FISHERY MANAGEMENT PLAN FOR U.S. WEST COAST FISHERIES FOR HIGHLY MIGRATORY SPECIES
AS AMENDED
APPENDIX B
STATUS OF MANAGEMENT UNIT STOCKS

Note: This appendix comprises sections 3.3.1-3.3.6 from the original FMP/FEIS published in August 2003. It summarizes the status of stocks at the time of FMP adoption. Stock status descriptions are periodically updated in annual SAFE documents.

B.1 Tunas

Tuna fisheries in the Pacific are currently managed by international bodies according to stock distinctions that generally coincide with the distribution of the major fisheries. For example, yellowfin, bigeye, and skipjack tunas have been assessed as eastern Pacific (EPO) and central-western Pacific (CWP) stocks (separated at 150^{o} W), while the more temperate albacore and bluefin tunas have each been separated into two stocks - north and south Pacific.

The international fisheries organizations that manage various stocks are listed in Table B–1. In the EPO, the IATTC assesses and manages species stocks with the goal of maintaining average MSY (AMSY). In the past there have been quotas emplaced for yellowfin and also for bigeye that are caught associated with floating objects. The responsibility of complying with such quotas is incumbent on member nations. In the north Pacific, the Interim Scientific Committee (ISC) is advised by international and national organizations, including the North Pacific Albacore Workshop, and in turn advises countries with interests in temperate tunas. There have been no quotas set for albacore and bluefin tuna.

The general control rule for tunas and billfishes is shown in Figure 4–2. B_{MSST} is shown as a range based on M of the different species (B_{MSST} /B_{MSY} =1-M $\geq$ 0.5). As indicated in the figure, no OY rule has yet been specified at international forums for these more productive species. However, in this FMP, a proxy OY is set for the tunas equal to MSY (i.e., the maximum value OY can take), except for bluefin tuna, which is treated as a vulnerable species; its OY is thus 0.75MSY.

North Pacific Albacore Tuna. Total annual catch from the northern stock is now approximately 100K mt, about half taken by surface gear (especially U.S. troll and Japanese baitboat) and half by longline gear (especially Japan). The longline gear takes mainly adult fish from temperate waters nearly all across the north Pacific. The surface gear takes mainly juveniles and subadults in the Transition Zone waters bordering the Subarctic Front. A high seas driftnet fishery for albacore and other tunas operated in the north Pacific between 1975 and 1993, but was terminated.

Longlining has recently become the fastest growing fishing mode exploiting the north Pacific stock. Previously, when Japan began targeting bigeye tuna after 1970, the effective effort on albacore had decreased and catches varied little at 10-18K mt/yr up to 1993. But catches rose to 30K mt in 1993 and then to 41K mt in 1997 as small longliners expanded Japan's coastal fishery. The longline CPUEs indicated that the adult stock had been increasing since the late 1980s (NPALBW 1999).

The highly variable surface catch of juvenile and subadult albacore has been mostly taken by the Japanese baitboat (pole and line) fleet that operates mainly west of the International Dateline. Both its catch and effort expanded into the 1970s, with 85K mt taken in 1976. Then through the mid 1980s catch and effort declined (Bartoo and Foreman 1993), the catches reducing to 6K mt by 1988. But a new trend of increasing catches and CPUE began after 1992, which has continued to the present (NPALBW 1999; NPALBW 2000).

The U.S. troll fishery, operating mainly east of the Dateline, is the other major surface fishery exploiting immature albacore, and its history is similar. Troll catch and effort, after a long period of expansion that produced 25K mt in 1963, declined after 1976 (as in the Japanese baitboat fishery), reducing to 2K mt in 1989. CPUEs declined too (unlike in the baitboat fishery), beginning in the early 1970s and lasting into the late 1980s (Bartoo and Foreman 1993). But like in the Japanese fishery, catch and CPUE both began increasing after 1992, the catches reaching approximately 11K mt by 1999 (NPALBW 1999; NPALBW 2000).

The abundance of surface albacore decreased during the 1970s and 1980s (Kleiber and Perrin 1991), but that trend, which was reflected in the catches, has since reversed. Total population biomass is now increasing, a trend that began by 1989 or earlier, which is shown by age-structured and other analyses from both the surface and subsurface fisheries (NPALBW 1999; NPALBW 2000).

Environmental change rather than fishing mortality may be driving the population (NPALBW 2000), as the above decline and recovery in the surface fishery phase-matches a similar decadal-scale change in the severity of north Pacific winter conditions (Au and Cayan 1998). Such a response would make it important that sufficient reproducing stock be maintained to enable robust recovery of production during favorable periods. The recent large catches by longliners, beginning about 1997, should therefore be monitored carefully.

Stock-wide MSY has been estimated at 80K-110K mt (Bartoo and Shiohama 1985; NPALBW 1999), and as much as 115-184K mt (NPALBW 2000), with present catches entering that range. The different MSY estimates pertain to what appears to be a low-productivity period (1952-1988) and a high-productivity period (1989-1998). The stock has been growing, and the biological ratios $F/F_{MSY} = 0.9$ and $B/B_{MSY} = 1.1$ determined for 1995 (Bartoo et al. 1997) have recently been estimated as 0.5 and 1.1 respectively (NPALBW 2000). The Bartoo and Shiohama (1985) estimate appears not to be biased upwards [as could result from the effort averaging procedure used (Polacheck, *et al.* 1993)], considering other results from studies using non-equilibrium production models for that same period and the overall, long term production cycle (NPALBW 2000). The present, high production period began about 1989, and total catches are now over 100K mt with the stock still increasing. By all indications, the north Pacific stock is healthy and not over exploited, at least for the present environmental regime. In recent years, West Coast catches have accounted for about 16% of the total north Pacific harvest.

U.S. troll fishers also fish south Pacific albacore, but that stock does not reach the West Coast EEZ. Only about 11% of the total catch from the south Pacific stock (1998=42K mt) is taken by trollers, of which the

U.S. catch (1998) was approximately 1.8 K mt (Childers and Miller 2000). Recent assessments indicate the south Pacific stock is healthy. This FMP treats only the North Pacific stock as an MUS.

