Draft Report[1]

North Pacific Albacore 'White Paper'

Prepared by

R. Michael Laurs[2] and Joe Powers[3]

Prepared for

U.S. Department of Commerce, NOAA
National Marine Fisheries Service
501 West Ocean Blvd., Suite 4200
Long Beach, CA 90802-4213
Order No. JF133F08SE4559

[1] Not to be cited or used without permission of NOAA/NMFS Southwest Regional Office
[2] Principal, RML Fishery Oceanographer Consultant, LLC, Jacksonville, OR 97530
[3] Professor, Dept. Marine Science, Louisiana State University, Baton Rouge, LA

Contents

North Pacific Albacore White Paper

1 Purpose and Need

1.1 Purpose

The purpose of this 'White Paper' is to review and analyze a range of reasonable management options for consideration in maintaining or reducing catch and/or effort in the U.S. North Pacific surface albacore fishery. This task is considered a necessary first step in a deliberate and thorough process for providing U.S. fishery managers with potential management options for the U.S. North Pacific albacore fishery. The intent of this 'White Paper' is to provide U.S. fishery managers with information regarding the albacore resource, the fisheries operating on it, and an analysis of a range of management options that could be considered for maintaining or reducing catch and/or effort in the U.S. surface fishery. An outcome of the analysis is that it later may serve as the basis of the NEPA process and thus serve as the building blocks that could be formulated into a range of rational management options for the U.S. West Coast albacore fishery.

1.2 Need For Information

The need for this information has been prompted by measures adopted by the Inter American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC) to cap international fishing effort on North Pacific albacore. Albacore tuna is a highly migratory species (HMS) that is harvested by many countries in the North Pacific Ocean. International management of the North Pacific stock of albacore tuna and fisheries operating on it are shared under the auspices of the IATTC and WCPFC. The Commissions formulate overarching regulations based on recommendations from scientific committees or staff. Member states negotiate agreements on regulatory mechanisms and once agreed upon, the actual implementation is left to the individual member and cooperating countries. In 2005, the IATTC and the WCPFC adopted resolutions for conservation of North Pacific albacore based on concerns that recent fishing effort may be above levels that are not sustainable in the long term. Both resolutions call upon their members and cooperating parties to take necessary measures to ensure that the level of fishing effort by their vessels fishing for North Pacific albacore is not increased beyond current levels, and to report all catches of North Pacific albacore to the Commissions at 6-month intervals. In addition, the WCPFC resolution requires that fishing effort be reported by gear type annually *"… in terms of the most relevant measures for a given gear type, including at a minimum for all gear types, the number of vessel-days fished."* In response to the IATTC and WCPFC resolutions, the Pacific Fishery Management Council (PFMC) tasked its Highly Migratory Species Management Team (HMSMT) to examine recent levels of U.S. West Coast North Pacific albacore fishing effort in order to establish the current effort level and enable decision makers to meet the requirements of the IATTC and WCPFC resolutions. Scientists of NOAA Fisheries' Southwest Fisheries Science Center (SWFSC), working in cooperation with the Council's HMSMT and HMS Advisory Subpanel (HMSAS) compiled statistics and analyzed trends in North Pacific albacore catch and effort for U.S. commercial and recreational fisheries (May 2007. *Characterization of Recent U.S. North Pacific Albacore Commercial Fishing Effort*, *Report and Analyses* prepared by NOAA Fisheries Southwest Fisheries Science Center with guidance from the Pacific Fishery Management Council's HMS/HMSMT.

2. Background Prospective Management Options

North Pacific albacore occupy areas that encompass multiple zones of national jurisdiction, as well as the high seas, and are exploited by fisheries of many Nations. As such, international agreement is necessary to conserve North Pacific tuna stocks and to ensure the viability of the fisheries. Article 64 of the United Nations Law of the Sea Convention mandates States to cooperate directly or through appropriate international organizations to ensure the conservation of tunas, including albacore. As noted earlier, the IATTC and WCPF share responsibility for the international management of the North Pacific stock(s) of albacore tuna and fisheries operating on it, with the actual implementation of management actions is left to the individual member and cooperating countries following agreements on the Commissions regulatory mechanisms. The PFMC has the responsibility to develop management actions required to address the concern regarding the U.S. West Coast albacore fishery. The North Pacific albacore tuna resource does not yet appear to be overexploited. However, excess fishing capacity has been identified as a problem because fishing effort may be above levels that are not sustainable in the long term.

2.1 Potential Management Options

Potential management options for the U.S. West Coast albacore fishery may be grouped into three general categories: 1) input and/or output controls added to present open access without property rights status of the fishery, 2) rights-based fishery management programs, and 3) status quo 'no action' scenario. These three general options will be discussed with the PFMC HMSMT and HMSAS on June 13, 2009. Contributions received will be used to assist in preparing specific management options for consideration regarding the management of the U.S. West Coast albacore fishery to address the problem of excess capacity identified by the IATTC and WCPFC.

2.1.1 Input and/or Output Controls Added to Present Open Access

Most U.S. fisheries were managed under open access until the end of the 20th century. Under this system of management, lucrative fisheries have often become over-capitalized resulting in excess capacity and over-exploitation of the resource. At some point to halt the over-exploitation, an authority may establish input or output controls on the fishery, e.g., vessel size, limit number days fished, catch limits, restrictions to fishing effort, or limit the characteristics (normally size or breeding status) of individual fish that may be taken legally. The West Coast albacore fishery is one of the few remaining open access fisheries on the West Coast. It requires a readily available permit and the possession of the necessary and appropriate gear to operate in the fishery; a few management mechanisms are also in place, e.g., mandatory logbooks and others that will be discussed later. The U.S. West Coast albacore fishery does not appear to be a good candidate for using the usual types of input or output controls applied in open access fisheries, nor would they likely be effective in satisfactorily reducing fishing effort. Perhaps, catch limits or trip limits could be established for the fishery to keep fishing effort in check, but these would likely have only limited success and create economic inefficiency. The fishery is based exclusively on immature fish, so setting a size limit where only mature fish could be landed would not work; it is not possible to distinguish the gender of an albacore without dissection, so allowing only males to be landed would not be successful; the distribution, availability, and vulnerability of albacore are all markedly affected by spatial and temporal variability in ocean conditions, so closed areas would be very difficult to establish and almost impossible to enforce. The highly migratory nature of the species and its limited seasonal distribution in waters off the west coast of North America also contribute to reducing the effectiveness of utilizing input or output controls. This outcome also would likely occur as the result of ongoing technological changes in the fishery, which have the effect of increasing effective fishing effort, even though nominal effort may remain constant (see Section 3.3.2.1.3). Regarding tuna fisheries, Allen et al (in press) state that "… *Allowing the resources to be treated as common property, open access, or controlled open access fisheries, has led to excess fishing capacity, which has led to overexploitation*"… "*It has been shown that such excess capacity exists in all oceans and so long as the concept of open access and common property management prevails, this problem of overcapacity will not be corrected.*"

2.1.2 Rights-Based Management Programs

Rights-based management programs include Limited Access (LA) and Limited Access Privilege (LAP) programs for managing fisheries resources.

2.1.2.1 Limited Access (LA) Programs

LA programs are commonly used to regulate entry into a fishery to promote the conservation and sustained yield management of fishery resources, and the economic health and stability of the fishing industry. They are a simple rights-based input controls, which provided the rights are guaranteed for a long time, give those with the right an interest in conservation, but on its own does not promote economic rationalization (Allen et al in press). The effectiveness of LA's for holding harvest at safe levels depends on a multitude of factors including the number of permits relative to safe harvest limits, the types of other management controls that are put in place, and on the potential for input substitution in the fishing process. Also, limited entry or limited access simply limits entry, but does not limit use or catch, nor does it take into account technological changes in fishing.

2.1.2.2 Applying LA to the U.S. West Coast Albacore Fishery

Applying a LA fisheries management program to the U.S. West Coast albacore fishery could result in short term and potentially long-term benefits to the fishery in maintaining its viability, as well as to preserving the health of the North Pacific albacore resource. However, the full effect on the albacore resource would not be realized until the other Nations harvesting North Pacific albacore stock(s) put management actions in place to keep excess capacity curbed. The timing is favorable for the U.S. to adopt a LA program for the West Coast albacore fishery since the number of U.S. vessels has been relatively stable during the recent 5 or more years and a control date of March 9, 2000 is in place in the HMS FMP. Setting up a LA program for the U.S. albacore fishery conceptually could be relatively straight forward since it is a single species fishery. Also, a LA program could be structured to allow transfers and it would establish an assemblage of participants for future management measures, including stronger forms of rights-based management.

2.1.2.2 Limited Access Privilege (LAP) Programs

LAP programs are market-based or rights-based fishery management programs whereby an individual fisherman, community, or other entity is granted the privilege to catch a specified portion of the Total Allowable Catch (TAC) of a fishery stock. Originally LAPs were referred to as Individual Fishing Quotas (IFQs), where an individual fisher is granted a specified portion of the TAC, or Individual Transferable Quotas (ITQs) where the IFQ could be transferred to another user. Over time the concept of IFQs has been expanded and is referred to as a LAP program in the amended Magnusson-Stevens Act (MSA) (Public Law 109-479). MSA specifies mandatory conditions and other provisions for designing LAP fishery management programs. MSA also is clear that any LAP is only a permit to harvest and does not confer any right to compensation and that there are no rights, title, or interest in any fish until it is harvested. NOAA Fisheries Service/Office of Policy has issued a comprehensive publication to assist Regional Councils and NOAA NMFS in the design and implementation of LAP programs (Anderson and Holliday eds. 2007). In summary, LAP programs are not ideal, appropriate, or desired for every fishery or region. However, they provide an option in fisheries management that can reduce the race for fish, promote conservation, minimize overcapitalization, create a safer fishery with a higher quality product that maximizes dockside values, and handle technical change well. If a fisher becomes more efficient than another through technical change or other means, that fisher may have the opportunity to simply buy more quota.

2.1.2.2.1 Applying a LAP Program to the U.S. West Coast Albacore Fishery

This action could result in major short term and long-term benefits to the fishery in maintaining its viability, as well as preserving the health of the North Pacific albacore resource. However, the full effect on the albacore resource would not be realized until the other Nations harvesting North Pacific albacore stock(s) put similar management actions in place. Adopting a successful LAP management program for the U.S. fishery would put the U.S. in an improved bargaining position to pressure other countries, notably Japan, to employ rights-based LAP type management programs for managing their albacore fisheries. This is especially important because the U.S. produces a little less than 20% of the total annual catch, whereas, Japan harvests more than 65%. An increase in fishing effort by Japan or other foreign countries, leading to overexploitation of the stock(s) could be seriously deleterious to the U.S. West Coast albacore fishery. The timing is favorable for the U.S. to adopt a LAP program for the West Coast albacore fishery since the number of U.S. vessels has been relatively stable for the recent 5 or more years and probably would not require the elimination of any vessels and the need for vessel buyouts. This would likely reduce the costs for designing and implementing a LAP program. Setting up a LAP program for the U.S. albacore fishery conceptually could be relatively straight forward since it is a single species fishery. However, designing and implementing a

LAP system for the fishery would be very challenging since 1) there are a large number of other international fisheries that operate on the same stock(s) and 2) there is considerable variability in the distribution and availability, as well as the vulnerability to harvest, of highly migratory albacore along the west coast of North America due spatial and temporal variability in North Pacific ocean conditions. In addition, the costs to design, implement, and operate a LAP program for albacore would be much higher than a LA program. Nevertheless, keeping the fleet capacities near that which can take the optimum catch will make other management measures in the future easier to implement and more effective should they be needed.

2.1.2.2.2 LAP Type Program For Management of Global Tuna Stocks

A LAP type rights-based fisheries management program is believed by Joseph (2003) and Allen et al (in press) to be the most viable solution available for the international management of global tuna stocks to address the problems of excess capacity and over-exploitation. Allen et al. (in press) state that "*…Unlimited entry into tuna fisheries must now change. Failing this, the inevitable outcome will be overexploitation of the world's tuna stocks. Rights-based management, (*the concept upon which LAP is based) *wherein catches are allocated to participants and fleets are limited in numbers, can bring this change and provide incentives to fishers to maintain fleets at optimal levels. To accomplish this requires a change in mind set and political will of many nations whose citizens participate in world tuna fisheries, both on the high seas and in coastal zones.*"

2.1.3 Status Quo 'No Action' Scenario

The status quo 'no action scenario' would make no changes in the present status of the U.S. West Coast albacore fishery as an open access fishery without controls to address fishing effort. As such, this could be interpreted as the U.S. not being responsive to the IATTC and WCPFC findings to take actions regarding excess fishing capacity as a potential problem because fishing effort on North Pacific albacore may be above levels that are not sustainable in the long term. There are many advantages to moving beyond the 'status quo', including, making good sense to prepare for the likelihood that over-fishing may be occurring on the stock, before the situation becomes a crisis and emergency action is required.

