 1972, in excess of 2.0 million mt, the total catch in the eastern Bering Sea followed a downward trend through 1977. Post-MFCMA catches have been relatively stable suggesting a possible end to this trend.

Historically, Japan has harvested the largest portion of the total catch. During 1979 for example, Japanese fishermen accounted for about 77 percent of the total catch, while Soviets, Koreans, Americans, Poles, and Taiwanese harvested 12%, 7%, 2%, 1%, and 0.2% respectively.

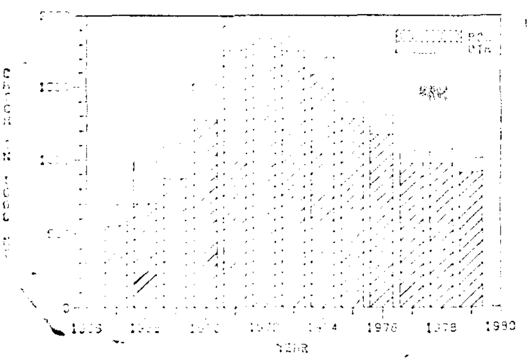

Fig 3. Annual catch of pollock and other roundfish species in the eastern Bering Sea, 1967-79. (POL=pollock, OTR=other roundfish.)

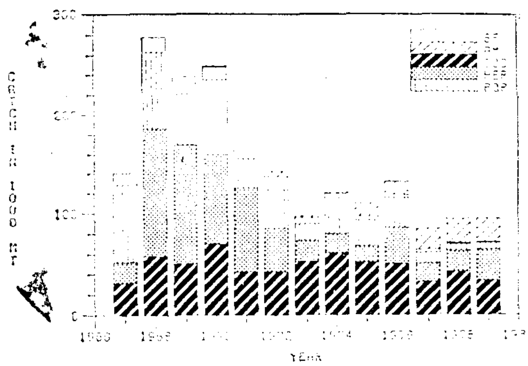

Fig 4. Annual catch of roundfish other than pollock in the eastern Bering Sea, 1967-79. (SF=sablefish, AM=Atka mackerel, COD=Pacific cod, HER=herring, POP=Pacific ocean perch and other rockfish.)

Roundfish, primarily pollock, dominate the catch associated with the eastern Bering Sea (Fig. 2 and 3). Pollock has been the major target species since the mid-1960's. Pollock is a rapid growing species reaching an average weight of 0.5kg and 40cm at 4 years of age (Bakkala, et al., 1979). Currently, catches consist primarily of fish 2 to 6 years old. Large catches in the early 1970's are believed to have caused declines in abundance (Fig. 3) (Bakkala, et al., 1979). However, catch restrictions placed on the fishery appear to have stopped the decline (Bakkala, et al., 1980). The stock is considered capable of supporting an annual catch of 1.0 million metric tons.

Other roundfish of importance include Pacific cod, Pacific ocean perch, sablefish, and Atka mackerel. Catch trends for each of these species are given in Fig. 4. The annual catch of Pacific cod by all nations peaked in 1970 at about 70,000 mt. Thereafter, the catch decreased to about 43,000 mt, and has been characterized since by a downward trend. Available evidence shows that the abundance of Pacific cod is increasing (Bakkala, et al., 1980). This increase has been attributed to strong year classes being recruited into the fishery.

Pacific ocean perch (POP) is the most abundant rockfish species in the eastern Bering Sea. This species supported a major fishery in the late 1950's and 1960's. After peaking in 1965(125,900 mt) catches declined from overfishing. It is recognized generally that POP stocks in this area are at low levels of abundance and in poor biological condition(Bakkala, et al. 1980).

Sablefish catches, after peaking in 1968, have decreased continuously. The 1968 catch exceeded 18,000 mt, while the 1979 catch was only about 1,100 mt. Changing fishing patterns and regulations have it difficult to follow trends in sablefish abundance in recent years. Apparent increases in the juvenile abundance suggest that the condition of the stock may improve; eventhough, long-term catch trends indicate that abundance is down.

Following the decline in the abundance of POP, the Soviet trawl fishery began to fish Atka mackerel in the early 1970's. Between 1970 and 1978 the Soviet catch of Atka mackerel increased from 949 to 22,622 mt, but in 1979 the catch declined slightly to 20,277 mt. Japan and the Republic of Korea have also participated in this fishery in recent years. For example, in 1979 their catches were 1,656 and 1,329 mt, respectively. Little is known about the population dynamics of this species; however, there is no apparent concern over the condition of the stock.

Flatfish catches in the eastern Bering Sea remained relatively stable between 1967 and 1979(Fig. 5). Yellowfin sole, the most abundant flatfish species, provided catches which ranged from about 42,000 to 167,000 mt during 1967-79, with the average being approximately 99,000 mt(Fig. 5). Current abundance is believed to near virgin biomass levels and the allowable biological catch has been set at 214,500 mt (Bakkala, et al., 1980).

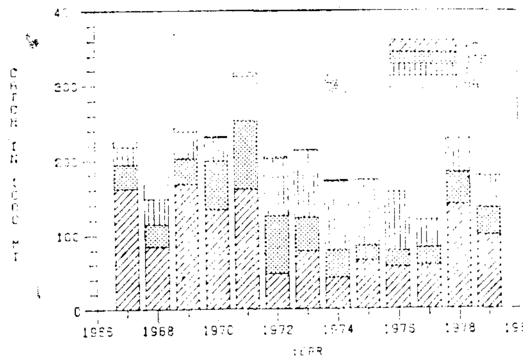

Fig 5. Annual catch of flatfish species in the Eastern Bering Sea, 1967-79. (YS=yellowfin Sole, OTF=flathead sole, Alaska plaice, and rock sole, TU=Arrowtooth flounder and Greenland turbot, HA=Pacific halibut.)