Status Summary: Stock status of albacore is reviewed at 1-2 year intervals by the North Pacific Albacore Workshop (members: United States, Japan, Canada, Taiwan). The workshop has no formal procedures for agreement or for management. Presently the albacore stock is healthy and not being overfished (F/F_{MSY}= 0.5-0.9; B/B_{MSY}= 1.10 > MSST), even though present catches are in the estimated MSY (overall mean 120K mt) and OY range (see Table 4–3 in the FMP). Stock and catches are both increasing as the high productivity regime continues. No quotas are contemplated, and no regional harvest guideline is recommended for the present 16% regional take of stock-wide production.

Yellowfin Tuna. In the eastern Pacific Ocean (EPO) yellowfin are caught by both surface and subsurface gears, but purse-seining dominates. Both immature and mature fish are taken. The Inter-American Tropical Tuna Commission (IATTC) regularly assesses the status of the EPO stock that is discussed below.

Purse-seining increased rapidly from the late 1950s and through the early 1980s as baitboats were replaced and fishing on dolphins became the dominant mode for capturing yellowfin. The expansion was interrupted by poor catches during the 1982-1983 El Niño that, in conjunction with the "dolphin safe" policy of U.S. canners, forced many U.S. seiners to the western Pacific. International fleet carrying capacity decreased through 1992 as the fleet re-structured, but has since increased. In 2000 there were 205 seiners totaling 181K mt carrying capacity, 52% being of Mexican and Ecuadorian flag and 5 % U.S. (IATTC 1999).

Catches declined slowly through and after the mid-1970s, culminating in the above 1983 low of 94K mt. Since then, catches have increased markedly, to 288K mt in 1989, and after a moderate decline, to 304K mt in 1999 (IATTC 2002).

CPUEs and estimates from cohort and other analyses show that, like the catches, the exploited yellowfin biomass decreased during the 1973-1982 period (up to the 1983 El Niño year), and then recovered. The recovery appears to have been due to a better recruitment regime and reduced fishing mortality upon young fish. Yellowfin abundance apparently reached its historical highest in 1986, and has since declined only slightly.

Production analysis indicates MSY is about 270K mt in the EPO, which includes the relatively small longline catch (IATTC 2000; Tomlinson 2001). The present fishing effort is near to or greater than that for MSY, as also indicated by yield-per-recruit analysis.

The stock appears near that for producing MSY, but with F higher than for MSY. Biological reference points were initially determined from the data presented in the IATTC 1999 Annual Report (Boggs, *et al.* 2000), and fishing mortality appeared to have been just above that needed to produce MSY, while stock biomass was very close to B_{MSY}, but well above the MSST limit (B_{MSST}/B_{MSY}=0.50) [Biomass B_{97} was the product of the abundance-at-age from the cohort analysis and weight-at-age; F_{97} was estimated as current catch divided by B_{97}; F_{MSY} was estimated as 0.8M (Restrepo, *et al.* 1998), with M=0.8; B_{MSY} was estimated as MSY (270K mt) divided by F_{MSY}. Then F_{97} /F_{MSY} = 1.08 and B_{97} /B_{MSY} = 0.95]. The equilibrium stock size, but not the catch, owing to strong recruitment during 1998-2000, appears to have declined slightly since. Presently (1998-99), the production model estimate of B/B_{MSY} averages about 0.86 (IATTC 2000) and the F/F_{MSY} ratio is about 1.30 (Tomlinson 2001). By control rule definition, overfishing is still occurring, although the stock is not overfished as the biomass ratio remains far above MSST (see Table 4–2 in the FMP). With the IATTC actively managing this stock through quotas and other measures, the overfishing is not expected to result in an overfished stock. Moreover, recent age-structured analyses suggest a healthy stock at non-equilibrium level possibly 41% above that for producing average MSY and with fishing mortality 89% of that for MSY (this assumes no stock-recruitment relationship) (Maunder 2002). Thus no Council action is needed to address overfishing.

The IATTC continues to manage this stock with quotas and other measures. Quotas on surface catches began in 1966, but not all were implemented over the years. The 1998 quota of 225K mt was the first emplaced since 1979. The 2001 quota was 250K mt, with provision for up to 3 added increments of 20K mt each if there is evidence for increased production, and the increments are thought to pose no danger to the stock. The quota was reached at the end of October 2001. A one month closure of all purse seine fisheries is proposed for December 2002 to limit total effort and fishing mortality on surface tunas.

Yellowfin catch from the West Coast EEZ, under 6K mt/yr in recent years, counts toward this quota, but is a minuscule fraction of the EPO catches. West Coast yellowfin catches from the EEZ are availability-driven and have no effect on the fishing mortality upon the EPO stock.

Status Summary: Stock status of yellowfin in the EPO is reviewed annually by the 10 member nation IATTC, and a quota for the EPO is now in place. MSY is estimated at 270K mt. Although the stock presently (1998-99) could be 14% below B_{MSY} with fishing mortality above F_{MSY} (B/B_{MSY}~0.86 > MSST; F/F_{MSY}~1.30), it is being managed for the MSY biomass, taking into account recruitment changes that vary actual stock levels. As a member nation, the U.S. must abide by IATTC measures. While OY has not been specified internationally, its proxy value is placed at MSY here (see Table 4–3 in the FMP). In view of the small catch fraction taken by West Coast fishers (1%), no regional harvest guideline is recommended at this time.

Bigeye Tuna. Bigeye are caught in tropical to temperate waters throughout the Pacific. Catches are relatively minor in comparison to that of the tropical tunas, but are particularly valuable for the fresh-fish market. Until recently, bigeye was caught primarily by longline gear fishing the mainly mature, deep-dwelling population.

In the EPO, longline catches of bigeye have decreased while purse-seine catches of younger, surface-dwelling fish have increased. The 1999 longline catch was 36K mt, down from the 102K mt peak during 1986. But the purse seine catches, historically less than 10K mt/yr, increased rapidly after 1993 as fishing switched to target the immature bigeye under FADs. The new fishing mode developed mainly west and southwest of the Galapagos Islands. Recently (1996, 1997), purse-seine catches of bigeye reached 51K mt, of which 90% was from FAD fishing. Total EPO catch by all gears in 1999 was 64K mt (IATTC 2002).

A Pacific-wide assessment of bigeye was conducted by Japan's National Research Institute of Far Seas Fisheries (Miyabe 1995) on the premise of a single stock. Little is known about exchange between eastern and the central-western Pacific bigeye populations, however, and there may be an eastern and a western stock. Information from this assessment provided estimates of the ratios F_{94}/F_{MSY} =1.09 and B_{94}/B_{MSY} = 0.99 (Boggs, *et al.* 2000). There is large uncertainty in these estimates, in part because of the recent increase in purse-seine catches of juveniles, but they suggested an overall, healthy population being fished near B_{MSY}.