3. Description of the North Pacific Albacore Resource

This segment of the 'White Paper' includes sections related to North Pacific albacore life history, biology, stock structure, and habitat and ecosystem; stock assessment; fisheries operating on the resource; economic analyses and bio-economic modeling; responsibilities for the management of U.S. fisheries operating on the albacore resource; and the U.S./Canadian Albacore Treaty.

3.1 Life History, Biology, and Ecology

Albacore is a highly migratory tuna found in all of the global oceans and Mediterranean Sea. It matures at a relatively early age of approximately 5 or 6 years (Ueyanagi 1957, Otsu and Uchida 1963) and has a moderate lifespan to about 10 to 12 years. The species is highly fecund with 0.8 to 2.6 million eggs per spawning (Ueyanagi 1957; Otsu and Uchida 1959). Spawning occurs generally throughout much of the year, with a peak usually in summer months (Otsu and Uchida 1959, and in the eastern Pacific off Mexico in winter months (Wetherall et al 1987). Spawning in the North Pacific takes place in subtropical waters between about 10^{o}N to 25^{o}N latitudes in the western Pacific (Ueyanagi 1957), in the vicinity of the Hawaiian Islands (Brock 1943, Otsu and Uchida 1959; Yoshida 1968;), and apparently to a lesser degree in the eastern Pacific off Guadalupe Island, Mexico (Scofield 1914, Anon. 1953, and Clemens 1961). Growth rates are moderate (Otsu 1960, Nose et al, 1957, Clemens 1961, Yabuta and Yukinawa 1963, and Laurs and Wetherall 1981). Estimates of the fork lengths at first birthday have been estimated to range from about 38 cm (Laurs et al 1985) to 45 cm (Clemens 1961), and the fork length at sexual maturity at approximately 90 cm or somewhat less (Otsu and Uchida 1959). Albacore, like other tunas, have a number of physiological and morphological specializations that adapt them to a fast, continuous swimming lifestyle in the pelagic open ocean environment. They must swim constantly to overcome their negative buoyancy and to continuously force water over their gills to maintain respiration (Brill and Bushnell 2001). They are endothermic as the result of a countercurrent *rete mirable* heat exchanger system (Carey and Teal 1966 Graham and Dickson 1981, and Graham and Dickson 2001), which enables them to maintain internal core body temperatures up to 10^{o} C warmer than ambient ocean water temperatures (Graham and Dickson 2001). Their metabolic rates are 2 to10 times higher than most other bony fishes (Graham and Laurs 1982). As a likely consequence, albacore are restricted to waters with dissolved oxygen saturations greater than 60% (Cech et al 1985). Albacore are also different from most other teleosts in having a high blood volume (Laurs et al 1981), high cardiac performance (Breisch et al 1983), specialized hemoglobin-oxygen dissociation characteristics (Cech et al 1984), and other cardiac and vascular system distinctions that adapt them (Lai et al 1987, White et al 1988; and Graham et al 1989) for fast swimming (Dotson 1976, Magnuson1978, and others. In addition, albacore have very large eyes for detecting prey and specialized fins and body form to reduce drag. Most albacore caught by trolling and pole-and-line fishing are from waters that have sea surface temperatures between 15^{o}- 19.5^{o}C (Clemens, 1961, Flittner 1963, and many others). Temperatures lower than 10^{o}C disrupt albacore physiological processes and may lead to fatality (Graham and Laurs 1982).

3.2 Habitat and Ecosystem

The habitat of albacore generally is open ocean pelagic waters, mostly in the vicinity of oceanic fronts. The horizontal dimension of albacore habitat in the North Pacific is linked to oceanic frontal structure associated with the Kuroshio Current, the Kuroshio Current Extension Waters, the North Pacific Transition Zone and the Subtropical Convergence Zone, and the California Current System. Oceanic frontal structure greatly influences the distribution, relative abundance, and availability of albacore, as well as the location of migration routes and rates, and their vulnerability to capture. Sub-adult albacore make trans-Pacific migrations associated with the NPTZ (Laurs and Lynn 1977) and have been linked with various regional or mesoscale features of the North Pacific Ocean (Laurs and Lynn 1977, Polovina et al 2001, Broder et al in prep). They move along oceanic thermal fronts as they migrate and form transient aggregations or patches in areas of local enrichment favorable for foraging (Laurs

1983; Laurs et al 1984, Laurs and Lynn 1977, 1991, Laurs et al 1977, Polovina et al 2001, Zainuddin et al 2006). The vertical distribution and albacore habitat is related to the configuration and depth of ocean vertical thermal structure and is mostly in waters located in or near the thermocline (Laurs 1982 and Koin in prep). The vertical distribution of pre-adult albacore is shallower than that of adult sexually mature albacore. As a consequence, pre-adult albacore are targeted by surface troll and pole-and-line fisheries in temperate zone waters of the North Pacific by the Japanese fishery in the western Pacific and the U.S. and Canadian fisheries in the eastern Pacific. Adult albacore are targeted by the Asian longline fisheries and are caught incidentally by the Hawaii-based longline fishery in the subtropical and tropical zones of the North Pacific. In coastal waters off the coast of North America, sea surface temperature, coastal upwelling, the Columbia River plume, and other oceanic frontal features, which play roles in the aggregations and behavior of prey species, all influence distribution, availability and catchability of albacore (Pearcy and Mueller 1970; Pearcy 1973, Laurs and Fiedler, 1984, and others). Albacore are opportunistic carnivores that occupy relatively high trophic levels. Their diet is made up of a variety of pelagic and mesopelagic species including small fishes, cephalopods, and crustaceans (Iverson 1962, Iverson 1971, Bernard et al 1985, Watanabe et al 2004, Glaser 2008; and others). Little is known about what animals prey on pre-adult and adult albacore, but predators on them are believed to be large marine mammals, sharks, and billfish. Young albacore have been found in stomachs of large tunas and other large fishes (Yabe et al 1958 and Yoshida 1965). Albacore distribution and availability is known to fluctuate extensively over a range of spatial and temporal scales, which may be related to ocean-atmosphere interactions, oceanic tele-connections, and large-scale climatic variability. Clark et al 1975 found that the distribution of albacore tuna along the west coast of North America and the growth of conifers in western North America are linked by large scale atmospheric flow patterns, which are influenced by air-sea interaction processes over the eastern North Pacific. Although the albacore and conifer ecosystems respond to their respective environments during different times of the year, there is strong evidence that they are reacting to the same climatic fluctuations that are responsible for major north-south shifts in North Pacific albacore availability along the coast of North America (Laurs Clark et al 1975). Modeling climate-related variability of tuna populations from a coupled ocean-biogeochemical-populations dynamics model, Lehodey et al (2003) demonstrated that El Nino conditions have negative effects on albacore recruitment in the western South Pacific. Similar El Nino effects are being examined and expected regarding recruitment of North Pacific albacore. Albacore provide a good example of Hallett et al, 2004 conclusion that large-scale indices are often better predictors of ecological processes and population fluctuations than local climate.

3.3 Stock Structure

In the Pacific Ocean there are believed to be separate and distinct stocks of albacore in the northern and southern hemispheres (Ueyanagi 1960; Nakamura 1969; Lewis 1990; IATTC 2006; and others). However, there is increasing evidence that there may be stock heterogeneity in both hemispheres. Essentially, the stock structure of North Pacific albacore is not fully understood and is a priority need for further research, perhaps, using modern genetic approaches, e.g., microsatellite DNA genetic methods.

This technique was recently successful in differentiating separate albacore stocks in the western and eastern South Pacific (Takagi et al, 2007). Genetic methods involving North Pacific albacore conducted more than two decades ago were inadequately sensitive for evaluating stock differentiation. For example, no significant genetic differences were found between albacore taken in the North Pacific and in the Atlantic off South Africa (Graves and Dizon1989). Likewise, chromosomal analysis techniques were found to have insufficient resolution to determine genetic differences within individual tuna species including North Pacific albacore (Ratty et al 1986).

3.3.1 Stock Structure of Albacore Entering West Coast Fisheries

The stock structure of North Pacific albacore that enter the fisheries off the coast of North America has been based historically on locations of spawning, tagging results, or fishery-related biological information. Scofield (1914 and 1914a) reported the discovery of albacore spawning in the area near Guadalupe Island, Baja Mexico and for about five decades it was surmised that albacore spawned in subtropical waters off Mexico and seasonally migrated along the coast to enter the surface fishery along the west coast of California. Tagging studies conducted in the 1950’s showed that North Pacific albacore, particularly sub-adults, undertake trans-Pacific migrations (Clemens 1961, Clemens and Craig 1965, Otsu and Uchida 1959, and others). This led to the belief that there is one stock of albacore in the North Pacific (Otsu and Uchida 1959; Clemens 1961; Otsu and Uchida 1963; Clemens and Craig 1965). However there is a large body of evidence summarized in the section that follows, which indicate that albacore entering the U.S. west coast fishery are not a homogeneous stock, but rather that the stock heterogeneity.

3.3.1.1 Morphometrics

An early preliminary morphometric investigation of albacore caught off Japan, Hawaii, and southern California concluded that albacore caught off California and off Japan are probably distinct and non-intermingling (Godsil 1948). Japanese albacore were characterized by a relatively shorter head and caudal region and longer abdominal or central trunk than specimens from off California. Hawaiian albacore appeared to resemble the Japanese more than California specimens, but there were insufficient Hawaiian samples to justify conclusions. Schaefer (1952) pointed out that there are shortcomings to defining albacore stock structure using morphometric data. However, the validity of findings using is approach is strengthened when considering the scientific evidence provided by other diverse studies.

3.3.1.2 Size Composition

Brock (1943) suggested that the North American coastal albacore fishery was comprised of two separate and independent groups of fish. He based this premise on the finding that size compositions of albacore landed in Los Angeles, which were caught off southern California, had larger modal peaks than albacore landed in Astoria, Oregon, which were caught off the Pacific Northwest (Brock, 1943). Similar findings where the size compositions of fish caught in coastal waters from the ‘southern’ and ‘northern’ areas have different modal peaks have been reported by other investigators, e.g., Laurs and Lynn 1977, Laurs and Wetherall 1981, Wetherall, et al 1987, and recently by Barr who is investigating the variability in the seasonal migration and size composition of albacore in the U.S. coastal fishery. Barr is using logbook records and size composition data provided courtesy of the NMFS/SWFSC from the albacore fishery database for the years 1961 – 2006. Figure 1 shows the average size by month of albacore caught north and south of 40°N for the years 1961 – 2006 (Barr MS thesis, Oregon State University, in prep).

3.3.1.3 Navy Vessel Offshore Albacore Surveys

Based on data from a Navy picket vessel survey data of albacore in waters extending several hundreds of miles off the North American coast, Flittner (1963) postulated that albacore congregate offshore and then split into two migratory components: early arrivals proceed to southern fishery areas off southern and central California and late arrivals turn northward to the coast off Oregon and Washington.

3.3.1.4 Artificial Radionuclide Concentration in Albacore Livers

Pearcy and Osterberg (1968) found that off Oregon and Washington that levels, as well as specific activities, of the artificial radionuclide Zn-65 in albacore livers sampled increased markedly during summer months. Association of albacore with the effluent of the Columbia River accounted for this enhancement. Zn-65 concentrations of albacore from southern and Baja California were about 10% of those off Oregon and Washington with no seasonal trends evident. Pearcy and Osterberg stated …*"We have no evidence either for immigration of Zn-65 tagged albacore into the southern California fishery or for immigration of southern albacore, with low Zn-65 content, into the northern fishery during one season."*

3.3.1.5 NMFS/American Fishermen Research Foundation Tagging Studies

Results from tagging studies reported by Laurs and Nishimoto 1979 and summarized in Table 4 in Laurs and Lynn 1991, suggest that at least two subgroups of albacore enter the fishery along the west coast of North America: a 'southern' subgroup south of about 40°N and a 'northern' subgroup north of that latitude. The two subgroups have different migratory patterns, with 'northern' fish making migrations between the eastern and western North Pacific and the 'southern' fish making migrations between the eastern and central North Pacific. There was very little exchange of tagged fish between north and south of 40°N, with less than 1% of fish tagged north of 40°N being recovered south, and vice-versa. About 5% of fished tagged north or south 40°N and recovered after being at liberty one year to three years, were recovered in the opposite area. In previous albacore tagging studies conducted by California Fish and Game during the 1950s, no albacore tagged off Baja or southern California were recovered off Oregon or Washington (Clemens 1961).

3.3.1.6 Growth Rates

Laurs and Wetherall 1981 found that albacore tagged and released south of 40°N had significantly higher growth rates than albacore tagged north of 40°N. They proposed that the differences in growth rates between the two subgroups likely explain the dissimilarity in the modal peaks of their respective size compositions. They postulated that the slower growth rates of the 'northern' subgroup result from their high energy requirements for the very long migrations across the North Pacific and that less energy may be available for somatic growth, than for the 'southern' subgroup, which undergo much shorter migrations.