The Greenland turbot and arrowtooth flounder catch peaked at about 103,000 mt in 1973 and 1974. Between 1974 and 1970 catches declined to about 42,000 mt in 1977 and then increased to 56,000 mt in 1979. The abundance of these two species has been stable since 1975.

Until recently, Pacific halibut and cod were the only two demersal species sought by United States commercial fishermen Halibut catches for the period 1967-1979 ranged from 200 to 1,300 mt with an average of about 400 mt. The current abundance of adult halibut is low and only small catches are allowed to enhance stock rebuilding(Bakkala, et al., 1980).

Since the mid-1970's, U.S. fishermen have dominated the eastern Bering Sea shellfish fisheries. The U.S.S.R. and Japan harvested king and Tanner(snow) crab in the 1960's and early 1970's they have since been phased out of these fisheries. American landings of king and Tanner(snow) crab in 1979 reached 88,100 and 35,000 mt respectively.

### 2. Gulf of Alaska

As in the Sea, native subsistence fisheries preceded commercial exploitation in the Gulf of Alaska(GOA). The first commercial groundfish fishery was a U.S. setline cod fishery in the 1860's followed by commencement of salmon activities in the late 1970's. Fisheries for halibut, sable fish, and other groundfish followed.

Alton(1981) has described the development of the Gulf of Alaska bottomfish and shellfish commercial fisheries into-and post-MFCMA periods. The pre-MFCMA period consisted of two phases. The first encompassed the period from 1867 through and immediately following the second world war. Development of cod, halibut, and sablefish fisheries characterized this time span. The beginning of the 1960's was used as the starting point for the second subdivision. This era was marked by the development of the crab and shrimp fisheries.

Distant water trawl fisheries in the Gulf of Alaska began in 1962, when the Soviets began fishing for POP. Japanese vessel entered the fishery in the following year, focusing their effort on POP and sablefish. Nations entering the fishery in subsequent years included the Republic of Korea, Poland, and Taiwan.

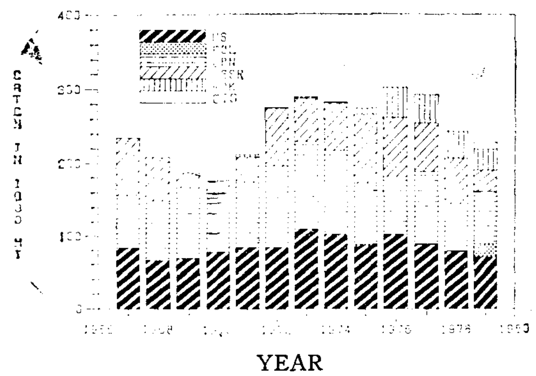

Fig 6. Annual catch of groundfish and shellfish in the Gulf of Alaska by nation, 1967-79. (US=United States, POL=Poland, JPN=Japan, USSR=Union of Soviet Socialist Republics, ROK=Republic of Korea, OTS=Mexico.)

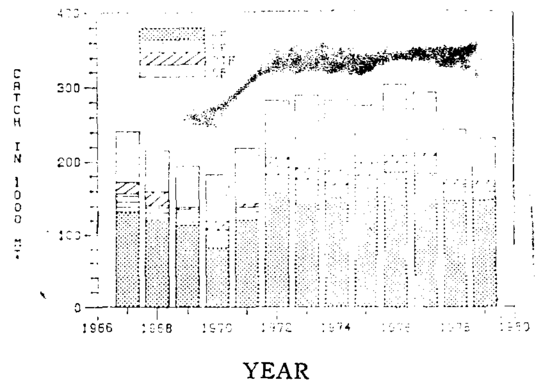

Fig 7. Annual catch by species groups in the Gulf of Alaska, 1967-79. (RF=roundfish, FF=Flatfish, OTF=other fish, SF=shellfish.)

Catch by nation and species grouping are presented in Fig. 6 and 7 for years 1967 through 1979. Pelagic fish and mollusk data were not included. These figures indicate that the total catch of bottomfish and shellfish went through several phases between 1967 and 1979. Decreasing annual catches characterized the 1967-1970 period, catches increased during the early 1970's, and fell again during the post-MFCMA period. Japanese, USSR, and ROK trawler fleets have harvested a majority of the bottomfish taken annually from the Gulf of Alaska. Small catches have also been taken by Polish and Taiwanese fishermen. U.S. bottomfish fisheries in the COA are small in relation to other nations. Landings during 1979, exclusive of halibut, were 7,000 mt.

Species caught in the bottomfish fishery in this area include walleye pollock, Pacific cod, Atka mackerel, sablefish, POP, other rockfish, and a variety of flatfish. As indicated by Fig. 7, roundfish dominate the GOA catch accounting for about 60% of the 1979 total bottomfish and shellfish catch. Pollock currently constitute the bulk of the roundfish catch(Fig. 8). in 1979, for example, pollock accounted for 66% of this group.

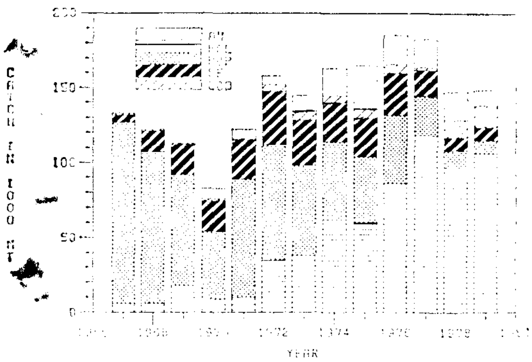

Fig 8. Annual catch of roundfish by species in the Gulf of Alaska, 1967-79. (AM=Atka mackerel, POL=pollock, POP=Pacific ocean perch and other rockfish, SF=sablefish, COD=Pacific cod.)