The bigeye stock/population in the eastern Pacific also appears near that for MSY, but with F above F_{MSY} and with evidence for a recent downturn of the spawning stock due to low recruitment. CPUEs from the EPO longline fishery and also cohort analyses indicate the EPO biomass had been declining since the mid-1980s (IATTC 1990). Production model analyses showed either over- or underfishing, depending upon the model, but with the non-equilibrium biomass still above that for MSY (IATTC 2000). MSY is approximately 66-92K mt (IATTC 2000). More recent age-structured analyses suggest (for the conservative case assuming a stock recruitment relationship) a healthy stock biomass (B/B_{MSY}=1.11) (see Table 4–2 in the FMP), but with F/F_{MSY}=1.11 that was supported, until recently, by large cohorts recruited during 1995-1997. Further, analyses showed that the spawning stock (age 3+ years) could have been reduced in 2002 to 74% of that for MSY due to low recruitment during 1998-2001 (Maunder and Harley 2002; Watters and Maunder 2002). There is much uncertainty in these findings, but the situation is being addressed by IATTC management measures that resulted from the concern over the catches of juveniles under FADs. The IATTC also adopted in 1998 a 45K mt quota on bigeye caught by purse seine, after which fishing on FADs is prohibited. That quota was not reached and has since been lowered to near the catch level of 1999, 40K mt. The one month December closure of purse seine fishing (see yellowfin tuna) will further limit the risk of excessive fishing mortality. No additional management action needs to be adopted by the Council to address overfishing in the eastern Pacific.

Present catches within the West Coast EEZ are too small to have any impact on the bigeye stock in the EPO or Pacific-wide, and are limited by local availability. The maximum catch during the 1990s was just over 100 mt.

Status Summary: The bigeye stock in the EPO appears near that for producing MSY, possibly with B/B_{MSY}=1.11, but there is concern over the increased fishing on juveniles and recent low recruitment which may have reduced the 2002 spawning stock to below that for MSY. Fishing mortality appears to be above that for MSY (F/F_{MSY} =1.11). IATTC reviews the status of bigeye in the EPO annually and emplaced in 1999 a 40K mt quota on juvenile fish caught associated with floating objects. As a member nation, the U.S. abides by that quota affecting floating object fishing. MSY is estimated at approximately 79K mt and is in the range of present catches (see Table 4–3 in the FMP). A proxy OY is placed here at the same level. In view of IATTC management and the small catch fraction taken by West Coast fishers (< 1%), no regional harvest guideline is recommended at this time.

Skipjack Tuna. Over half the tuna catch from the Pacific is skipjack, presently about 190K mt/yr from the EPO and 1,200K mt/yr from the CWP. The majority is caught by purse seiners, but also by baitboats, especially in the western Pacific. Catches have risen since 1995 due to the increased fishing with FADs. Skipjack catches are notably variable among years (IATTC 2000).

Population reduction from exploitation appears minimal for both eastern and western stocks, with abundance highly variable. CPUE seems affected more by environment or inherent population instability than by exploitation. Consistent downward trends in catch rate have not been demonstrated in either the EPO or CWP.

First estimates of the B and F ratios relative to MSY were obtained, in part, from these minimal fishing effects that indicate a healthy Pacific stock (Boggs, *et al.* 2000). Assuming from the lack of CPUE decline that B/B_o is near 1.0 in both the EPO and CWP, and that B_{MSY}/B_o =0.4 (Restrepo, *et al.* 1998), then B/B_{MSY} = 2.5 for both the eastern and western stocks of skipjack. There is no estimate of F/F_{MSY} for the eastern stock, although Hampton et al. (1999) estimated it to be 0.25 for the western stock. While the above ratios suggest a better understanding of this species' dynamics than is the case, both stocks do appear to be far above the biomass and below the mortality levels requiring remedial management action. West Coast landings are a minuscule fraction of the EPO catches.

Status Summary: The EPO skipjack stock appear healthy (see Table 4–2 in the FMP) with no indication of the upper limit to sustainable catches. The IATTC reviews the status of skipjack annually. Neither an MSY or an OY has been determined for EPO skipjack, but here proxies for both are taken as the average level of recent catches (190K mt) (see Table 4–3 in the FMP). In view of the small catch fraction taken by West Coast fishers (3%), no regional harvest guideline is recommended at this time.

Bluefin Tuna. North Pacific bluefin are mainly caught in the western Pacific principally by purse seine and troll gears, but also by longline and other gears, the catches averaging 20K mt/yr stock-wide (1995-1999). In the eastern Pacific, catches are much less, averaging 3.5K mt/yr (1990-1997) and taken primarily by purse seiners (IATTC 1999). The latter fishing occurs off southern California and especially Baja California Mexico, mainly between spring and fall and within 100 miles of shore.

There is probably a single north Pacific stock with trans-Pacific migratory patterns. Spawning appears restricted to waters between Japan and the Philippines, in contrast to the other tunas like yellowfin, bigeye, and skipjack that are reported to spawn over vast areas of the Pacific. In the eastern Pacific, bluefin are nearly always immatures, 1 and 2 years of age. These fish migrate from the western Pacific in temperate latitudes as 1 year olds, and probably begin returning as 2 year olds. Some linger longer before returning. Fluctuations in the eastern Pacific catch, from 0.4K to 8K mt/yr during the 1990s, appear to be related to varying proportions of western Pacific fish involved in this migration (Bayliff 2001).

The vital rates and abundance trends of bluefin are poorly known, especially in the western Pacific. The adult stock fished by the international longline fleet appears to have declined between the 1950s and mid-1980s (Tomlinson 1996), but there may also have been changes in migratory patterns and in stock availability. Total catches from all fisheries have decreased since the 1950s, but with large, temporal fluctuations and a recovery during the 1990s (IATTC 2001; Itoh 2001). While the decrease is more apparent in the eastern than in the western Pacific, recent catch rates from the eastern Pacific surface fishery have been high, although erratic (IATTC 1999). While bluefin spawning is restricted and localized in the western Pacific, there is no evidence for a reduced adult biomass having an effect on recruitment. Overall, the effects of exploitation are inconclusive because of lack of reliable abundance indexes for the western fisheries. No biomass and fishing mortality ratios relative to MSY have been determined.