3.3.1.7 Birth-date Distributions

Wetherall et al 1987 estimated birth-date distributions for the 'north' and 'south' albacore by using tag release and return statistics, and growth models computed from the tag data. Each of 521 albacore provided two estimates of its birth date, one based on release length and date and another on corresponding recapture statistics. The findings suggest that the 'north' fish are born primarily during the April-October period, with a peak in July; whereas, the 'south' albacore appear to be born mostly during the November-June period, with a peak in February.

3.3.1.8 Migration Patterns by Age at Release

Wetherall et al 1987 noted that the general variation in tag return patterns between albacore tagged inshore of 145^{o}W in the 'north' and 'south' zones provide interesting results when analyzed by age group. Most of the albacore in the 60 – 70 cm range at time of tagging were made in subsequent years in the area of release. Recaptures from fish in the 70 – 80 cm range and the 80 – 90 cm range when tagged were made in increasingly higher proportion away from their area of release, with a greater percentage coming from the central and western Pacific fisheries. However, albacore in the largest size class and tagged in the 'north' area of the eastern Pacific had a much greater rate of recapture in the western Pacific than their 'south' counterparts. The latter were still recaptured mainly in the region where they were released, or offshore east of the Dateline. This apparent difference in migration behavior of the larger albacore is particularly interesting because these are mature fish. This difference suggests the possibility of separate spawning areas.

3.3.1.9 Fisheries and Stock Structure

The tagging data demonstrate that the two proposed subgroups are for the most part harvested by different fisheries. Fish north 40^{o}N, which make trans-Pacific migrations between eastern and western North Pacific, are harvested by the U.S. troll/pole-and-line fishery north of 40^{o}N and the Japanese baitboat and Asian longline fisheries west of the Dateline. Whereas, fish south 40^{o}N, which make migrations between the eastern and central North Pacific, are fished on by the U.S. troll/pole-and-line fishery south of 40^{o}N and the Asian and Hawaii longline fisheries east of the Dateline.

3.3.1.10 Length of Fishing Season and Catch Rates

Preliminary findings made by Barr (in prep.) show that the 1) distribution and spatial range of the fishery oscillates between the north and south areas over periods lasting about a decade or more; 2) average season length in northern area is 96 days and in the southern area is 146 days; 3) average annual catch per day (CPUE) is 77.6 and 48.2 fish/day north and south of 40^{o}N, respectively; and 4) the average CPUE during peak months of the fishing season is higher in the northern area than in the southern area Figure 2). The results are compatible with the proposed stock heterogeneity of albacore entering the coastal waters of North America.

3.3.1.11 Research Needed

Information gathered from a broad range of sources indicates that a better understanding of the possibility of stock heterogeneity of North Pacific albacore may be needed to effectively manage the resource. Appropriate genetic studies are required to further investigate the likelihood that two subgroups of albacore enter the U.S. albacore fishery. In addition, stock assessments of North Pacific albacore, which have assumed a single stock, need to be evaluated regarding the likelihood of albacore stock heterogeneity. It may be found that it is necessary to structure management actions for specific fisheries and/or segments of fisheries.

3.3.2 Fisheries Operating on North Pacific Albacore

North Pacific albacore are targeted or caught incidentally by numerous fleets from a number of Nations. These include pelagic longline fisheries conducted in the western and central North Pacific by Japan, Taiwan, and Korea, and in the central North Pacific by the U.S. Hawaiian longline and hand-line fisheries; a pole-and-line fishery carried out in the western North Pacific by Japan; a troll and limited pole-and-line fishery executed in the eastern North Pacific by the U.S; a troll fishery conducted by Canada; and a U.S. recreational hook and line fishery that takes place mostly off southern California and to a lesser degree along the entire U.S. west coast. Several other countries also have minor fisheries with various fishing gears that incidentally catch North Pacific albacore. Asian drift-gillnet fisheries targeted albacore across much of the North Pacific mostly during the mid-1970s and 1980s, but were halted by U.N. action in 1992. Information on the annual amounts of catch taken by country and gear type for 1952 – 2007 is given in Table 1 and Figure 3, respectively. For the most part, only basic fishery data are available for most of the fisheries catching albacore in the early years. However, in recent years the data provided by countries with fisheries catching albacore have been improved and expanded to include: catches and number of vessels, summarized catch and effort, and size composition of the catch. The record high total catch of North Pacific albacore for all nations combined was 125,433 mt in1999 and the record low catch was 37,325 mt in 1991 (ISC 2008). During the 5 year period 2003 - 2007, the total catch ranged from 62,722 mt to 92,647 mt and averaged 78,730 mt. Fisheries based in Japan accounted for 66.6% of the total harvest, followed by fisheries in the U.S. 15.9%, Chinese-Taipei 8.2%, Canada 6.3% and all other countries 2.8%. The percentages of the catch of North Pacific albacore by gear type were: pelagic longline 37.5%, pole-and-line 36.8%, troll 20.2%, and all other gears including the U.S. recreational hook and line 5.5%, see Figure 4.

3.3.2.1 U.S. West Coast Albacore Fishery History and Trends in Fishing Effort

A history of the U.S. west coast albacore fishery and an analysis trends in fishing effort are presented below. A review of the fishing methods and equipment used by the U.S. west coast fleet is given in Dotson 1980.

3.3.2.1.1 History of the Fishery

The U.S. west coast fishery began in the early 1900's when fishers commenced targeting on seasonally migrating albacore in near-shore ocean waters off southern California to meet the needs of a tuna cannery established there. In 1903, an experimental pack of 700 cases of albacore led to the development of the U.S. tuna canning industry. The troll fishery for albacore gradually spread northwards, but was restricted to waters off California until the late 1930's, when it extended to coastal waters off the states of Oregon and Washington, and eventually to off British Columbia, Canada. Until the late 1970's, the troll fishery usually began operating in early July, when migrating albacore approach the west coast of North America, and was primarily conducted in near-shore oceanic waters. From 1961 through 1979, approximately 99% of the reported U.S. catches of North Pacific albacore were made within 200 miles of the North American coast, with 84% off the U.S. coast and 9% and 7% in the jurisdictional waters of Mexico and Canada, respectively. From the late 1970's until about 2000, U.S. albacore fishers with larger vessels began troll fishing in the early spring months on the high seas. Some of these vessels operated as far west as the International Dateline and beyond, to extend the fishing season by intercepting albacore migrating towards the coast of North America locating high catch rate areas. However, during the recent about five or so years, the fishery has operated mostly within a few hundred miles of the coast, apparently because of high fuel and other costs. The history of the U.S. pole-and-line fishery for albacore differs somewhat from that of the troll fishery, and is linked to the U.S. tropical tuna fishery for yellowfin, bigeye, and skipjack tunas. The pole-and-line method of catching albacore, which is also referred to as bait-boat or live-bait fishing, also began in the early 1900's with vessels operating within a one-day run from port to provide product for the tuna cannery located in southern California. A poor catch of albacore in 1918 forced pole-and-line boats to shift to fishing for tropical yellowfin and skipjack to fill the cannery's demand for tuna. In subsequent years, even though the availability of albacore may have been high, the amount of pole-and-line effort expended for albacore was thereafter greatly influenced by events in the tropical tuna fishery. Nevertheless, in some years up to 40% of the annual catch of albacore on the west coast was caught by pole-and-line vessels. In the late 1980s, U.S. pole-and-line vessels were prevented from catching bait, which is used to fish for tropical tunas, in the Mexican EEZ. Consequently, most of the pole-and-line vessels were soon sold to other countries or converted to albacore troll fishing. From the late 1980s through about 2000 there were no or only very small amounts of albacore caught by U.S. pole-and-line fishing. However, resurgence in U.S. pole-and-line fishing began in about 2003, and up to about 15 – 20 or so vessels presently use this fishing method in the U.S. fleet. The frequency of records for troll and pole-and-line gear types in the NMFS SWFSC west coast albacore logbook database for the years 1961 – 2006, provides a timeline showing a rough approximation of the relative amounts of U.S. albacore troll and pole-and-line fishing, Figure 5 (from Barr in prep.). Traditionally, over 90% of the albacore catch by the U.S. West Coast fishery has been purchased by major U.S. processors for canning and marketed as premium 'white meat' tuna. However, in recent years the large U.S. processers have purchase only about 10% of the catch. As a consequence, fishers have developed alternative markets. An increasing amount of the catch is being marketed in the fresh and fresh-frozen trade, canned by small 'boutique processers, and exported to Europe (WFOA Website).

3.3.2.1.2 Trends in U.S. Albacore Fishing Effort

In the 1940's there were about 500 vessels in the U.S. west coast albacore fleet. A high of about 3,000 vessels was reached in 1950; the number dropped to about 1,000 by 1960, climbed to approximately 2,100 during the 1970's and dropped to fewer than 500 boasts in the late 1980's (Laurs and Dotson 1992). Characterization of recent U.S. North Pacific albacore commercial fishing effort was recently examined in response to a PFMC request. The report and analyses were prepared by NOAA NMFS Southwest Fisheries Science Center and the PFMC HMSMT (PMFC 2007); this work was carried out under the leadership of Suzy Koin at the SWFSC. Table 2 shows the number of troll/pole-and-line vessels, number of vessel days, and landings for the years 1996 – 2005. During this 10 year period the number of vessels ranged from 549 in 2005 to 1,121 in 1997, and averaged 750; the number of vessel-days ranged from 21,445 in 1998 to 45,572 in 1997, and averaged 29,630; and the landings ranged from 9,122 mt in 2005 to 16,938 mt in 1996 and averaged 12,347 mt. Histogram plots of the number of vessels by year, and of the number of vessel-days and landings are shown in Figures 6a and 6b, respectively. Trends in days-fished for the troll/pole-and-line fishery, as well as those estimated for all U.S. commercial fisheries landing North Pacific albacore, show that effort, while somewhat variable, has not been increasing. Over the 5 year period 2001 – 2005, while the number of troll/pole-and-line vessels decreased somewhat, vessel-day effort remained nearly level. There appears to be little relationship between the number of vessel-days and landings (Figure 7). The mean number of vessel-days and amount of catch by gear type for all U.S. commercial fisheries landing North Pacific albacore during the period 1996 – 2005 is shown in Table 3. The effort days and amount of catch for troll/pole-and-line fleet were 29,630 days and 12,347 mt, respectively; for the Hawaii-based longline were 2,486 days and 1,048 mt, respectively; and all other gears were 920 days and 106 mt, respectively. The bulk of the catch, 90.4 %, was harvested by the troll/pole-and-line fleet, 6.8% by the Hawaii-based longline fishery in the central Pacific, and 2.8% by other commercial gears, e.g., California gillnet fishery, purse seiners, Hawaii handline fishing, etc. (Table 4).

3.3.2.1.3 Economic Research and Bio-Economic Modeling

Economic research has centered on measuring the annual rate of increase in technical change for the US and Canadian surface hook and line fleet over the period 1981-2006 (Squires and Vestergaard 2009). The empirical analysis employs the catch and days fished data used in the international stock assessments by the population biologists of the fishery's representative countries (McDaniel, Crone, and Dorval 2006). These catch and days fished data are for all landings by all vessels. Vessel numbers for the U.S. over 1981-2066 were obtained from the PacFIN Research Data Base and for Canada over 1995-2006 were obtained from the Department of Fisheries and Oceans. Econometric estimation of a Schaefer type production function allowed for technical change and technical inefficiency, specified fishing effort as a composite of days fished and vessel numbers, and employed stock estimates from the international stock assessments (see Section 3.3.3 below). (The details can be found in Squires and Vestergaard 2009.) The estimated annual rate of technical change was about 3.5%. Ultimately, this rate is a residual value, but a confident estimate of annual technical change of at least 2% and up to 3.5% is warranted.

The annual rate of technical progress is due not to changes in the gear per se, but is due to increased understanding of ocean conditions allowing forecasting of fish locations through temperature sensing devices reinforced by satellites, improvements in interpretation, and GPS, all of which give information about the overall distribution of albacore, dramatically reduces searching, and eases finding schools below the surface. Improved communications and computer technology onboard albacore fishing vessels, as well as shore-based, allow sharing of information among members of code groups, reducing search time, and increasing catch rates. Acoustic devices, such as sounders, are also increasingly sophisticated. The fishing gear itself has remained relatively static. Improved weather forecasts extend the end of the fishing season.

The effect of relatively high rates of fishing power or increase in technology are to undermine the effectiveness of input controls and shift the management focus to an output or catch orientation. A major advantage of a rights-based LAP management program is that the fishery manager does not have to explicitly account for the growth in technology (although it needs to be incorporated into population assessments). Instead, the market for catch shares accounts for the lowering of fishing costs and increasing catch rates.