The dominance of pollock in GOA catches is of recent origin. Prior to the mid-1970's, catches were mostly POP with the catch peaking in the mid-1960's at about 350,000 mt. This excessive removal of fish from the stock, that in its prefishery condition constituted between 1.4 to 1.8 million mt, is considered to be responsible for the sharp decline in abundance (Quast, 1972). After peaking in 1965, POP catches fell to about 70,000 mt in 1969. This decline continued through the 1970's, with 9,000 mt. taken in 1979.

The decreased abundance of POP shifted trawler effort to other species, primarily walleye pollock and Atka mackerel. As a result, pollock catches increased from 10,000 mt in 1971 to 121,000 mt in 1977. Catches during 1978 and 1979 decreased to 97,000 and 83,000 mt respectively. Atka mackerel catches increased from 7,000 mt, in 1970 to a high of 29,000 mt in 1975. Since 1975 catches have decreased through regulation and lack of fishable concentrations of fish. By 1979, the catch decreased to 11,000 mt.

Research survey results indicate that pollock stocks increased substantially between the early 1960's and the 1970's, and the current potential yield for this species has been estimated to be about 169,000 mt per year (Alton, 1981). Atka mackerel stocks are considered to be healthy. In the absence of any evidence of overfishing, the allowable biological catch has been set at 24,800 mt (Low, et al., 1980).

Full exploitation of the Gulf's sablefish resource occurred in the mid 1960's, when a Japanese longline fishery was added to a small U.S. fishery. Catches increased rapidly, peaked in 1972(37,000 mt), and since have trended downward. The 1979 catch was 9,000 mt.

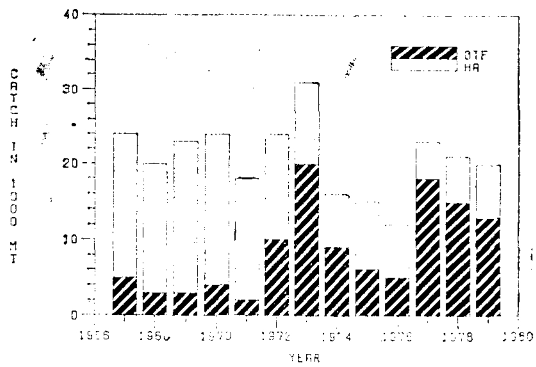


Fig 9. Annual catch of Pacific Halibut and other flatfish in the Gulf of Alaska, 1967-79. (HA=Pacific halibut, OTF= flatfish other than halibut, primarily Arrowtooth flounder.)

Sablefish stocks are considered to be at low levels of abundance relative to earlier years. Therefore, the allowable catch has been set at 13,000 mt.

Prior to 1978, Pacific cod were taken only as an incidental catch in trawl fisheries. Catches up until this time did not exceed 6,000 mt. In 1978, the cod catch increased to about 12,000 mt lowing the development of a Japanese longline cod fishery in the western Gulf. Because of the healthy status of the cod stock, the allowable biological catch has been set at 60,000 mt (Low, et al., 1980). This catch restriction was established because of the high incidental catch of halibut in the fishery.

The exploitable biomass of flounders, excluding halibut, for the GOA has been estimated to be 772,000 mt(NPFMC, 1979). Exploitable biomasses by species or species group are: 304,000 mt for turbot, 205,000 mt for rock sole, 108,000 mt for flathead sole, and 155,000 mt for the other flounder species. Flatfish species, other than halibut, have been subject to little fishing pressure. Post-MFCMA catches of this species group have been less than 20,000 mt with turbot the most important flatfish in the trawl fishery.

Historically, North American fishermen have focused their effort on Pacific halibut. Annual landings reached an all-time high of 24,000 mt in 1962. Catches have decreased since because of reduced stock abundance.

### 3. Washington-Oregon-California Coast

Early commercial harvests centered upon salmon and halibut which also constituted the aboriginal subsistence fishery. The close proximity to fishing grounds and the large variety of fishery resources available led to a rapid diversification of fishing activity.

Fishing in this area by distant waterfish fleets of other nations began in the early 1960's. In 1962, the Japanese and Soviets expanded their fishing activities into this area in hopes of finding abundant supplies of POP. However, the POP resource off the coast of the Pacific Northwest was small relative to that found in the eastern Bering Sea and GOA. The low abundance of POP caused the Soviet fleet to focus their effort on the large Pacific whiting resource. Vessels from The Republic of Korea, Poland, East Germany, West Germany, and Bulgaria have also fished in this area.

Bottomfish and shellfish catches for the WOC area are shown in Figures 10 and 11. Date present in Figure 10 indicate that U.S. catch has trended upward since the early 1970's. The reverse has occurred for the U.S.S.R. fishery, the most active nation fishing in the area. After peaking at over 200,000 mt in 1970, Soviet catches were restricted to 150,000 mt during the 1973-76 period. Post-MFCMA catches declined further with 97,000 mt taken in 1979.

After a short-lived reduction fishery that took place in the mid-1960's the interest of U.S. fishermen in Pacific whiting was rekindled in 1978 with the advent of a U.S.-USSR joint venture. In this initial effort, two U.S. trawlers delivered about 900 mt of whiting to two Soviet trawler/processors. The joint venture catch increased to 9,000 mt in 1979 and was about 28,000 mt in 1980.