Bluefin catches by West Coast fishers constitute a small, but not insignificant fraction (10%) of the stock-wide catch. West Coast catches would need to be figured into catch reductions, should such be recommended at international forums.

Status Summary: IATTC reviews the status of north Pacific bluefin tuna occasionally. Catches have decreased since the late 1950s, but now appear to be in recovery. West Coast fishers take about 10% of total catches, mainly the juveniles that migrate irregularly to the eastern Pacific. Evidence for overfishing or for persisting decline in the stock, which is mainly in the western Pacific, is lacking. There are no standardized effort measures for the western fisheries for developing abundance indexes. An MSY has not been determined, but a proxy value is taken here to be the average level of recent catches (20K mt), with a proxy OY 75% of that MSY. The bluefin tuna is thus treated as a vulnerable species. It is the least productive and with the most restricted spawning among the tunas. Its population status is also problematic because there are no indexes that reliably reflect overall stock abundance. But in view of the stock being primarily in the western Pacific, the lack of international agreement on stock status relative to MSY, and the West Coast fishery not directly affecting the spawning stock, no regional harvest guideline is recommended at this time.

B.2 Pelagic Sharks

Sharks need to be managed with special care because their productivities are low compared to most exploited teleost fishes - a result of late ages at maturity and low fecundities (see Table 4–2 in the FMP). The common thresher is slightly more productive than the other sharks, yet its population is capable of increasing by only 4-7% per year when at its MSY-producing size (productivity r =0.04-0.07, with annual Population Growth Rate (PGR=e^r-1) the same, 4-7%). The PGR represents the annual surplus fraction of the standing population, and the catch fraction from the population should not exceed this rate for the corresponding catch to be sustainable (assuming the exploited segment also grows at this rate). The maximum catch fraction beyond which this shark's population should collapse ($PGR_{MAX} = e^{2r}-1$ for the logistic model) averages 12%, still a small fraction of the population. If depleted to 50% below the biomass that produces MSY, the time needed to recover with fishing eliminated (the doubling time $T_D = \ln2/1.5r$ for the logistic model) is about 9 years (range:7-12 yrs). The less productive sharks require smaller catch fractions and have longer doubling times.

Thus even low overall exploitation rates, in terms of catch fractions of populations, could overfish these sharks, or even collapse their populations, and expected recovery times can be 1-2 decades or more. And since individuals that have not yet reproduced will often be taken (they are already large-sized as immatures), conservation of reproductive potential should be a continuing concern. Fisheries for such sharks thus require preventive, conservative management, i.e., development under protective regimes. At the least, protection of reproducing females and prevention of rapid expansion of fishing effort are needed.

None of the HMS sharks of this FMP is now actively managed internationally, and pelagic sharks are not assessed regularly by international fishery management organizations. There is, however, international and national concern over the health of shark populations, which has resulted in guidelines contained in the International and National Plans of Action for the Conservation and Management of Sharks (Section 1.7.4). Presently there are no international or regional quotas for the HMS MUS sharks in the Pacific, but there is a tri-state harvest guideline for the common thresher of 578 mt (340 mt dressed weight; PSMFC 1990), which has been exceeded once.

Figure 4–3 in the FMP illustrates the general control rule for sharks. B_{MSST} is closer to B_{MSY} than is the case for teleosts because of lower natural mortality M (cf. Fig. 3-2). As vulnerable species, HMS sharks should be managed for some precautionary OY target. The example shown in Figure 3-3 corresponds to that used here as the proxy OY for vulnerable species, viz., OY=0.75MSY. Harvest guidelines (see Section 4.4 in the FMP) are set equal to this OY.

Common Thresher. Most commercial landings of common thresher are presently taken in the California-Oregon drift gillnet fishery for swordfish, where this shark is the second most valuable species landed. Some are also caught by setnets and small-mesh drift nets. Adults as well as immatures are taken, although less adults than in previous years prior to the springtime area/season closures. The drift gillnet fishery began in 1977-78 in the Southern California Bight (SCB), with the thresher specifically targeted. From early on and amid signs of population decline, various season and area restrictions were implemented by the State of California to protect reproducing females, marine mammals, and the increasingly targeted swordfish; there was also concern over possible takes of striped marlin.

The spring-season directed fishery originally began February 1, but by 1990, drift gillnet fishing was either entirely prohibited, or restricted to distances greater than 75 miles from shore up through mid-August (Hanan, *et al.* 1993). Drift gillnetting was allowed inshore the rest of the year (August 15 to January 31), but with various time and area limits. These closures strongly reduced fishing effort, especially within 20 miles of shore where most threshers were caught.

Catches peaked early in the California drift gillnet fishery with approximately 1000 mt taken in 1982 (Hanan, *et al.* 1993), then declined sharply in 1986, and have been moderately low since. CPUE also declined. Since 1990 annual catches have averaged 200-300 mt (1990-1998 period), and appear to have stabilized (Holts 1988).

The early increase to peak catches with a strong decline thereafter, along with declining fishing effort and CPUE, is symptomatic of the "fishing-up" effect (Ricker 1975), i.e., early elevated catches from unsustainable fishing that produces strong stock reduction and fishery contraction. This is an expected exploitation pattern for low productivity species that have nevertheless accumulated sizable, fishable biomasses.

Exploitation reduced the common thresher population as indicated by the decline in CPUE (Holts, *et al.* 1998), but the magnitude of decline was also affected by the various area and time closures, the offshore expansion, and the shift in emphasis within the fishery from shark to swordfish. The closures initially reduced annual catches by approximately 50% of the peak years (Cailliet, *et al.* 1991; Hanan, *et al.* 1993), and likely altered catchabilities by size and reproductive behavior. Reduction of the population indicated that this thresher shark stock was substantially regional, with rather limited interchange with populations elsewhere.

Present levels of fishing effort appear to have allowed stock regrowth, as seen in the rise of CPUEs in certain areas (Hill, *et al.* 1997). Catches should continue to increase as the population recovers, but sustainable levels will always be much less than the unsustainable catches of the early years (MSY is equivalent to as little as 4-7% of the standing population that supplied the initial fishing-up catches). While present fishing effort in the California drift gillnet fishery has been decreasing, and permits are not being re-issued, continued recovery is not necessarily assured. Future fishing effort could increase and become concentrated in the Southern California Bight due to new regulations restricting fishing during a portion of the season north of Point Sur to protect the leatherback turtle (see Appendix D, Section D.1.2).