Preliminary bio-economic modeling accounting for technical progress and in a surplus production framework demonstrated the importance of accounting for technical change on the optimum resource stock (Squjres and Vestergaard 2009). The empirical results are too preliminary to provide reliable estimates for management purposes, but do illustrate the long-term effects of the steady march of technology on estimates of resource stocks and their optimum use. Not accounting for technical change clearly leads to inappropriate management measures.

3.3.3 North Pacific Albacore Stock Assessment

North Pacific Albacore stock assessments have been conducted by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) and its predecessor, the North Pacific Albacore Workshop for the last several decades. The most recent assessment was conducted in December of 2006 (Stocker 2006). The ISC charge is to provide scientific advice for management of North Pacific albacore through assessments and the associated activities of collating and maintaining international data bases, coordinating biological research (including the setting of research priorities) and facilitating the development of assessment methods. Because of the ISC and its predecessor's long history of scientific activity in regards to North Pacific albacore, it remains the principal scientific body providing input to both the WCPFC and the IATTC.

3.3.3.1 Assessment Methods

The current assessment is based upon Virtual Population Analysis (VPA) methods in which catch, catch-at-age, and indices of abundance (standardized catch-per-effort data, CPUE) are statistically fit by a backward projection model. The methodology is well-known and used in many assessment arenas. Assumptions of the method are also well-known, as are the ramifications of deviations from those assumptions. The major assumptions of VPA are that catch-at-age are estimated without error and are complete, i.e. that catches-at-age are available from all fishing sectors, and that the standardized catch-per-effort indices are proportional to the abundance of the age-groups that are selected by the gear from which the CPUE is derived. During the most recent assessment, alternative modeling approaches were explored, most notably Stock Synthesis Version 2 (SS2). In addition to utilizing CPUE data, the SS2 approach uses statistical forward projection methods in which catch-at-age can be measured with error and data need not complete for all sectors. Conversely, this method requires explicit modeling of the stock-recruitment relationship and of the age or size selectivity by the fisheries. The ISC is likely to move toward using SS2 more prominently in its next assessment in 2010 (ISC 2008). Presumably, this method would allow utilization of tagging data more directly in the analysis, as well. This would allow spatial dynamics and spatial management to be explored. However, model development issues preclude this from being implemented within the next assessment cycle.

3.3.3.2 Indices of Abundance

The CPUE indices of abundance evaluated in the assessment included longline indices, troll indices and pole and line indices from Japanese, US and Taiwanese fisheries. General linear modeling methods were used for standardization in which spatial, seasonal and other effects were examined to determine if their impact on the index was likely related to abundance or to other extraneous factors.

3.3.3.3 Assessment Results

Trends in spawning stock biomass (SSB) and fishing mortality rate are shown in Figures 8a and 8b, respevtively. Pertinent conclusions from Stocker (2006) were: "… *although current SSB reached a historically high level in 2006 (roughly 153,000 mt), projected levels of SSB are forecasted to decline to the long-term average (approximately 100,000 mt) observed over the modeled time period (1966-05), i.e., the stock is predicted to decline to the equilibrium level of roughly 92,000 mt by 2015. Further, the ISC-ALBWG strongly recommended that all countries support precautionary-based fishing practices (e.g., limits on current levels of fishing effort) at this time, given the following:*

(1) the current level of fishing mortality (i.e., spawning potential ratio of F17) is high relative to commonly used reference points and often associated with overfishing thresholds in various fisheries world-wide;

(2) a retrospective analysis indicated a noticeable trend of over-estimation of stock biomass over the last two assessment cycles;

(3) the considerable decline in total (North Pacific Ocean) catch over the course of the last two years, particularly in 2005, when the total harvest (roughly, 62,000 mt) was the lowest recorded since the early 1990s."

3.3.3.4 Biological Reference Points

Biological reference points are the standards by which status of a stock is measured. Typically there are two such standards in fisheries assessment and fisheries management: 1) a measure of fishing mortality rate (*F*) which should not be exceeded and 2) a minimum level of SSB. The former defines the metric of overfishing and the latter defines the level at which the stock is considered overfished. Formal criteria for these measures have yet to be adopted by the WCPFC and the IATTC. However, proposals for doing this have been introduced at the WCPFC. In the interim the ISC has begun to explore options for doing this (Stocker 2006, ISC 2008). In particular, the the 2006 assessment report (Stocker 2006) noted that *" a fishing mortality-based reference point ($F_{SSB\text{-}Min}$) designed to ensure that SSB in future years remains within the range of the historical 'observed' SSB was introduced at an earlier ISC Plenary Meeting conducted in 2005. Even though the ISC forum has not yet determined which reference points are appropriate for North Pacific albacore (or other highly migratory stocks), preliminary discussions within the ISC Plenary forum in 2005 regarding candidate SSB-based 'thresholds' to consider, including: minimum 'observed', lower 10th percentile, lower 25th percentile, and median. In this context, at the 95% probability of success, all of the thresholds (lower 10th percentile, lower 25th percentile, and median) would require reductions in future F from the current estimated level (F=0.75); noting that the future F=0.64 associated with the minimum 'observed' SSB target is roughly equal to the current rate. However, this minimum SSB value occurred at the beginning of the overall, estimated time series and necessarily reflects additional uncertainty. Thus, the ISC-ALBWG felt that the thresholds based on the lower 10th percentile, lower 25th percentile, and median represented more robust and ultimately, precautionary thresholds that should be considered."*

Subsequently, biological reference points based upon proxies of the fishing mortality rate at maximum sustainable yield (MSY) were explored (ISC 2008). The proxies ranged from $F_{20\%SPR}$ to $F_{40\%SPR}$. Note that an F_{SPR} proxy for MSY is not necessarily the most appropriate choice for a management limit. However, the results are consistent with previous assessment results that the North Pacific albacore stock is experiencing fishing mortality rates that are near full exploitation.

3.3.3.5 Implications of Assessment Results for Management

In response to North Pacific albacore assessments, limits on any further increases in fishing effort have been established by the WCPFC and the IATTC. Should more rigorous measures be needed to control albacore fishing effort, then this implies that mechanisms for international and thus, spatial control might be needed.

3.3.4 Management of Domestic North Pacific Albacore Fisheries

The U.S. West Coast and the Hawaii-based fisheries targeting or incidentally catching albacore in the U.S. EEZ are the responsibilities of the Pacific Fishery Management Council and the Western Pacific Fishery Management Council, respectively.

3.3.4.1 West Coast Fishery

U.S. fisheries targeting albacore in the U.S. EEZ off the west coast are managed under the PFMC HMS Fishery Management Plan (FMP). Management measures in place, which also apply to U.S. vessels fishing on the high seas and landing their catch in the U.S., include: a HMS fishing permit, 100% logbook reporting, control date of March 9, 2000, area closure that prohibits the use of longlines targeting HMS within the HMS management area, and daily bag limit of 10 albacore per recreational angler in southern California and 25 in Oregon and Washington. The State of

California has a 7 pound minimum size limit for albacore on the books, which was decreased from 9 pounds in 1957. The size limit was apparently put in place for processing efficiency.

3.3.4.2 Hawaii-Based Fisheries

U.S. fisheries targeting or incidentally catching albacore in the U.S. EEZ around Hawaii and the U.S. Pacific Islands are managed under the Western Pacific Fishery Management Council (WPFMC) Pacific Pelagics Fishery Ecosystem Plan (PPFEP) FMP. Management measures include: a HMS fishing permit (the Hawaii-based longline fishery is closed to new permits), 100% logbook catch reporting, observer requirements, area closures and fishing gear modifications to reduce fishery interactions with sea turtles, and fishing gear and fishing operation adaptations to reduce interactions with seabirds.

3.3.5 U.S. /Canada Albacore Tuna Treaty

The Treaty was initially put into effect in 1981, amended in 2002, and codified by law in April 2004. U.S. and Canadian delegations met three times in 2008 to negotiate future and specific aspects of the Treaty. An additional meeting regarding exchange of data under the Treaty was held in May 2009.

3.3.5.1 Provisions of the Treaty

The Treaty allows fishing vessels of both countries to fish for North Pacific albacore in the respective EEZ waters outside 12 miles of the other county and to access certain ports to obtain supplies and services and to land their catch. U. S. vessels have access to British Columbia ports in Coal Harbor, Port Hardy, Prince Rupert, Victoria, Vancouver, and Ucluelet. Canadian vessels have access to ports in: Bellingham and Westport, Washington; Astoria, Newport, and Coos Bay, Oregon; and Eureka, California. The Treaty also establishes regulations regarding vessel marking, record keeping, and reporting requirements when operating in each other country's waters; and calls for exchange of fisheries data between the governments of the two Nations. In addition, the Treaty provides for agreed fishing limits on reciprocal fishing access such that over periods of 3 years, the number of fishing vessels that will be permitted to fish under the Treaty will decrease. The fishing access limit can be set by each nation as either a maximum number of individual vessels from one Nation that can fish in the waters of the other Nation for up to 4 months in a single year; or a maximum number of vessel-months in a single year. Both Nations use vessel-months. In 2004 this number was limited to 680 vessel-months, in 2005 to 560 vessel-months, in 2006 to 500 vessel-months and in 2007 the limit was dropped to 376 vessel-months. Negotiations conducted in 2008 for a new 3-year fishing regime included limiting the number of Canadian vessels to 110, none of which can be pole-and-line vessels and the number of U.S. vessels fishing in Canada to remain within historical levels; defining the month vessel access period as starting June 15 and ending October 31; and that and that either country may terminate the new regime in the event that international or domestic management measure are adopted. Preparation of a report from May 2009 meeting is underway.

3.3.5.2 Amount of U.S. and Canadian Albacore Caught in Each Others EEZ

The percentage of U.S. catch caught in the Canada EEZ during 2004 – 2008 ranged from 1 to 4%. However, in earlier years when the availability of albacore was high in 'northern' waters and there was a much larger U.S. pole-and-line albacore fleet, the U.S. catch in the Canadian EEZ has been considerably higher. The annual total Canadian albacore catch and amount of the total caught in the U.S. EEZ, and the catch values in Canadian dollars are given in Figures 7a and 7b, respectively. Albacore catch and catch value data are from Canadian Government courtesy of a U.S. fishers association representative. There has been a large increase in the Canadian total catch of albacore as well as the amount caught in U.S. EEZ waters beginning in the late 1990s. During 2003 to 2007 the amount of Canadian catch made in the U.S. EEZ has ranged from 1,725 to 3,891 mt. or approximately 60 to 80% of the total Canadian annual catch. The value in Canadian dollars during this period ranged from approximately C$3.65 million to C$13.65 million. In addition to the apparent benefit to U.S. coastal processors of albacore landed by Canadian fishermen in west coast ports, the Canadian stopovers may also benefit local communities through expenditures for fuel and supplies while they are in port. A Canadian government survey that sampled a subsection of their fishermen that fished in the U.S. EEZ during 2002 – 2007 estimated that approximately $700K to $800k in expenditures were made annually by Canadian fishermen while in U.S. ports. No information was found on the amounts of expenditures by U.S. fishers during stopovers in Canadian ports.

4 Prospective Options and Their Impacts to the Affected Environment

(To be prepared using inputs from PFMC HMS Management Team and Advisory Panel)

5 Consultation and Coordination

Information used in the preparation of this report has been obtained from interviews and correspondence with fisheries scientists, managers, and the members of the albacore fishing industry. A listing of persons and their affiliation includes:

National Marine Fisheries Service Southwest Fisheries Science Center: John Childers, Paul Crone, Sam Herrick, Roger Hewett, Suzy Koin, Gary Sakagawa, Dale Squires, and Russ Vetter. In addition, a seminar related to the report was presented by RML at the Southwest Fisheries Science Center where there was much discussion from fisheries scientists.

National Marine Fisheries Service Southwest Regional Office: Craig Heberer, Mark Helvey, Katie Hodges, Corrine Pinkerton, and Heidi Taylor.

U.S. Albacore Fishing Industry: Chip Bissell, Wayne Heikkila, John LaGrange, Jack Webster, and Natalie Webster. In addition, a seminar related to the report was presented by RML to the annual meeting of the Western Fishboat Owners Association where there was much discussion from albacore fishers, albacore processors, and albacore support industry representatives.

Oregon State University College of Ocean and Atmospheric Science: Mac Barr, Lorenzo Ciannelli, William Pearcy, and Jason Phillips. In addition, a seminar related to the report was given at OSU by RML where there was much discussion from academic marine scientists.