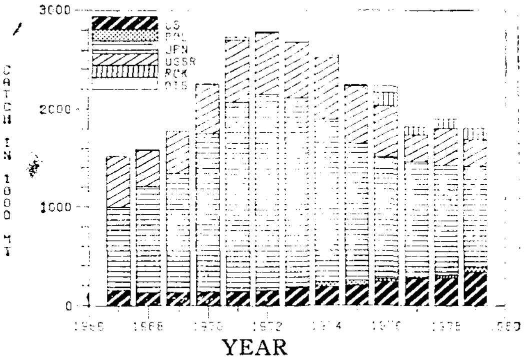


Fig 10. Annual catch of groundfish and shellfish by nation in the eastern Bering Sea, Gulf of Alaska, and off Washington-California, 1967-79. (US=Unitd States, POL=Poland, JPM=Japan, USSR=Union of Soviet Socialist Republics, ROK=Republic of Korea, OTS=other nations.)

As indicated by Figure 11, roundfish dominate catches taken in WOC bottomfish fisheries. Species caught in these fisheries, in addition to Pacific whiting, include Pacific cod, lingcod, sablefish, POP, and other rockfish. The allowable biological catch for this complex has been estimated to be about 244,000 mt (PFMC, 1980). Pacific whiting account for 72% of this total. The total catch during 1979 for this complex was about 156,000 mt of which 79% was Pacific whiting. POP is the only species in the group that has been specified as being severely depleted in the Pacific Coast Groundfish Plan (PFMC, 1980).

Between 1967 and 1979 the catch of flatfish, exclusive of halibut, increased from 15,000 to 28,000 mt. The allowable biological catch for this group has been estimated to be about 34,000 mt(PFMC, 1980). Dover sole is the most abundant species in the group. with an allowable biological catch of 19,000 mt. Only small quantities of flatfish have been taken in the non-U.S. fisheries. The fishery to date has been dominated by U.S. fishermen.

## Ⅲ. Management Issues

Catch trends for the northeastern Pacific Ocean and eastern Bering Sea indicate that distant water fleets have played an important role in the development of fisheries in these areas. Attracted by vast supplies of fish were taken(Figures 10 and 11). After reaching this peak, annual catches declined through 1977 as the result of catch restrictions developed to prevent overfishing. Annual catches for 1978 and 1979 indicate a possilbe short term stabilization of catches due to management measures.

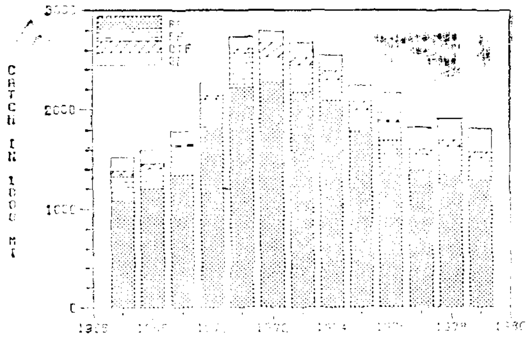


Fig 11. Annual catch by species groups in the eastern Bering Sea, Gulf of Alaska, and off Washington-California, 1967-79. (RF=roundfish, FF=flatfish, OTF=other fish, SF=shellfish.)

Large removals by distant water fishing fleets heavily impacted stocks of the U.S. Coast. All along effort, have been badly depleted. In all three areas, POP stocks have been reduced to a small fraction of virgin biomass levels. Fig. 12 shows the decline in CPUE that occurred in the GOA Japanese trawl fishery between the early 1960's and 1970's. Concurrent with this decline was an increase in walleye pollock abundance. Surveys conducted in the Gulf of Alaska in 1961 and 1974 indicated that the density of the pollock stock increased, while the POP stock density decreased in the Sanak, Chirikof, and Yakutat regions of the Gulf (Fig. 13). It has been stated that, "Although this trend in pollock abundance may well be attributable to natural fluctuations of some environmental variable, its apparent synchrony with the decline of POP leads one to suspect the eve-

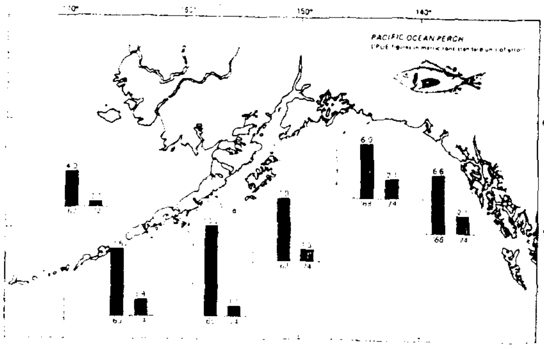


Fig 12. Regional decline in the catch-per-unit of effors(CPUE) of Pacific ocean perch in the Japanese trawl fisher in Alaskan waters between the 1960's and early 1970's.

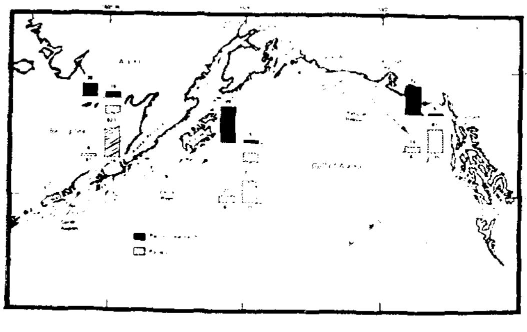

Fig 13. Changes in stock censity of Pacific ocean perch and walleye pollock in the Gulf of Alaka as suggesed from changes in survey catch rates (kg/hr) between 1961 and 1974-75.

nts are causally related (Somerton, et al., 1978)."To shed light on this issue, Somerton et al. (1978) examined the relative importance of various prey items composing each species' diet and the manner in which these items are taken. Results of the study indicated that the diet of POP and pollock in the small and intermediate size ranges is essentially identical. The larger groups differ due to the divergence of pollock from a strictly euphausid diet. The diet of larger pollock was found to contain significant amounts of shrimp and fish. It must be noted that a high degree of overlap in diets, by itself, does not demonstrate competition for food. Competition takes on significance only when food becomes a limiting resource. Competitively inferior species faced with limited supplies of preferred prey will alter their diets which could lead to lower growth rates and reproductive potential. The absence of hard data, however, makes it impossible to isolate the forces which lead to the changes in abundance.