Common thresher populations off Baja California are thought to be of the same stock as fished off the U.S. West Coast (Eitner 1999). Transboundary movements of tagged specimens have been observed between California and off Mexico. Little is known about the fisheries off Mexico, however, since the shark landings there are not routinely reported by species, and the pelagic thresher shark is also common off Mexico.

A harvest guideline is proposed here based on estimates of local maximum sustainable yield (LMSY), i.e., as obtained from the stock portion presently accessed by the West Coast drift gillnet fishery (LMSYs necessarily underestimate stock-wide MSY). The LMSY, as estimated here (Au and Show, SWFSC, La Jolla, work in progress), is actually a proxy for true LMSY, as the method does not use exploitation rate based on mortality rates (yet undetermined) to estimate size of the locally exploited population from the catch. Rather, it uses the population growth rate (PGR) as determined from the thresher's rebound potential *r* (Smith et al. *In press*). PGR is less than true local exploitation rate ($=(F/Z)(1-e^{-Z})$) (A.E. Punt, Univ. Washington, pers. comm. 11/9/01), as it refers to the total population rather than the exploited ages only, and it is specifically the *sustainable* rate. It is thus a conservative estimate of exploitation rate. The PGR method estimates sustainable production in terms of potential surplus population growth.

Since the population recovery began when relative population size was $0.32\text{-}0.33B_o$ (from CPUE trend), and when the sustainable (equilibrium) catch was between 500 mt (recovery began after the catch fell below this level), and 306 mt (recovery is continuing under this nearly level catch of recent years), dividing a catch within that range by the PGR then, which is assumed to just sustain that catch, gives an estimate of the overall local population size at that time. That population size, incorporated in the logistic production model with *r*, provided an estimate of B_{LMSY} and LMSY (see Figure B–1). Assuming the equilibrium catch to be 350, 400, or 450 mt at time of recovery (between 1992-1993), the method determined proxy LMSYs of 390, 450, or 510 mt, respectively. These are minimal estimates of LMSY and especially MSY, since there is no adjustment for the unknown production off Mexico.

The proposed harvest guideline, 340 mt, is the proxy OY equal to 75% of the mid-point LMSY, 450 mt (see Table 4–3 in the FMP). It is less than the present 578 mt coast-wide guideline adopted by the Pacific States Marine Fisheries Commission in 1990 (PSMFC 1990).

Present available biomass appears to be just above B_{MSY} (~$1.10B_{MSY}$, see Figure B–1) and therefore above the Biomass Flag Ratio (= 0.96 B_{MSY}), and much above B_{MSST} (=$0.77B_{MSY}$) (see Table 4–2 in the FMP). Exploitation is presently producing about 300 mt (rw) from the available stock. Since the CPUE trend shows stock recovery, overfishing is not likely occurring, and F/F_{MSY} is < 1.0. The common thresher is no longer a primary target for most commercial fishers, so if catches could be held to present levels, the recovery could reach over 75% of B_o (according to the above logistic production-biomass relationship).

Status Summary: The common thresher occurs throughout the tropical and temperate Pacific but is not managed internationally and there are no quotas. It is more abundant near coasts, and there appears to be a regional stock off southern California and Baja California, judging by how that population declined after fishing began off California in the early 1980s (plus fishing off Mexico) and the results of tagging experiments. With time and area restrictions emplaced since 1990, the population now appears to be in recovery (B/B_{MSY}~1.10; F/F_{MSY} < 1.0), which should continue as long as present catch levels do not increase. Based on the midpoint proxy estimate of local maximum sustainable yield from the population available to the West Coast gillnet fisheries, 450 mt, a new regional harvest guideline equal to OY, 340 mt, is recommended. The harvest guideline is conservative, because it is reduced from LMSY, which itself underestimates stock-wide MSY as it does not include production from off Mexico.

Pelagic Thresher and Bigeye Thresher. Little is known of the biology and status of these sharks, and especially of their reproductive requirements. Individuals taken within the management area are thought to be on the edges of their habitat ranges, including depth-wise for the bigeye thresher which ranges into mesopelagic waters. They are minor components of West Coast fisheries, taken incidentally and presumably not overexploited, at least locally. The bigeye thresher occurs regularly but in low numbers (~9% of common thresher catch) in drift gillnet catches, whereas the pelagic thresher is taken mainly in warm-water years. Both species are caught off Mexico, and the pelagic thresher is reported to be an important component of Mexican shark catches. These species appear to have thin or semi-isolated populations Pacific-wide. Present West Coast catches total under 50 mt/yr.

MSYs, biomasses, or fishing mortalities relative to MSY of these sharks are unknown, but local proxy MSYs (LMSY) are estimated here from average catch levels (Table 3-5). At the regional or local level, LMSY for the pelagic thresher is estimated as 20 mt, the average catch during the El Niño years of 1983,1984, and 1997 when catches more likely reflected the potential for West Coast fishers. The bigeye thresher's LMSY is estimated as 40 mt, the average catch for 1982 to 1999. The proxy OYs are 75% of these values.

Status Summary: Pelagic and bigeye threshers populations occur throughout the tropical and temperate Pacific but are not managed internationally, and there are no quotas. They are thought to be more vulnerable to overfishing than the common thresher shark (see Table 4–3). Little is known of their abundance and stock structure. Considering their minor importance in West Coast catches and their proxy LMSYs (average catch levels are 20 and 40 mt respectively) that are likely substantial underestimates of stock-wide MSYs, no harvest guidelines are recommended at this time.

Shortfin Mako. This shark is taken primarily by the California drift gillnet fishery for swordfish, but also in smaller amounts by California-based longliners operating outside the EEZ (Vojkovich and Barsky 1998). It is also sought by sport anglers. Although present (1994-99) commercial catches are only ~60-130 mt/yr, the mako is still the third most valuable species taken in the drift gillnet fishery. Pacific coast catches peaked early at 400 mt in 1987, then declined especially during the 1990s. During 1988-1992, there was an experimental longline fishery for makos and blue sharks in the SCB.