6 Attachments

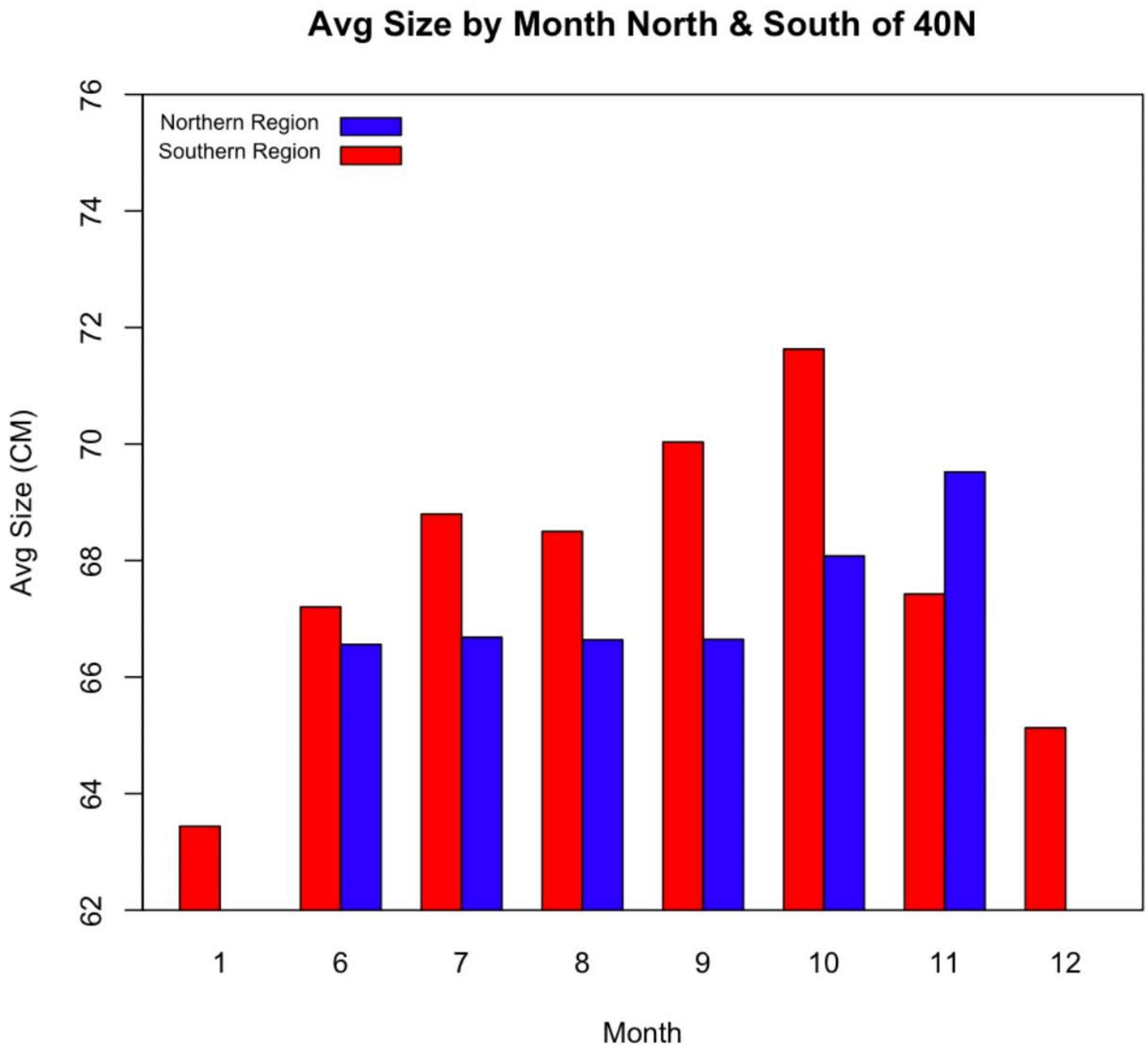

Figure 1. Average Size by Month North and South 40°N (from Barr in prep)

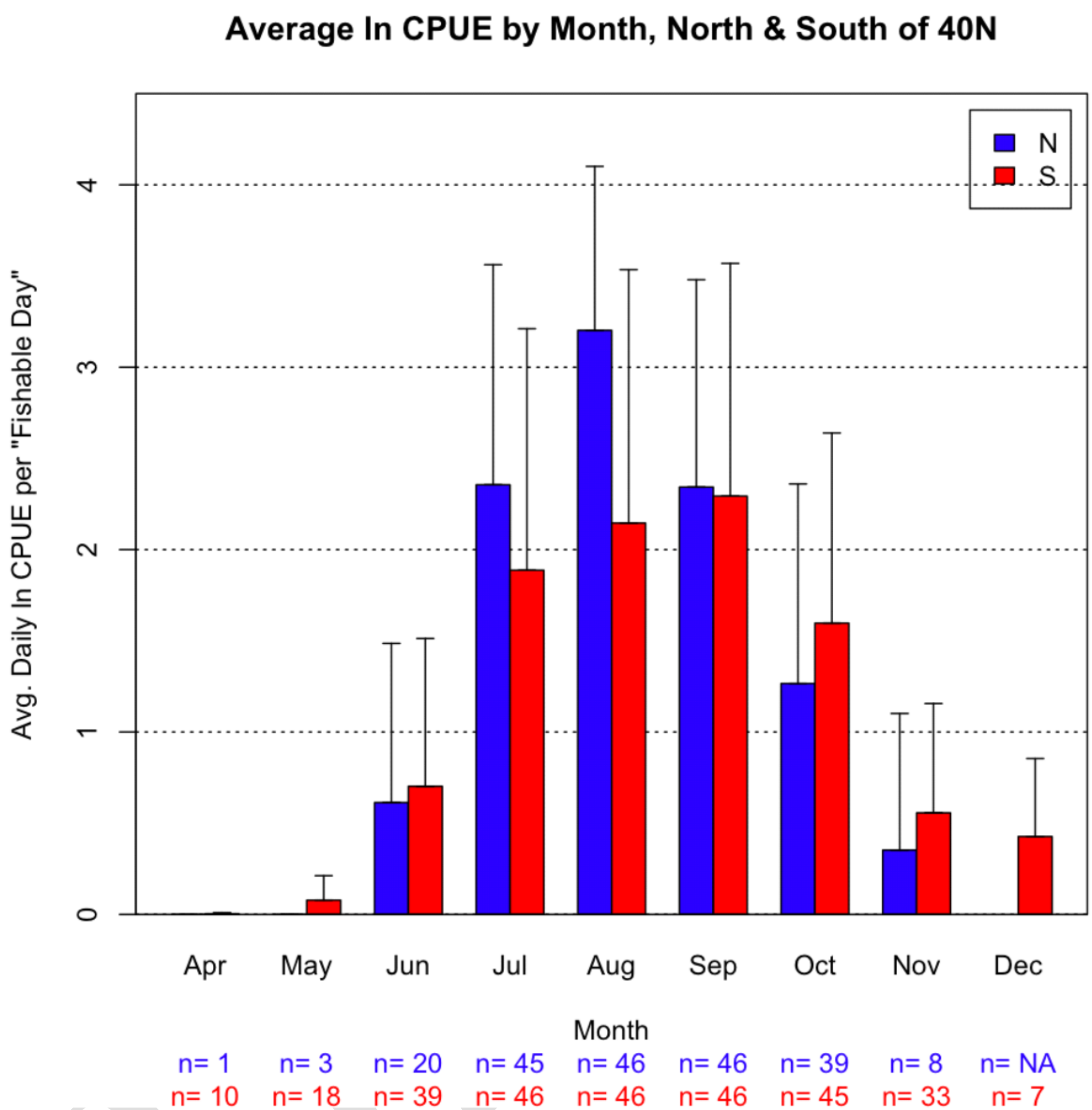

Figure 2. Albacore Average CPUE by month north and south of 40°N. From Barr (in prep).

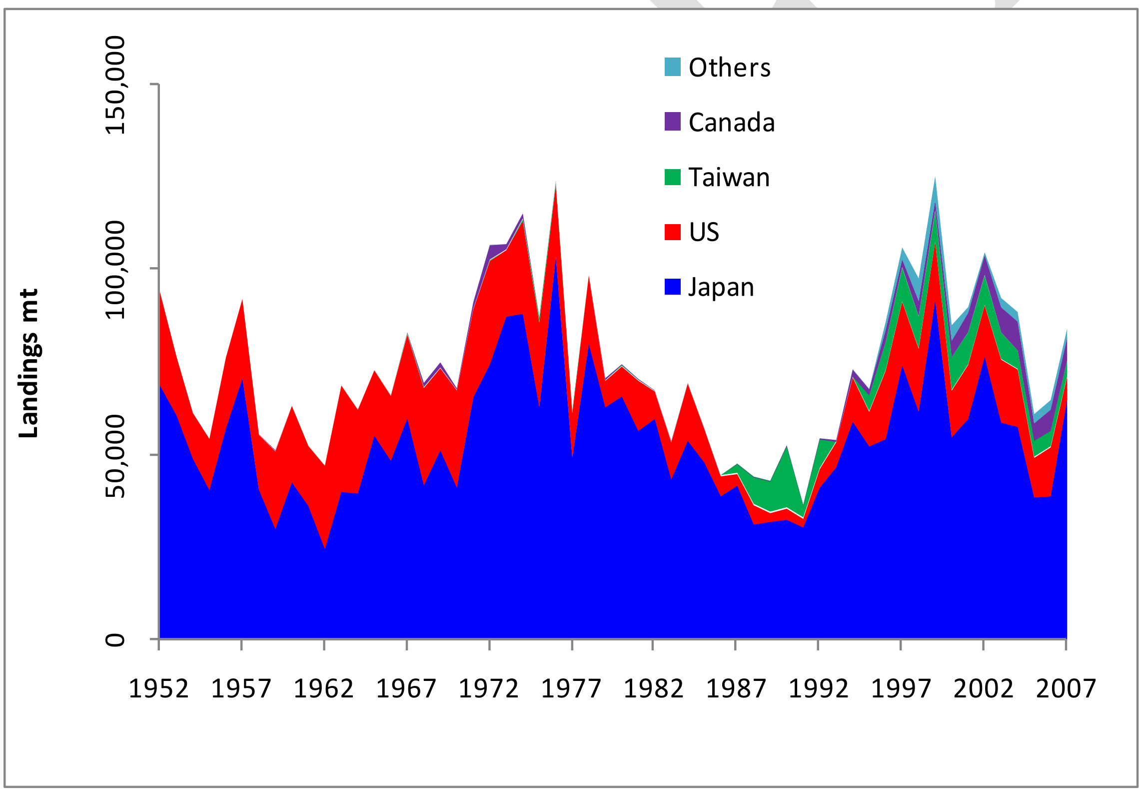

Figure 3. Total annual North Pacific albacore catch by country.

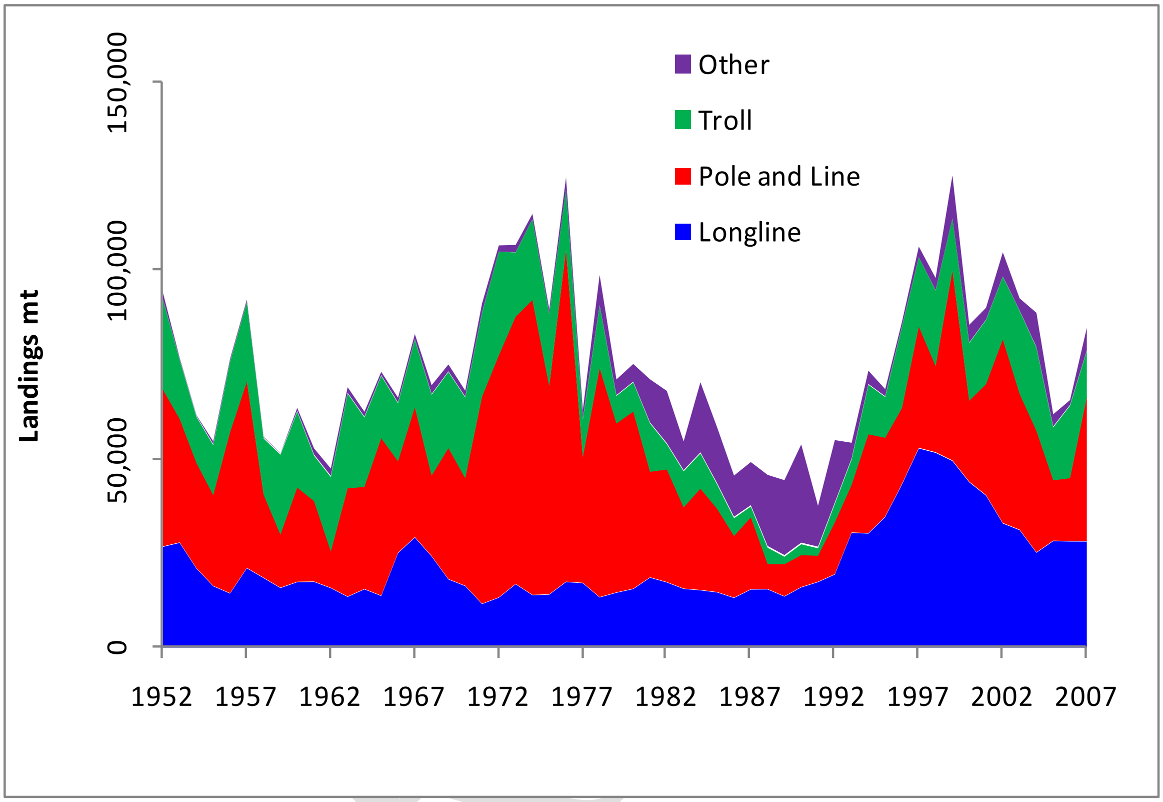

Figure 4. North Pacific albacore catch by gear.