Trawl fishing effort has also affected the abundance of Pacific halibut. While retention of halibut in the trawl fisheries is prohibited, large incidental catches occur. During 1980, for example, over 1.4 million halibut were taken in the Bering Sea and Gulf of Alaska. A majority of these fish are young juvenile fish several years from entry into the domestic longline fishery. Upon capture these fish must be returned to the sea immediately, however, the mortality rate is considered near 100%.

Low abundance of halibut stocks has resulted in stringent catch quotas being placed upon the U.S. longline fishery. In recent years an increase in the number of juvenile halibut has been observed in reserved in research surveys in the GOA and eastern Bering Sea. This increase has been attributed to restrictions that have been placed on trawl fisheries.

Large quantities of king crab, salmon, Tanner crab are also taken by trawlers. Incidental catches in the eastern Bering Sea of these three species in numbers were estimated to be about 858,000(781 mt), 120,000(381 mt), and 11,108,000(2,057 mt), respectively, in 1980. These incidental caches have become an increasing source of concern. Several native Alaskan groups, which claim a high degree of dependence on salmon, initiated formal court action in 1980 to reduce the incidental catch of chinook salmon in the Bering Sea. Efforts by the natives culminated in the

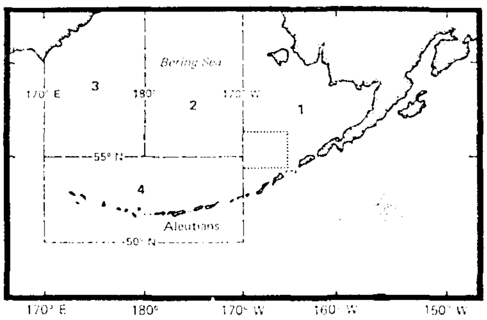


Fig 14. U.S Bering Sea and Aleutian Islands statistical areas(Area included in dots represent the part of Area 1 that will be closed when the proposed incidental quota of chinook salmon is taken).

submission of proposals to the National Marine Fisheries to amend the eastern Bering Sea Preliminary Fishery Management Plan to limit the incidental catch of chinook salmon in U.S. statistical Area 2 and a portion of Area 1 to 65,000 fish(Figure 14). Once a nation reaches its assigned quota of salmon, it must cease fishing in these areas.

Experience over the last couple of years indicates that large incidental catches of Pacific halibut, king, and Tanner(snow) crab are also likely to occur in a U.S. trawl fishery. The joint venture fisheries in the Bering Sea took about 205,000, 290,000, and 179,000, respectively, of these three species. The size of these incidental catches suggests that growth of the U.S. trawl fishery may result in conflict between trawl and fixed gear(crab pots and longline) fisheries. Resolution of the conflict will require that the North Pacific Fishery Management Council address the issue of the determination of the optimal strategy for harvesting fishery resources in the eastern Bering Sea.

The discussion to this point has been limited to interactions between fish species and fisheries. Marine mammals play important roles in the ecological systems of the north eastern Pacific Ocean and northeastern Bering Sea. The total consumption of finfish by marine mammals in the eastern Bering Sea has been estimated to be about 3 million mt annually(Laevastu and Larkins, 1981), wish about 2/3 of the species being of commercial significance. Therefore, the marine mammal consumption of fish may be about twice the commercial catch. While the quantity of fish consumed is open to question, it is generally recognized as being large. In any case, it is not known if the not impact upon fish population is good or bad. However the important role occupied by marine mammals in the ecosystem requires consideration of fishery-marine mammal interactions in the formation of fishery management strategies.

While predation is one of the more important processes at work in the ecosystem, there is a multitude of other processes at work that effect the abundance of fish. Environmental factors, reproduction, recruitment, and seasonal migration are important. Tyler (1979) found close correspondence between abundance of age 6 Dover sole near the mouth of the Columbia River on the west coast of the U.S. and offshore divergence of water mass. Determination of abundance factors controlling fluctuations in abundance of commercially important species is one of the main tasks of fisheries scientists. The success of failure of fishery management efforts is dependent upon acquisition of this information.

One final issue requires discussion prior to concluding this brief discussion of important management issues. Marine fish stocks of the northeastern Pacific Ocean and eastern Bering Sea are common property. Ownership, therefore, does not occur until capture. Because fish stocks are common property resources, alterations of fishing activities by any one fisherman will affect the catches of all the users of the same stock. Unless stocks are lightly fished, the net addition to the total catch of the fleet by the incremental vessel will be less than its catch. The difference is due to the reduction in the catch by existing boats caused by the additional vessel. Entry decisions by fishermen are made on the gross catch for their vessel. It is for this reason that individual and societal interests diverge in the use of fishery resources.

The economic waste that occurs with the use of common property resources has been discussed at length in the literature(Crutchfield, 1961, Scott, 1979) and need not be reiterated. Resolution of the open access problem is an urgent problem in northeastern Pacific Ocean fisheries. In the case of the developing U.S. groundfish fishery, an opportunity exists for avoiding over-expansion of the fleet before it occurs.