The drift gillnet fishery primarily takes juveniles and subadults age 3 or less, the SCB evidently being an important nursery and feeding area for immatures (Cailliet, *et al.* 1991; Hanan, *et al.* 1993). Catch localities are like that of the common thresher, but with less nearshore concentration (unpublished Observer Data, SWFSC/NMFS, La Jolla, CA).

The shortfin mako is an oceanic shark widespread throughout the tropical and temperate Pacific. It is regularly taken by longline gear on the high seas. Off the West Coast, warmer years are associated with more northward movement. Makos off Mexico are likely of the same stock fished in U.S. waters, and makos tagged in the SCB have been recaptured as far south as Acapulco. Most makos caught off California are juveniles 1-3 years of age. Adults are infrequently taken and mature females are very rare. Presumably, makos move offshore as they mature.

Considering the mako's tropical to warm-temperate, ocean-wide range and the low availability of adults to the fishing gear (Cailliet, *et al.* 1991), it seems unlikely that this species has been depleted off the West Coast. Still, the mako's productivity is low (0.04-0.06/yr), and the SCB is undoubtedly important as a nursery/growing area. A reasonable assumption is that present time-area restrictions on drift gillnet fishing provide valuable protection for immature makos, at least for the regional stock. The longline experimental fishing program (1988-1992) was terminated in part because of the high catch rate of these immature fish. Catch statistics suggest this shark was not overexploited like the common thresher, though the studies are not yet complete (D.W. Au and C. Show, SWFSC/NMFS, La Jolla, CA). The CPUE rates, while variable and affected by the changes in the drift gillnet fishery and the effects of warm-water years, indicate a possible overall decrease not yet near B_{MSY}. But it is difficult to reconcile the decrease with the fishing effort that has been decreasing, the very narrow age span in the fishery, and the adult portion of the stock that is largely inaccessible. Abundance changes in the exploited immature fish that gather in the SCB may not reflect the effects of local fishing or the whole stock, which is thought to be wide-ranging and possibly EPO wide, or greater. The ratios B/B_{MSY} and F/F_{MSY} are here tentatively estimated to be > 1.0 and < 1.0 for the stock, respectively, and the 1981-1999 average catch of 200 mt is the present estimate for the LMSY proxy; 75% of that value is vulnerable species OY and the recommended harvest guideline, 150 mt (see Table 4–3 in the FMP).

Status Summary: The shortfin mako occurs throughout the tropical and temperate Pacific but is not managed internationally, and there are no quotas. It is widely distributed in pelagic waters, and the population fished off the West Coast is likely part of a stock that extends considerably to the south and west. West Coast HMS fisheries take mainly juveniles, of unknown proportion to the overall stock. Clear effects of exploitation have not been shown, and the local stock is tentatively taken to be not overfished ($B/B_{MSY} > 1.0$; $F/F_{MSY} < 1.0$). But it is important to protect critical life stages of sharks, and so a harvest guideline of 150 mt, 75% of the 1981-99 average catch in the EEZ, is recommended pending better information, especially from the fisheries off Mexico.

Blue Shark. This is probably the most commonly caught shark in the EEZ and Pacific- wide. It is usually not landed because of low market value. West Coast catches are estimated from observer data. Up to about 300 mt may be caught, but most are discarded (Holts, *et al.* 1998; Holts and Sosa-Nishizaki 1988). It is taken in both the drift gillnet and longline fisheries. Experimental longlining for blue sharks was conducted in California waters in 1979-1980 and again in 1988-1992 (the latter was the mako-blue shark experiment) in attempts to develop markets. Peak reported landings were 87 and 92 mt in 1980 and 1981 respectively. Since 1985, landings have averaged less than 5 mt (Holts, *et al.* 1998).

The blue shark is extensively distributed from tropic to temperate, and coastal to oceanic waters of all oceans. It may be the most abundant of all large marine, top predators. Its northern reproducing/nursery areas appear to be the subtropic-subarctic transition waters spanning the entire north Pacific, including southerly extensions along the Pacific rim coasts (Nakano 1994). Based on distribution, there appears to be a single, Pacific-wide stock. Comparison of the disparate size distributions from the drift gillnet fishery off California and the longline fishery operating north of Hawaii indicates that subadults move out from West Coast waters to join the oceanic, adult portion of their population as they approach maturity, females leaving at younger ages than the males.

There is some evidence for stock decline in the central Pacific (Nakano 1996), but not yet evidence of overfishing. The north Pacific blue shark stock appears healthy (Kleiber et al. MS[1]). Their results indicate the population is above B_{MSY} with $F/F_{MSY} < 0.5$, and that MSY could be 1.7-3.0 X Catch (1993-98 average). Applying that factor to the estimated > 50K mt catch for the north Pacific (after Nakano and Seki MS[2]), MSY was estimated as ~120K mt (see Table 4–3 in the FMP). There is insufficient information from coastal drift gillnet and longline fisheries to infer local stock status, because the extent of exchange between coastal and oceanic populations of blue sharks is unknown. But present catch levels off the West Coast, while poorly documented, are very likely sustainable, given the apparent health of the Pacific stock. Also, constraints on the drift gillnet fishery and the U.S. anti-finning law afford added protection for these sharks, which are mostly juveniles and subadults.

Status Summary: Blue shark, the most oceanic of the HMS MUS sharks, occurs throughout the Pacific from tropic to temperate seas. It is not actively managed internationally and there are no quotas. Recent studies indicate the species, which may comprise a single Pacific-wide stock, is abundant and healthy ($F/F_{MSY} < 0.5$), in spite of being incidentally fished by high-seas, longline fleets for over 50 years. MSY for the north Pacific stock is tentatively estimated to be approximately 120K mt. Therefore, no harvest guideline is recommended at this time.

B.3 Billfishes/Swordfish

The primary billfishes caught in West Coast EEZ waters are swordfish by drift gillnet and longline and striped marlin by sportfishing (commercial marlin fishing is not allowed in California). Both species are widespread and oceanic in distribution. Their population biology and behavior are not well known. Based on life history characteristics, they are at least moderately productive (see Table 4–1 in the FMP).

Management of marlins and swordfish is under the purview of the same international fisheries organizations as for the tunas. Presently, there are no quotas. The general management control rule for billfishes is the same as for tunas (see Figure 4–2 in the FMP). In this FMP, OY is taken to be the same as MSY (or proxy) for swordfish but a precautionary 0.75MSY for striped marlin. There is much uncertainty over the catches and stock structure of both these species, but especially for the latter, which is therefore treated as vulnerable.