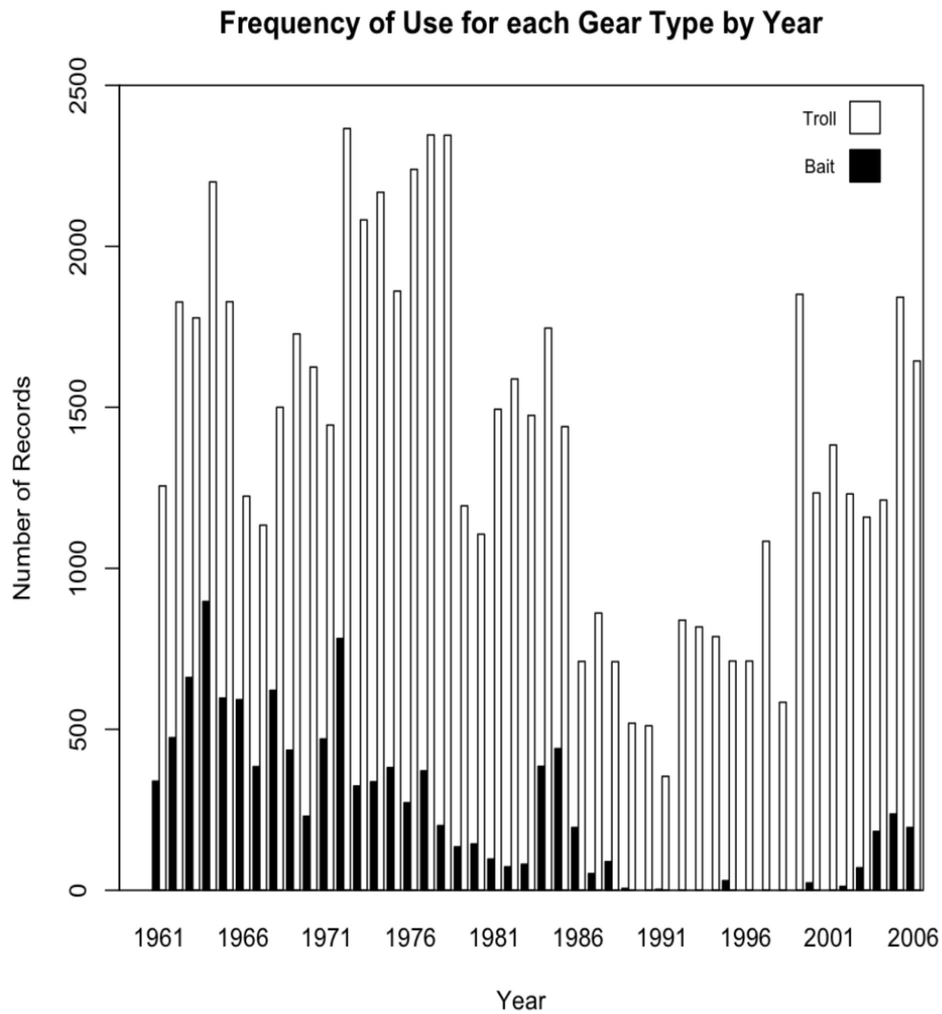

Figure 5. Frequency of logbook records, 1961 – 2006. From Barr (in prep).

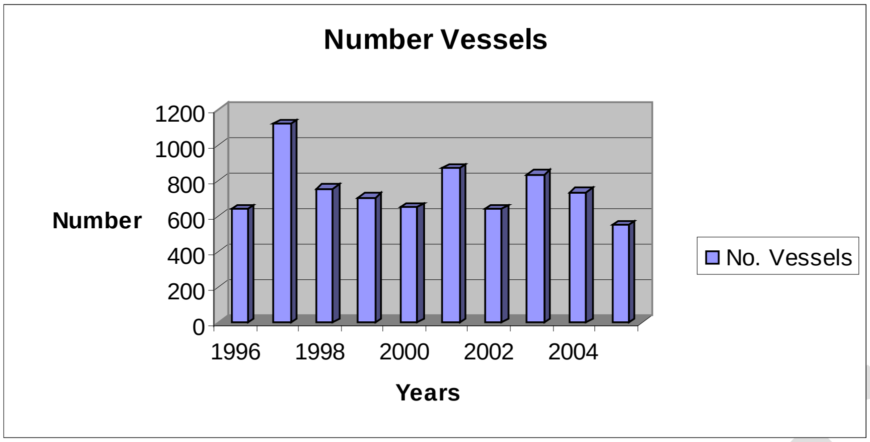

Figure 6a. Number of albacore troll and pole-and-line vessels, 1996 – 2005.

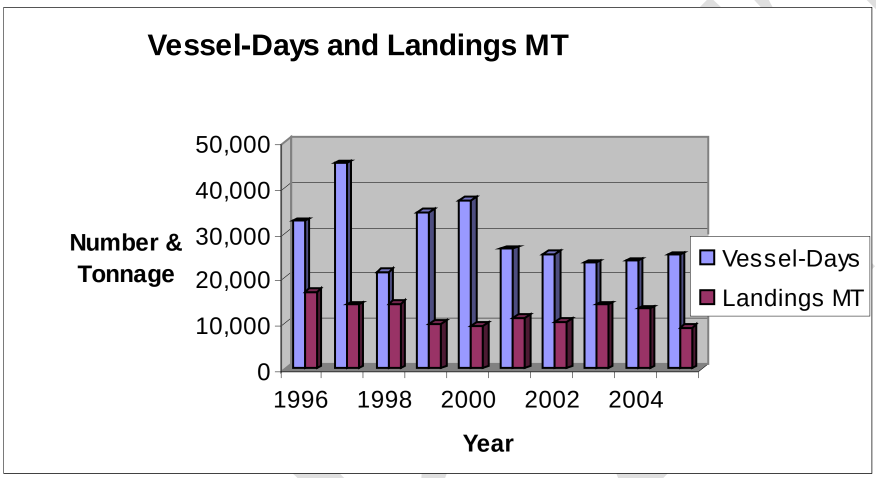

Figure 6b. Number of albacore vessel-days and tonnage, 1996-2005.

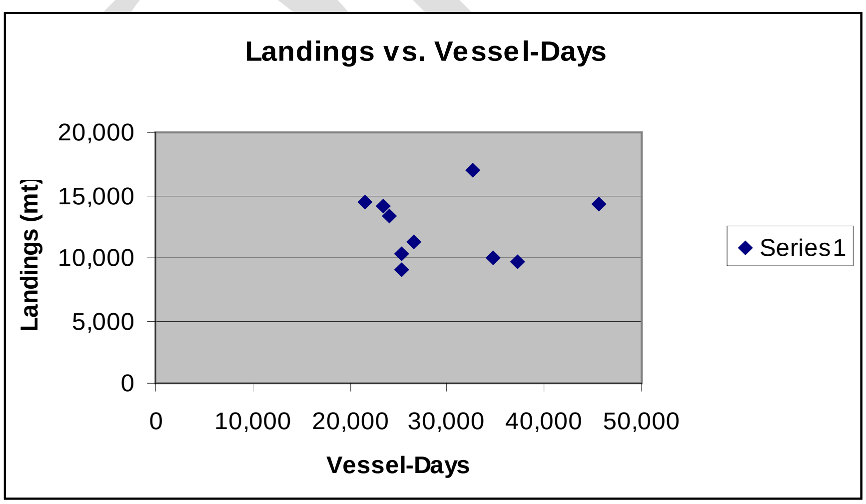

Figure 7. Annual albacore landings vs. vessel-days, 1996 – 2005.

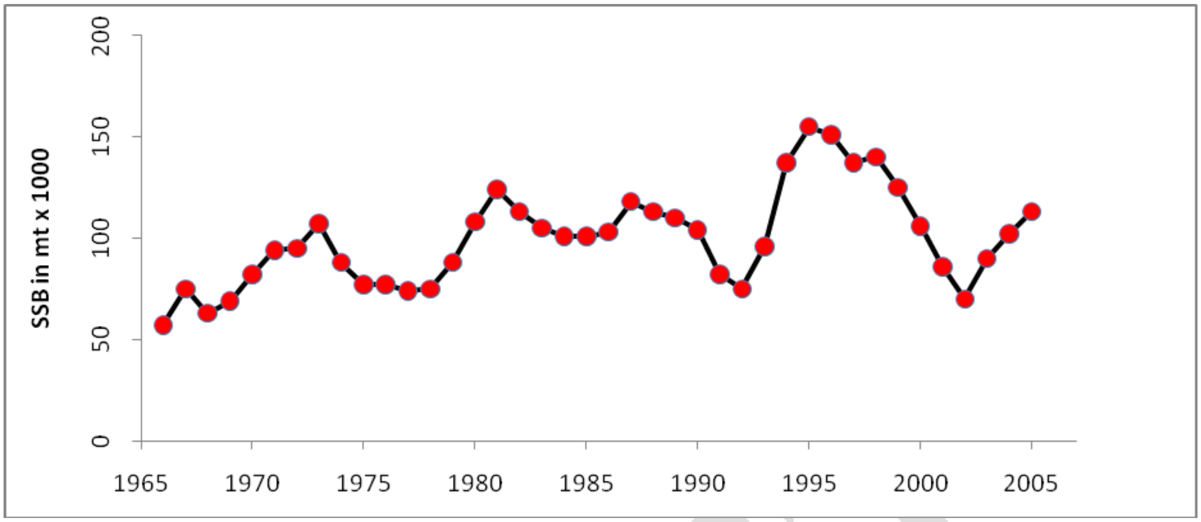

Figure 8a. North Pacific albacore spawning stock biomass.

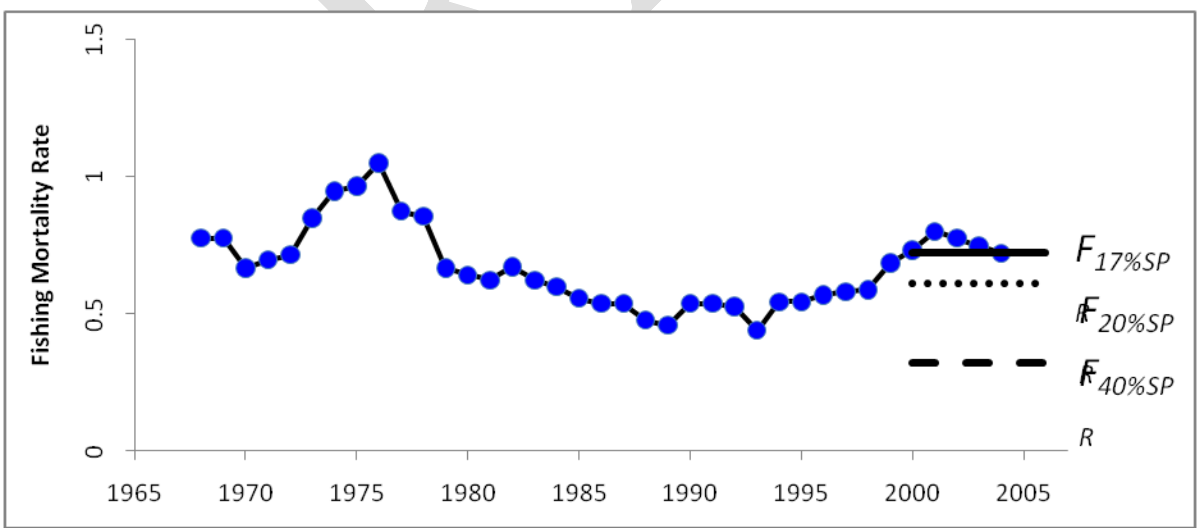

Figure 8b. North Pacific albacore fishing mortality rate.