## Ⅳ. Research Needs and Strategies

The role of the manager is to control a fishery in such a way that society receives the highest possible net benefits from its use. Factors that enter into the calculation of net benefits depend upon the specific objectives of management. A narrow definition of management objectives could result in net benefits including only the value of the catch and harvesting costs. A much larger number of items, in most cases, will be included in the equation. For example, the formulation could be expaned to include research, implementation, enforcement, and data acquisition costs. The manager, in addition to being concerned with the magnitude of net benefits, must also be aware of how they will be distributed among the parties affected by management action. This brief description of a fishery manager's job might suggest that the task is relatively easy. In reality, however, the task is quite complex. Fish abundance fluctuates from year-to-year(Fig. 15). Over time, fish stocks rise or decline and are replaced by one another for reasons that are quite independent of the fishery and beyond the manager's control. Many of the factors controlling the economics of the fishery are also subject to rapid and unpredictable change. Very little is known about the dynamics of fishermen behavior. These

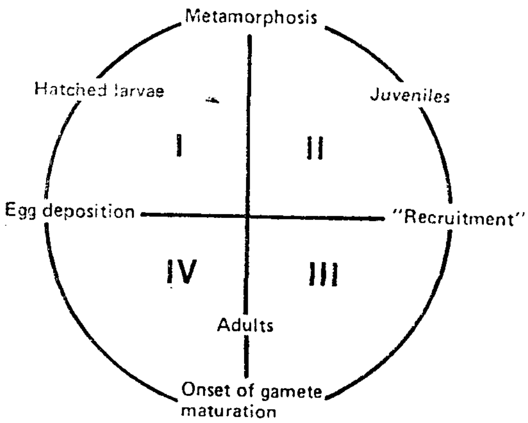


Fig 15. Schematized life cycle of fishes (Source: FAO, 1980).

features of the fisheries environment make description and prediction difficult. Increased realization of the complexity of fishery systems has generated interest in holistic management approaches. That is, there has been an increased awareness of the need to take into account the interrelationships that exist between and within biological, economic, and social components of the fishery. The end result of the desire to approach management in this manner has been an increased interest in ecosystem models.

Various approaches have been taken to ecosystems modeling. The following is a list of differences that exist between various models that have been developed:

1. trophodynamic: "bottom up" versus "top down",
2. biomass based versus numbers/weight based,
3. spatially segmented versus spatially homogeneous, and
4. explicit age/size versus age distribution.

Selection of the approach used in modeling is dependent upon the nature of the problems being examined and the availability of data.

An example of a bottom-up/number based model is the multispecies model which has been developed by Anderson and Ursin(1977). Being a bottom-up approach, their model starts with primary production and works up the trophic pyramid Their model, in addition, is spatially homogeneous and has explicit size classes. The marine biota part of the model is an extension of Beverton and Holt's(1957) single species stock assessment model. The extension was made by partitioning total mortality into three components: fishing, predation, and "other" mortality. The end result of the partitioning was the addition of an equation to the single species stock assessment model which describes the number of deaths due to predation. Growth rates in the model were allowed to vary by season and with the availability of food.

Top-down biomass based ecosystem models recognize that predation is one of the main processes controlling the ecosystem. The "apex predators," marine mammals, birds, and many since they remove fish by predation from given areas and return parts of the metabolic products and "wastes" as nutrients to other areas, are the point of departure for this approach to modeling. Figure 20 presents the principal processes which are emphasized in top-down simulation models currently being developed at the Northwest and Alaska Fisheries Center (NWAFC). The following are the major processes affecting the biomass of a given species that are contained in the models:

(a) growth, which is influenced by temperature, availability of proper food:
(b) recruitment, which is dependent on spawning success, a complex process depending on the size of spawning stock and the mortality of eggs and larvae by various

causes:

(c) post-larval and juvenile fish predation, by other species and by cannibalism:

(d) mortality from old age, spawning stress mortality, and mortalities from disease;

(e) migrations including immigrations and emigrations:

(f) feeding, including food requirements for maintenance and growth and space-time variation of food composition:

(g) the fishery.

Given deficiencies in the knowledge of phytoplankton and zooplankton production in the northeastern Pacific and eastern Bering Sea, trophodynamic ecosystem simulation might yield unreliable results if basic organic production was used as a starting point. Instead, standing stocks of plankton in the model were simulated with harmonic relationship, which were tuned to reproduce known seasonal changes in the availability of plankton. Initial quantities of benthos were set at known values and then allowed to grow and be grazed. Standing stocks of plankton and benthos determine the upper limits of the total biomass (carrying capacity) in a given region.

The relative merits of bottom-up, top-down, number based and biomass based models have been discussed by Laevastu and Larkins(1981) and will not be repeated. Suffice it to say that each approach has strengths and weaknesses. Experiments with the NWAFC top-down biomass based model for the eastern Bering Sea indicate a need to expand the understanding of:

a. primary and secondary production.

b. predation.

c. recruitment.

d. marine mammal numbers and dynamics, and

e. the effect of enviromental factors on important components of the ecosystem.

If the information demands of fishery managers are to be met, there is a need to continue the development and refinement of ecosystem models for the northeastern Pacific and eastern Bering Sea. Experience with these models indicates that there must be an expansion in the understanding of important ecosystem processes. The discussion of research that will contribute to the fulfillment of these needs is facilitated by using a circle diagram of the life cycle of fish that is illustrated in Figure 15. The life cycle of fish in the diagram is divided up into four stages. Stage I includes the egg through metamorphosis phase. The juvenile through pre-recruit phase is encompassed by Stage II. Stage III and IVinclude the post-recruit or adult phases.

Fish during their life cycle are affected directly and indirectly by man. Direct effects.

which arise from removal of individuals from the stock, are operative in the post-recruit phase. However, removals can also affect juveniles(Stage II) via stock rejuvenation(Marasco and Laevastu, 1981). Pollution and habitat destruction producing activities indirectly affect fish in early stages of their life cycle via environmental degradation.