Swordfish. Longline fleets from Hawaii and Japan have harvested most of the swordfish from the north Pacific, over 17K mt in 1997 (FAO Areas 61 and 77). Hawaii-based effort and landings escalated in the early 1990s with arrival of swordfish boats from the U.S. Atlantic. This fleet averaged 5.4K mt/yr or 37% of the central-eastern north Pacific catch during its peak 1991-1993 years (Skillman 1998), but then shifted emphasis toward bigeye tuna (the actual target of the Japanese fleet). Some of the boats subsequently withdrew, but the catch was still nearly 3.3K mt in 1998 (WPRFMC 1999). The Hawaiian fleet worked the eastern end of the area fished by Japan, the waters north of Hawaii to 50° N latitude. This fleet is now prohibited (since June 12, 2001) from longlining for swordfish north of the equator by

[1] Kleiber, P, Y. Takeuchi, and H. Nakano. MS. Calculation of plausible maximum sustainable yield (MSY) for blue shark *(Prionace glauca)* in the north Pacific, SWFSC Admin. Rep. H-01-02; also Dept. of Commerce 2001.

[2] Nakano, H., and M.P. Seki, MS, Synopsis of biological data on the blue shark *Prionace glauca* Linnaeus, Nat. Res. Inst. Far Seas Fish., Japan.

the NMFS Emergency Interim Rule for the protection of sea turtles (see Chapter 1, section 1.6.6 in the FMP for current restrictions on this fishery).

Off the U.S. and Mexican West Coasts, drift gillnetters, harpooners, and longliners (the latter fishing outside the US EEZ) take 1-2K mt per year (Holts and Sosa-Nishizaki 1988). The West Coast catch, primarily from the California drift gillnet fishery, peaked in 1984-1985 at 2.9-3.4K mt. Catches declined following driftnet restrictions (see Common Thresher Shark) and now average about 1.4K mt annually (1995-1999). The West Coast catch amounts to about 12% of the EPO catch. The driftnet fishery is now restricted (since August 24, 2001) from fishing basically north of Point Sur, California from August 15 through November 15 to protect leatherback turtles (Chapter 1, section 1.6.6).

Swordfish occur throughout the tropical-temperate Pacific with concentrations in the north Pacific from east of Japan to northeast of Hawaii, and also off central Mexico, South America, and in tropical waters of the central and western Pacific. The stock structure appears complex and there may be more than one stock in the Pacific.

The species should be relatively productive and resilient to fishing (Ward and Elscot 2000, also Table 4-1). Females are estimated to mature at 144 cm eye-FL (DeMartini, *et al.* 2000), probably at 5-6 years of age (Sosa-Nishizaki 1990), and spawning probably occurs all year in the tropics and at least seasonally in temperate waters. But immatures (both sexes) comprise about 50% of the catch (by number) in both the oceanic longline and coastal driftnet fisheries, and the vital rates of the species are poorly known. Estimates of growth rate, summarized by Boggs (1989), have been obtained from a few small samples and are to be considered provisional (Skillman 1998). In particular, the growth of large individuals remains poorly defined. Thus there is considerable uncertainty in aging the catches, and fishing and natural mortality rates are questionable (Skillman 1998).

Various trend analyses have been conducted and a new assessment model has been developed to determine the status of Pacific swordfish. No evidence could be found, up through 1992, of any effect from fishing by the Japanese fleets (Bartoo and Coan 1989; Nakano 1998; Uosaki 1998). A more up-to-date assessment using age-structured models and including both Japanese and Hawaiian fishery data was inconclusive due to uncertainties on stock structure, size composition in catches, and population parameters (Bartoo and Hinton 1999; ISC 1999). The new simulation assessment model developed at NMFS SWFSC-Honolulu Laboratory, in conjunction with the WPRFMC, used a best amalgamation of data, parameter estimates, and hypotheses to conclude that $F_{96}/F_{MSY} = 0.10$ and $B_{96}/B_{MSY} = 2.47$, indicating that north Pacific swordfish had not been overfished. The level of uncertainly for these ratios is considered high however (Boggs, *et al.* 2000).

Standardized CPUE from off Mexico and the western U.S. show swordfish in the EPO (east of 150^{o}W) either increasing or with level time trend and at levels greater than for MSY (Hinton and Bayliff 2002b). The present ban against swordfish fishing for the Hawaii longline fleet should also be benefitting the stock. Continued monitoring is imperative, however, as both immature and mature ages of this top predator are exploited.

Status Summary: Pacific swordfish are widely distributed in the Pacific and may comprise one or more stocks. In the EPO, its status is regularly reviewed by the IATTC. No quotas have been set and no MSY has been estimated. But recent NMFS and IATTC assessments indicate the EPO stock or population is healthy with respect to fishing mortality and biomass relative to MSY ($B/B_{MSY} > 1.0$; $F/F_{MSY} < 1.0$). Here, proxy MSY and OY are taken as the average recent catch level, 12.5K mt (Table 3-5), noting also the assessment uncertainties and the need for careful monitoring in the international fisheries. In view of the stock's apparent health in the EPO and the relatively small catch fraction taken by West Coast fishers (12%), no regional harvest guideline is recommended at this time.

Striped Marlin. This tropical-subtropical species is taken importantly by tuna longliners and by sportfishers. In 1997 the Pacific-wide, commercial catch (mainly by Japan) was at least 7.4K mt of which approximately 3.6K mt was from the eastern Pacific (FAO Area 77). These catches are almost certainly under-reported as they are taken incidentally. The West Coast sports catch occurs during spring-summer when striped marlin move into southern California waters. This catch averages about 300 fish annually (20-50 mt).

The seasonal marlin that occur in California waters appear to originate primarily from high-density areas off the southern end of Baja California Sur, part of the species' horseshoe-shaped distribution spanning the Pacific (Squire and Suzuki 1990). North, south, and eastern and western Pacific stocks have been proposed for assessing the status of striped marlin.