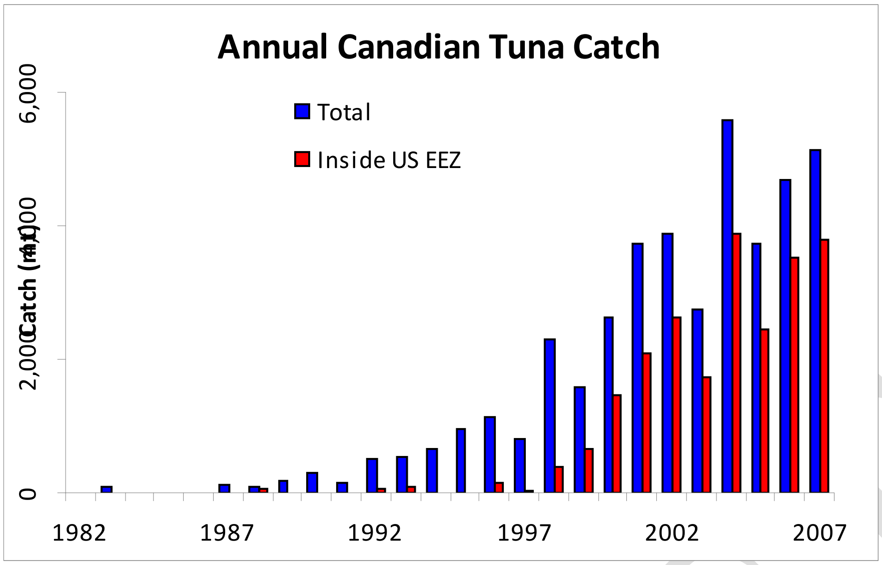

Figure 9a. Annual Canadian total albacore catch and catch made in US EEZ.

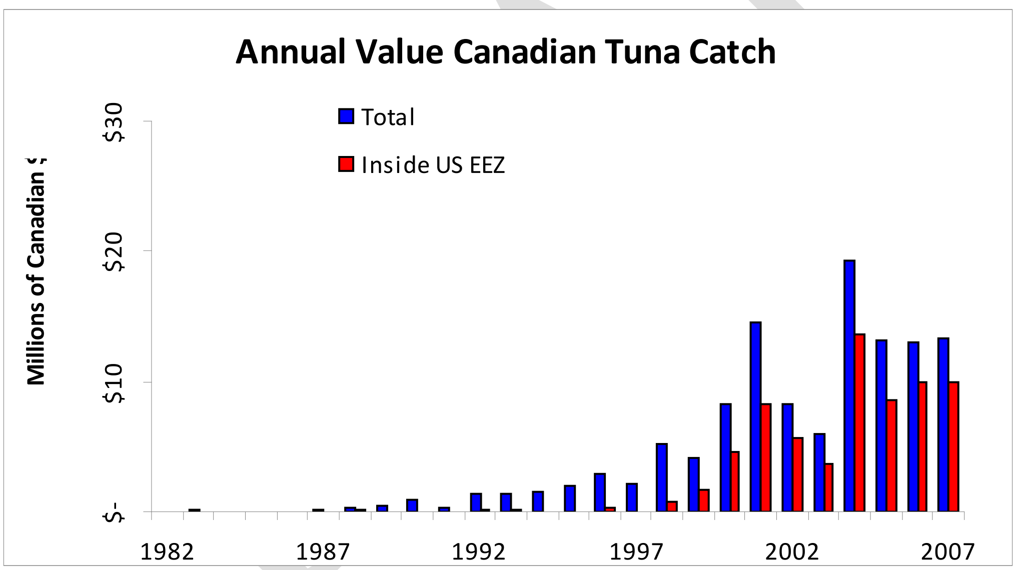

Figure 9b. Values of annual Canadian total albacore catch and catch made in U.S. EEZ.

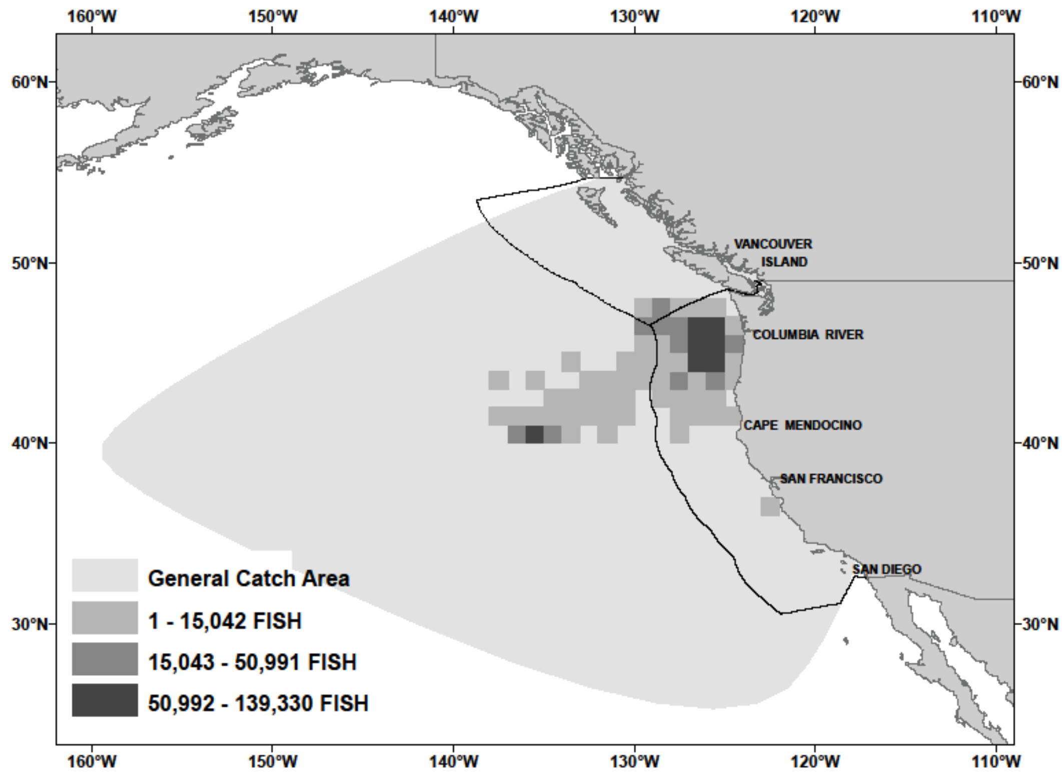

Figure 10: Distribution of U. S. albacore catch and effort for 2008 (Source NMFS/SFRO)

	Canada	Japan	Korea	Mexico	Taiwan	US	Others	Total
1952	71	68,865	0	0	0	25,262	0	94,198
1953	5	60,868	0	0	0	15,934	0	76,807
1954	0	49,088	0	0	0	12,406	0	61,494
1955	0	40,657	0	0	0	13,850	0	54,507
1956	17	57,208	0	0	0	19,239	0	76,464
1957	8	70,787	0	0	0	21,473	0	92,268
1958	74	40,739	0	0	0	14,910	0	55,723
1959	212	30,121	0	0	0	20,995	0	51,328
1960	5	42,737	0	0	0	20,661	0	63,403
1961	4	36,351	0	41	0	16,253	41	52,690
1962	1	24,737	0	0	0	22,526	0	47,264
1963	5	40,161	0	31	0	28,740	31	68,968
1964	3	39,763	0	0	0	22,627	0	62,393
1965	15	55,324	0	0	0	17,693	0	73,032
1966	44	48,576	0	0	0	17,530	0	66,150
1967	161	59,959	0	0	330	22,646	0	83,096
1968	1,028	41,934	0	0	216	26,302	0	69,480
1969	1,365	51,374	0	0	65	22,195	0	74,999
1970	390	41,319	0	0	34	26,279	0	68,022
1971	1,746	65,691	0	0	20	23,783	0	91,240
1972	3,921	74,513	0	100	187	27,995	100	106,816
1973	1,400	87,449	0	0	0	17,987	0	106,836
1974	1,331	88,237	0	1	486	25,058	1	115,114
1975	111	63,023	2,463	1	1,240	22,858	1	89,697
1976	278	103,612	859	41	686	19,345	41	124,862
1977	53	49,342	792	3	572	12,040	3	62,805
1978	23	80,122	228	1	6	18,442	1	98,823
1979	521	62,984	259	1	81	7,158	1	71,005

Table 1. North Pacific albacore catches (mt) by country and fisheries, 1952 – 2007.

	Canada	Japan	Korea	Mexico	Taiwan	US	Others	Total
1980	212	65,925	603	31	249	8,106	31	75,157
1981	200	56,611	475	8	143	13,605	8	71,050
1982	104	59,893	500	0	38	7,417	0	67,952
1983	225	43,515	687	0	8	10,059	0	54,494
1984	50	53,952	652	107	0	15,491	107	70,359
1985	56	48,107	867	14	0	9,124	14	58,182
1986	30	39,005	967	3	0	5,391	3	45,399
1987	104	41,842	1,366	7	2,514	3,160	7	49,000
1988	155	31,363	1,425	15	7,389	5,232	15	45,594
1989	140	32,084	1,173	2	8,390	2,386	2	44,177
1990	302	32,629	1,022	2	16,705	3,038	2	53,700
1991	139	30,594	855	2	3,410	2,323	2	37,325
1992	363	41,289	286	10	7,866	5,034	10	54,858
1993	494	46,806	32	11	5	6,788	11	54,147
1994	1,998	59,077	45	6	83	11,969	164	73,342
1995	1,763	52,452	440	5	4,280	9,339	142	68,421
1996	3,316	54,394	333	21	7,596	18,517	2,261	86,438
1997	2,168	74,324	319	53	9,119	17,192	3,281	106,456
1998	4,177	61,776	288	8	8,617	17,020	6,165	98,051
1999	2,734	91,912	107	57	8,186	15,812	6,625	125,433
2000	4,531	54,887	414	103	8,842	12,634	4,247	85,658
2001	5,248	59,851	82	22	8,684	14,618	1,620	90,125
2002	5,379	76,655	113	28	7,965	13,918	855	104,913
2003	6,861	58,849	144	28	7,166	17,044	2,555	92,647
2004	7,856	57,713	68	104	4,985	15,512	2,631	88,869
2005	4,829	38,682	520	0	4,472	10,692	2,527	61,722
2006	5,819	38,948	520	109	4,317	13,266	2,636	65,615
2007	6,112	65,273	520	40	4,317	5,969	2,567	84,798

Table 1 (cont.). North Pacific albacore catches (mt) by country and fisheries, 1952 – 2007.

U.S. Albacore Troll/Baitboat Fleet: No. Vessels, Vessel-Days, and Landings 1996 - 2005

Year	No. Vessels	Vessel-Days	Landings (MT)
1996	640	32,717	16,938
1997	1,121	45,572	14,252
1998	755	21,445	14,410
1999	705	34,643	10,060
2000	649	37,331	9,645
2001	870	26,566	11,210
2002	641	25350	10,387
2003	836	23,442	14,102
2004	734	23,979	13,346
2005	549	25,252	9,122
Average	750	29,630	12,347

Table 2. Summary of U.S. albacore troll/pole-and-line fleet: number of vessels, vessel-days, and landing (mt), 1996 – 2005.

1996 – 2005 Mean Effort-Days and Amount Catch by Gear Type for U.S. Commercial Fisheries Landing Albacore

Gear Type	*Effort Days*	*Amount Catch (MT)*
Troll/Bait-boat	29,630	12,347
Hawaii Longline	2,486	1,048
Other Gears (Gillnet, HI Handline, Purse Seine, etc.)	920	106

Table 3. 1996 – 2005 mean effort days and catch for U.S. commercial fisheries landing North Pacific albacore.

Average Relative Proportion Total U.S. Commercial Albacore Landings by Fishery 1996 - 2005

Fishery	Percent
Troll/Baitboat	90.4
HI Longline	6.8
Other Gears	2.8

Table 4. Average relative proportion of total U.S. commercial albacore landings by fishery, 1996 – 2005.

Monthly Vessel Month Utilization

2008							
	June	**July**	**August**	**September**	**October**	**November**	**Total**
US	0	0	24	34	11	4	73
Canada	6	79	110	107	53	4	359

Table 5. Distribution of vessel months used by U.S. and Canadian fleets for 2008.
Source NMFS/SWRO

7 References Cited

Allen, R., J. Joseph, and D. Squires. In Press. "Managing World Tuna Fisheries with Emphasis on Rights-Based Management," In R.Q. Grafton, R. Hilborn, D. Squires, M. Tait, and M. Williams, editors, *Handbook of Marine Fisheries Conservation and Management. Oxford:* Oxford University Press.

Allen, R., J. Joseph, and D. Squires, editors. In Press. *Conservation and Management of Transnational Tuna Fisheries*. Ames, Iowa: Blackwell Publishing.

Anderson, L.G. and M.C. Holliday, eds. 2007. The design and use of limited access priviledge programs. NOAA Technical Memorandum, NMFS-F/SPO-86: 156 pp.

Bartoo, Norman, and Terry J. Foreman. 1994. A review of the biology and fisheries for North Pacific albacore (*Thunnus alalunga*). FAO Fish. Tech. Pap., 336 (2): 173-187.