The importance of egg and larval survival to recruitment is generally accepted. Feeding, growth, and predation processes are very important in early phases of the life cycle. Patchiness is known to characterize the availability of plankton in the northeastern Pacific and eastern Bering Sea(Laevastu and Larkins, 1981). Larval survival, therefore, requires that they encounter appropriate quantities of food to promote feeding. Environmental factors have been shown recently to play important roles in the early part of the life cycle of fish. The sensitivity of reproductive success of pelagic fish stocks to the dissipation of fine-scale food strata by wind mixing during early larval feeding has been found by Lasker (1975, 1978). Offshore transport during the larval drift period has also been suggested as having a detrimental affect on fish stock (Bakun and Parrish, 1980). Using multivariate correlation methods, Tyler(1981) reported that in a region on the continental shelf of the northwestern United States, 65% of the variation in the cohort strength of Dover sole and 84% of English sole was accounted for by upwelling conditions. A preliminary examination of the number of age 4 pollock in the eastern Bering Sea shows a high correlation between abundance and water temperature(Bailey, personal communication). Growth of juveniles is considered to be seasonal and effected by temperature. Ambient temperatures and anomalies will affect growth and the length of time they are susceptible to predation. Temperature also affects growth in the post-recruit phases of the life cycle.

The following physical characteristics of the ocean environment have been identified as having important affects on fish during their life cycle(Bakun and Parrish, 1980):

1. horizontal advection.
2. vertical stability.
3. convergence and divergence.

A need exists for the development and testing of hypotheses-relating indexes of the physical phenomena listed above and stock conditions. Availability of this type of information for the northeastern Pacific and eastern Bering Sea is very limited and resticted mostly for waters off the coasts of Washington, California, and Oregon. It is recognized that linkages between environmental processes and biological phenomena are complex and difficult to observe or investigate experimentally. It is felt, however, that efforts directed at isolating these relationships will yield substantial dividends.

Predation is considerd to be one of the most important processes at work in the ecosystem. Quantitative knowlege associated with the predation mechanism is limited, however. Information on food consumption by prey species and food intake for each predator age required to isolate predator/prey relationships. Information on predation for northeastern Pacific and eastern Bering Sea fish stock is spotty. Since a comprehensive stomach analysis program is lacking for the area, studies have been conducted in a piecemeal and ad hoc manner. Collection of the required data requires a well planned and continuous stomach analysis program. Essential information that must be collected includes the size of the predator, the number and weights of prey species, the size of prey organisms, and the weight of the stomach. Further, sampling should occur throughout the geographical distribution of the predator and several times during the year.

Accessibility of various prey during foraging and the selectivity process must also be known to infer properties of the mechanism governing food selection. Isolation of the selectivity process could require an extensive stomach sampling program and several years of data. In the interim, there is a need to develop and test, to the extent possible, selectivity hypotheses. The Anderson-Ursin(1977) log-normal model represents one possibility. This model assumes that there exists a preferred prey size and that the predator-preferred-prey-size ratio stays constant throughout the predator's lifetime. Accessibility is controlled by inherent protective and avoidance behavior characteristics of potential prey. Recently completed field work in Puget Sound indicates that newly hatched pacific whiting become susceptible to predation of invertebrate zooplankton if unfavorable temperatures retard growth.

Carrying out surveys to determine food consumption and its composition will place considerable demands upon research vessel time and scientific man-power. Careful planning must take place, therefore, to ensure cost effective operation of the program. Diffiiculties working in the early stages of the life cycles could require performance of simulations in mini-ecosystems.

While much of the data available for fish stocks in the northeastern Pacific are associated with the post-recruit stages of the life cycle, there still exists large data gaps. Seasonal migrations, spawning times, an areas of growth and reproduction are all in need of further exploration.

The northeast pacific and eastern Bering Sea support a large number and variety of marine mammals. Current versions of NWAFC ecosystem models do not allow for two-way interactions between marine mammals and fish stocks. Given the number of marine mammals and their feeding characteristics, food requirements are calculated and then passed to remaining parts of the model. Realistic treatment of interactions between marine mammals and fish stocks requires improved estimates of their numbers, a better understanding of their feeding habits and requirements, and improvement in the understanding of their population dynamics.

For ecosystem models to be truly holistic, linkage of ecological components with economic and social elements is required. Once the concept of multispecies management is accepted, there is a need to determine what is to be optimized. This question can not be answered in ecological terms only and must include econmic and social considerations. Inclusion of economic considerations in the models requires an understanding of the dynamics of fleet operations, the nature of price and cost determining forces, and the linkages that exist between the fishing industry and the remaining sectors of the relevant economies.

Uncertainty is a pervasive phenomena in fisheries production. Many factors, including weather, fish abundance, regulations, and general economic conditions interact to create a complex decision making environment for fisherman. Vagaries of nature and markets contribute to variability of prices, yields, and net returns associated with fishing actvities. Modeling decision making in this type of environment requires knowledge of the fishermen's willingness to bear risk, or equivalently, knowledge of their risk preference. While this has been a topic of concern among agricultural economists(Young, 1979 and Mapp, et al., 1979), examination of issue in the fisheries context is lacking.

Several methods have been proposed to examine the risk attitudes of producers (Young, 1979): (1) direct elicitation of utility functions; (2) ex-perimental methods; and (3) observed economic behavior with respect to input demand and output supply. The first of these approaches requires direct acquisition of information from producers. The third involves comparison of observed economic behavior with behavior predicted by theoretical models incorporating risk and risk preference. Problems associated with elicitation of producer responses to hypothetical questions and rewards coupled with the cost-conducing interviews, suggests that method 3 should be used to study risk preferences of fishermen. It is necessary to indicate that this method is not problem free. Failure to take into account the fact that fishermen base their decisions upon multiple objectives such as profits, leisure work consideratons, and personal considerations could lead to erroneous conclusions.

Information on fishermen's risk preferences and the factors that affect them would facilitate the design of management measures that would stimulate development of the U.S. groundfish fishery. This knowledge would also make it possible to determine how management policies would affect the structure of the fishery; that is, encourage the use of small versus large vessels. The analysis of the distributive impacts of risk-modifying policies may require reliable risk preference measurements for different groups of fishermen.