Barr, Mac. In prep. Are there two subgroups of Albacore, *Thunnus alalunga*, in the North Pacific? Evidence from variability in seasonal migration and size composition for two subgroups in the Coastal Fishery of North America. MS. Thesis, Oregon State Univesity.

Bernard, H. J., Hedgepeth, J. B., & Reilly, S. B. 1985. Stomach contents of albacore, skipjack, and bonito caught off southern California during summer 1983. CalCOFI Report 26: 175-182.

Brill, R.W. and P.G.Bushnell. 2001. The cardiovascular system of tunas. In: B.A. Block and E.D. Stevens, eds., Tuna physiology, ecology, and evolution, 79-120. Academic Press, San Diego, CA.

Brock, V.E. 1943. Contributions to the biology of the albacore (*Germo alalunga*) of the Oregon Coast and other parts of the Pacific. Stanford Ichthy. Bulletin 2: 199-248.

Carey, F.G. and J.M. Teal. 1966. Heat conservation in tuna fish muscle. Proc. National Academy Science. 56: 191-195.

Cech, J., R. Michael Laurs. And Jeffery B. Graham. 1984 Temperature-Induced Changes in Blood Gas Equilibria in the Albacore, *Thunnus alalunga*, a Warm-Bodied Tuna. Jour. Exper. Biology 109:21-34.

Clemens, H.B. 1961. The migration, age, and growth of Pacific albacore (*Thunnus germo*), 1951-1958. California Department of Fish and Game, Fish Bulletin 115: 128pp.

Dotson, R.G. 1976 Minimum swimming speed of albacore, *Thunnus alalunga*. US Fishery Bull.74: 955-960.

Flittner, G.A. 1963. Review of the 1962 seasonal movement of albacore tuna off the Pacific coast of the United States. Commercial Fisheries Review 25(4): 7-13.

Glaser, S. 2008. Food web ecology of albacore tuna in the California Current. Ph.D. Thesis.

Scripps Institution of Oceanography.

Godsil, H.G. 1948. A preliminary population study of the yellowfin and albacore. Cal. Fish and Game Fish Bulletin 70

Graham, J.B. and K.A. Dickson. 1981. Physiological thermoregulation in the albacore *Thunnus alalunga.* Physiol Zoo1 54:470-486.

Graham, J.B. and K.A. Dickson. 2001. Anatomical and physiological specializations for endothermy. In: B.A. Block and E.D. Stevens, eds., Tuna physiology, ecology, and evolution:121-166. Academic Press, San Diego, CA.

Graham, J.B. and R.M. Laurs 1982. Metabolic rate of albacore tuna, *Thunnus alunga*, Marine Biology 72: 1-6.

Graham, J.B., W.R. Lowell, Lai N. Chin, and R.M. Laurs. 1989. O_2 tension, swimming-velocity, and thermal effects on the metabolic rate of the Pacific albacore *Thunnus alalunga.* Exper. Biology. 48(2):89-94.

Graves, J. and A. Dizon. 1989. Mitochondraial DNA sequence similarity of Atlantic and Pacific albacore, *Thunnus alalunga.* Can. J. Fish. Aquat. Sci. 46(5):870-873.

Inter-American Tropical Tuna Commission. 2006. Stock Assessment Report Status of albacore in the Pacific Ocean 2005. pp. 255-283.

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). 2007. *Annex 5*: Report of the albacore working group workshop (November 28-December 5, 2006, Shimizu, Japan) *in Report of the Seventh Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, Plenary Session.* Busan, S. Korea, July 25-30, 2007. 53 p.

International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). 2008. *Annex 6*: Report of the albacore working group workshop (February 28-March 6, 2008, La Jolla, USA) *in Report of the Seventh Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, Plenary Session.* Takamatsu, Japan, July 22-27, 2008. 43 p.

Iversen, R. T. B. 1962. Food of albacore tuna, *Thunnus germo* (lacépède), in the central and northeastern Pacific. Fishery Bulletin. 62, 459-481.

Iverson, I. L. K. 1971. Albacore food habits. Fish Bulletin.California Department of Fish and Game. 152:11-46.

Koin, S. 2008. Archival tagging North Pacific albacore tuna. Symposium Advances in Tagging and Marking Technology, Auckland, New Zealand, February 24-28. 2008. Abstract.

Lai NC, Graham JB, Lowell WR, Laurs RM (1987) Pericardial and vascular pressure and blood flow in albacore tuna *Thunnus alalunga.* Exp Biology. 46: 187-192.

Laurs, R.M., 1982. The vertical distribution and small scale movements of albacore tuna in relation to oceanographic features as indicated by acoustic tracking, oceanographic sampling and satellite imagery. Underw. Telem. Newsl., 12(2), 10. (Abstract).

Laurs, R.M. 1983. The North Pacific albacore – an important visitor to California Current waters. California Cooperative Fisheries Investigations Report. 24:99-106.

Laurs, R.M. and R.G. Dotson. 1992. Albacore. In *California's Living Marine Resources and Their Utilization*. W. S. Leet, C. M. Dewees, and C. W. Haugen (Eds.), 136-138. Sea Grant Extension Program, Department of Wildlife and Fisheries Biology, University of California, Davis, CA 95616.

Laurs, R.M. and R.J. Lynn. 1977. Seasonal migration of North Pacific albacore, *Thunnus alalunga*, into North American coastal waters: distribution, relative abundance, and association with transition zone waters. US Fishery Bulletin 75(4): 795-822.

Laurs, R.M. and R.J. Lynn. 1991. North Pacific albacore ecology and oceanography. NOAA Technical Report NMFS 105: 69-87.

Laurs, R.M. and R. Nishimoto. 1979. Results from North Pacific albacore tagging studies. South West Fisheries Science Center (SWFSC) Administration Report No. LJ-79-17

Laurs, R. M., and J. A. Wetherall. 1981. Growth rates of North Pacific albacore, *Thunnus alalunga*, based on tag returns. US Fishery Bulletin.79(2):293-302.

Laurs, R.M., P.C. Fielder, and R. Montgomery. 1984. Albacore tuna catch distributions relative to environmental features observed from satellites. Deep-Sea Research 31: 1085-1099.

Laurs, R.M., R. Nishimoto, and J.A. Wetherall. 1985. Frequency of Increment Formation on Sagittae of North Pacific Albacore (*Thunnus alalunga*). Can. J. Fish. Aquat. Sci. 42(9): 1552-1555.

Laurs, R.M., R.J Ulevitch, and D.C. Morrison. 1978. Estimates of blood volume in the albacore tuna. In: Sharp, G.D. and A.E., Dizon Eds. The Physiological Ecology of Tunas. pp 135-140. Academic Press, New York.

Laurs, R.M., H.S.H. Yuen, and J.H. Johnson. 1977. Small-scale movements of albacore, *Thunnus alalunga*, in relation to ocean features as indicated by ultrasonic tracking and oceanographic sampling. U.S. Fishery Bulletin 75(2):347-355.

Lehodey , P., F. Chai , and J. Hampton (2003): Modelling climate-related variability of tuna populations from a coupled ocean-biogeochemical-populations dynamics model. Fisheries Oceanography. (12)45: 483-494.

Lewis, T. 1990. South Pacific albacore stock structure: a review of available information. WP/5 3rd South Pacific Albacore Workshop, October 9 – 12, 1990, Noumeau, New Caldonia.

Magnuson, J.J. 1978. Locmotion by scombroid fishes: Hydrodynamics, morphology, and behavior. In: Fish Physiology, vol. 7: 239-325, eds: W.S. Hoar, D.J. Randall, and F.P. Conte. Academic Press. New York.

McDaniel, J.D., P. R. Crone, and E. Dorval 2006. Critical Evaluation of Important Time Series Associated With Albacore Fisheries (United States, Canada, and Mexico) of the Eastern North Pacific Ocean (2006). ISC/06/ALBWG/09, ISC Albacore Working Group Workshop, November 28-December 5, 2006, Shimizu, Shizuoka. Japan.

Nakamura, Hiroshi. 1969. Tuna Distribution and Migration. Fishing News (Books) Ltd., London: 76 pp.

Nose, Y., H. Kawatsu, and Y. Hiyama. 1957. Age and growth of Pacific tunas by scale reading. [In Japanese, English Summary] In Suisan Gaku Shusei: 701-716. Tokyo Univ. Press, Tokyo.

Otsu, T. 1960. Albacore migration and growth in the North Pacific Ocean as estimated from tag recoveries. Pacific Science. 14:257-266.

Otsu, T. and R.N. Uchida. 1959. Sexual maturity and spawning of albacore in the Pacific ocean. Fishery Bulletin 148 (59): 287-305

Otsu, T. and R.N. Uchida. 1963. Model of the migration of albacore in the North Pacific ocean. Fishery Bulletin 63 (1): 33- 44

Pacific Fishery Management Council. 2007. Characterization of Recent U.S. North Pacific Albacore Commercial Fishing Effort.

Pearcy, W.G. 1973. Albacore oceanography off Oregon. Fishery Bulletin (71): 489-504.

Pearcy, W.G. and J.L. Mueller. 1970. Upwelling, Columbia River plume and albacore tuna. 6th Remote Sensing Environment. Ann Arbor, Michigan. P. 1101-1113.

Pearcy, W.G. and C.L. Osterberg. 1968. Zinc-65 and Maganese-54 in Albacore *Thunnus alalunga* from the west coast of North America. Limnology and Oceanography 8: 490-498.

Polovina, J.J., E. Howell, D.R. Kobayashi, and M.P. Seki. 2001. The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography 49: 469-483.

Ratty, F.J., Y.C. Song, and R.M. Laurs. 1986. Chromosomal analysis of albacore, *Thunnus alalunga*, and yellowfin, *Thunnus albcacores*, and skipjack, *Katsuwonus pelamis*, tuna. US Fishery Bulletin 84(2):49-476.

Scofield, N.B. 1914. The tuna canning industry in southern Californina. 23rd Biennial Report Fish and Game Commission for years 1912-1914: 111-122.

Squires, D. and N. Vestergaard. 2009. Technical Change and the Commons. Working Paper, Center for Environmental Economics, University of California San Diego. http://econ.ucsd.edu/~tgroves/CEE/papers/Squires_Vestergaard_Feb2009.pdf.

Stocker, M. 2006 (editor). *Report of the ISC – Albacore Working Group Stock Assessment Workshop*. National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu-ku, Shizuoka 424-8633 Japan, November 28-December 5, 2006. Paper available from NOAA/NMFS/SWFSC, 8604 La Jolla Shores Dr., La Jolla, CA, 92073. 72p.

Takagi, M., S. Chow, and N. Taniguchi. 2007. Preliminary study of albacore (*Thunnus alualunga*) stock differentiation inferred from microsatellite DNA analysis. US Fishery Bulletin 99(4):697-701.

Ueyanagi, S. 1957. Spawning of the albacore in the Western Pacific. Report Nankai Regional Fisheries Research Laboratory. 6:113-121

Ueyanagi, S. 1969. Observations on the distribution of tuna larvae in the Indo-Pacific Ocean with emphasis on the delineation of the spawning areas of albacore, *Thunnus alalunga*. Bulletin of the Far Seas Fishery Research Laboratory 2: 177-256.

Watanabe, H., Kubodera, T., Masuda, S., & Kawahara, S. 2004. Feeding habits of albacore *Thunnus alalunga* in the transition region of the central North Pacific. Fisheries Science. 70(4), 573-579.

WFOA. WFOA website. Early history tuna industry in California. WFOA.com

Wetherall, J.A., R.M. Laurs, R.N. Nishimoto, and M.Y. Yong. 1987. Growth variation and stock structure in North Pacific albacore. Working Paper prepared for the 10th North Pacific Albacore Workshop. Shimizu, Shizuoka, Japan. August 11-13, 1987.

White, F.C., R. Kelly, S. Kemper, P.T. Schumacker, K.R. Gallegher, and R.M. Laurs. 1988. Organ blood flow haemodynamics and metabolism of albacore tuna, *Thunnua alalunga* (Bonniterre). Exp. Biology. 47:161-169.

Yabuta, Y. and M. Yukinawa 1963 Growth and age of albacore. Rep. Nankai Reg. Fish. Res. Lab. (17):111-120.

Yabe, H.S., S. Ueyangi, S. Kikawa, and H. Watanable. 1958. Young tunas found in stomach contents. Nankai Regional Fisheries Research Laboratory Report 8:31-48.

Yoshida, H.O. 1968. New records of juvenile albacore *Thunnus alalunga* (Bonnaterre) from stomach contents. Pacific Science. 19:442-450.

Zainuddin, M., H. Kiyofuji, K. Saitoh and S.-I Saitoh. 2006. Using multiple-sensor satellite remote sensing and catch data to detect ocean hot spots for albacore (*Thunnus alalunga*) in the northwestern North Pacific. Deep-Sea Research II 53: 419-431.