Knowledge of the risk preference of fishermen by itself does not provide a complete understanding of the dynamics of fleet behavior. Considering the case of a single fisherman who owns a single multi-purpose vessel, he is faced with making a decision on how to allocate fishing time during any given year across an array of choice possibilities. The problem facing the fisherman, then, is one of selecting the prospect that maximizes his decision criterion. Diagrammatically the problem is depicted in portfolio's curve. The opportunity set of feasible fishing plans lies on or below the curve. Only portfolios on the curve are efficient, that is, they constitute fishing plans having maximum expected net return for a given variance of net returns. For any portfolio below this curve, a portfolio on the curve can be found to yield greater rewards.

Application of portfolio analysis techniques can also be made in the fisheries management setting. Frequently, managers are faced with making gear, season, size restriction, quota, and user group decisions. A prerequisite to application of this technique is determination of expected net returns for various gear, season, size restriction, quota, and user group combinations. Results of analyses of this type would provide valuable insights that would contribute to resolution of incidental catch, size restriction, and quota issues which have been before managers of eastern Bering Sea, GOA, and WOC fisheries.

Variability of prices for catches was identified previously as contributing to the risk fishermen face. Since prices are determined by product demand and supply, analyses are needed to isolate the importance of various demand and supply determining forces. Some work in this area has been performed. A detailed exvessel, wholesale, and retail price mode has been developed for pacific halibut(Marasco, 1978). Exvessel price relationships for king crab, Tanner(snow) crab, and the various salmon species have been estimated (Terry, 1980). While this research has provided useful insights and information, there is a need to expand these efforts, especially for groundfish species. The market is worldwide with large quantities of ground-fish products being traded between producing and consuming countries.

Acquisition of an understanding of linkages between the fishing industry and other economic sectors in regions where fisheries are based requires development of regional inter-industry econometric models. The purpose of these models is to predict now employment, income, and population will behave when regional economic activity varies.

Complete impact assessment of fishery managememt decisions requires information derived for these models.

Interfacing social factors with biological and economic parts of the model represents a significant undertaking. Successful execution of this task requires description, preferably in quantitative terms, of the relevant social system. The need exists to develop a set of social indicators to describe important phenomena associated with relevant social systems. Once this is accomplished, factors that cause the indicators to change must be identified. Since these indicators are components of social system models, a last step in the process is their integration into a comprehensive description of the system. The goal of this effort at the national level, for example, is the development of a supplement to economic indicators and National Income Account prepared by the U. S. Bureau of Labor Statistics and the Council of Economic Advisors. The complexity of this undertaking will make progress slow. Integration of social considerations into fishery mamagement. models is dependent, however, upon progress made in this area.

The preceding discussion of research needs was not meant to be exhaustive. It was meant to touch briefly upon research needs that are critical to satisfying the information demands of managers of northeastern Pacitic and eastern Bering Sea fish stocks. The direction that research takes during the 1980's will be dictated by a desire to further develop and refine ecosystem models of the area.

## Ⅴ. Conclusion

The northeast Pacific and eastern Bering Sea supports large diverse finfish and shellfish complexes. Recent action by the United States extending its fisheries jurisdiction to 200 miles has provided a new setting within which solution to management can be developed. Creation of this new institutional setting has resulted in an enormous expansion in the demand for scientific information. These needs are no longer limited to biological concerns. Emphasis has been focused recently on the need to understand the economic and social settings and how they will be affected by management decisions. This holistic approach to fisheries management has increased interest in ecosystems models and the coupling of these models with economic and social components. Successful completion of this task will required understanding of ecosystem, economic, and social processes associated with fisheries. Particular attention should be devoted to acquiring information on growth, reproduction, migration, and predator prey processes associated with an area's fish stocks. The impact of environmental factors on these processes must also be examined. Fleet dynamics, price and cost determining forces, industry linkages with other sectors of the community or regional economics, and quantitative description of the relevant social systems should be the focus of economic and social research.

Finally, the need for international collaboration in management must be stressed. Some northeast Pacific and eastern Bering Sea fish stocks migrate over long distances, with the fish failing to recognize political boundaries. Further, nearly all the fish stocks are harvested by several nations. Catch and effort statistics from all participants in the fishery are required, therefore, to study status of stocks. These features require cooperation and coordination of research activities. The International North Pacific Fisheries Commission has facilitated this type of interaction in the past. Perhaps the proposed Pacific International Council for Exploration of the Seas, PICES, will be the vehicle that allows interaction between all users of the area's fisheries in the future.

## 參 考 文 献

金仁台・朴九秉(1963): 水産經濟論.

朴九秉・鄭俊秀(1978): 漁業經營指針.

張褧鎬(1966):水産經營學

Anderson, L. G. (1973): Optimum Economic Yeild of a Fishery Given a Variable Price of Output.

Anderson, L. G. (1977): *The Economics of Fisheries Management.*

Beverton, R. J. and Holt, S. J. (1957): *On Dynamics of Exploted Fish Populations.*

Bell, F. W. and Hazleton, J. E. (1967): *Recent Developments and Research in Fisheries Economics.*

Crutchfield, J. A. and Zellner, A. (1962):Economic Aspects of the Pacific Halibut Fishery.

Gulland, J. A. (1956): On the Fishing Effort in English Demersal Fisheries.

Hannesson, R. (1978): *Economic of Fisheries.*

Larkin, P. (1966):Exploitatton in a Type of Predator-Prey Relationship.

Ricker, W. E. (1975):Computation and Interpretation of Biological Statistics of Fish Populations.

Schaefer, M. B. (1954): Some Aspects of the Dynamics of Populations Important to the Management of the Commmercial Marine Fisheries.