Regionally, CPUEs from eastern and central North Pacific sportfishing localities have shown no particular trend during the last 25 years (Billfish Newsletter 1999; Ch. 2, Fig. 2-20), although increased angler efficiency and oceanographic or other effects on fish behavior could be masking declines. But notably, the recreational catch off California has decreased since the mid-1960s (see Appendix A, Fig. A-18), and average fish size has also declined (see Appendix A, Fig. A -19). Major problems in interpreting these trends are lack of comparable data on angler effort and efficiency over the same period. The above decrease in average size indicates that mortality could have increased 1.8 times the initial rate in 1900, based on the relationship between mortality rate and average size in an equilibrium population (D.W. Au, SWFSC/NMFS, La Jolla, CA). This increase suggests exploitation approaching the level for MSY, assuming that a mortality twice that of natural mortality (assumed prevailing in 1900) produces MSY. But this result may not reflect the dynamics of the population if the size of marlin entering the EEZ is not representative of the population as a whole, or is affected by long-term environmental or other factors.

Decrease in average size is also seen in EPO fisheries data for north of 10^{o}N, but the stock in the entire EPO presently appears to be healthy (Hinton and Bayliff 2002a). In their analysis, fishing effort was standardized for depth preference of the fish before determining a relationship to stock production. They concluded that during 1991-98 F/F_{MSY} decreased from 1.4 to 0.7 and B/B_{MSY} increased from 0.62 to 1.07, i.e., a good recovery from a precautionary overfished (but not depleted) condition (see Table 4–2 in the FMP). MSY was estimated to be 4.5K mt (see Table 4–3 in the FMP). Striped marlin seem not to be now overfished Pacific-wide as well. Longline catch and effort series did not indicate stock-wide overfishing through the mid 1980s (Skillman 1989; Suzuki 1989), and presently, the Standing Committee on Tuna and Billfish (SCTB 1999) does not consider striped marlin to be overfished. It recognized, however, the poorly known vital rates, catches and catch rates, the latter from catches that are incidental to targeted tunas. Overall, the fishing pressure on striped marlin should have decreased since the mid 1970s, because of the shift in longline fishing to target deep-dwelling bigeye tuna and because of fleet-size reductions (Hinton and Bayliff 2002a).

Striped marlin show significant genotypic heterogeneity by area, indicating that management at regional levels might be particularly appropriate (Graves and McDowell 1994). However, Hinton and Bayliff (2002a), while acknowledging the uncertainty of stock structure, concluded there was insufficient evidence, including the genetic, to reject the hypothesis of a single EPO stock. Still, localized substocks could be strongly impacted by fisheries, and if in fact there are northern and southern stocks, the northern stock could be not much recovered beyond the overfished condition. At more localized levels, Squire and Au (1990) showed that local depletion can quickly result from nearby commercial longlining. The Council should be alert for regional effects of fishing.

Status Summary: The status of striped marlin is reviewed occasionally to regularly by the IATTC and ISC. The overall EPO stock appears now healthy and not overfished (B/B_{MSY}=1.07; F/F_{MSY}=0.70). There are no international quotas. MSY has been estimated as 4.5K mt. In view of the catch and stock structure uncertainties the striped marlin is treated as a vulnerable species here, and its OY is thus placed at 75% of MSY. But since commercial harvest of striped marlin is presently prohibited by California, no West Coast harvest guideline is recommended for the seasonal influx of fish, which occurs in the U.S. EEZ at the edge of the species' range.

B.4 Others

Dorado (Dolphinfish). This tropical species has increasingly appeared in the SCB, especially in recent years. Up through the early 1970s only a few hundred were caught by summertime sport anglers, but by 1997 28,600 fish were taken (~186 mt). Increase of dorado may be the result of decadal-scale, poleward warming of eastern Pacific surface waters that is extending the species' habitat (Norton 1999).

The dorado is at least seasonally abundant in all warm Pacific waters and a fast-growing, extremely productive species. Females are mature at an early 4-7 months, and spawning occurs all year, at least in the tropics. Based on life history, the species' rate of population increase could be more than 34 percent per year, and the recovery time from depletion (doubling time) less than 1.5 years (see Table 4–1 in the FMP). But adult natural mortality (M) must also be very high, the life span being only 2-4 years (Oxenford 1999). The ability of species to sustain added fishing mortality is related to the productivity - natural mortality ratio, not just productivity (Caddy and Csirke 1983). Thus with high M, dorado production may be limited even while the species is resilient. Dorado are not typically in huge schools, unlike the tropical tunas.

While dorado occur throughout the tropical Pacific, their migrations are more localized in comparison to that of the large, truly oceanic billfishes and tunas (Oxenford 1999), and thus management of regional substocks is pertinent. Seasonal dorado caught in the SCB are thought to be from populations reproducing off Mexico, the fish entering the West Coast EEZ from the edge of their range. Total catches from such regional populations are poorly documented since much of the fishing is artisanal. There are no estimates of MSY for the eastern Pacific, or of biomass or fishing mortalities relative to it. However, if reported catches from off California to Peru (FAO Area 77) are viewed as underestimated MSY and OY, West Coast catches are a small fraction of those levels (see Table 4–3 in the FMP).

Status Summary: The dorado is a fast-growing, widespread species of tropical seas that occurs seasonally in the SCB. Regional populations are not regularly reviewed by the IATTC or SPC and presently there is no management and no quotas. The population is presumed to be healthy. The recent average catch level, 450 mt, is taken here as a proxy MSY and OY for the EPO. Considering that West Coast fishers are accessing only the northern fringe of an extensive regional population, a population that should be able to rebound quickly from exploitation even if significantly reduced, and that its West Coast fishing is primarily recreational, no harvest guideline is recommended at this time.

B.5 Summary of Management Unit Species' Overfishing/Overfished Status at the Time of FMP Adoption

Table 4–2 in the FMP summarizes the overfishing/overfished status of HMS management unit species in terms of the proposed default control rule (See section 4.1.2 in the FMP), i.e., with SDC reference points expressed as ratios: $F/F_{MSY} > 1.0$ for overfishing; $B/B_{MSY} < B_{MSST}/B_{MSY}$ for the overfished condition; and the particular conservative Flag Ratio shown in Figure 3 -1 (=1.25(B_{MSST}/B_{MSY}). Values for these ratios are estimated as described under each species in section 3.3, which discusses additional evidence for health status beyond the ratios themselves.

The MUS appear generally healthy, although understanding of the pelagic and bigeye thresher shark populations is poor. *Overfishing* appears to be occurring only with bigeye and yellowfin tuna in the EPO, possibly with F/F_{MSY} amounts 11% and 30% greater than for producing MSY for the two species, respectively (see Table 4–2 in the FMP, cols. 3, 4). This overfishing is not expected to reduce those stocks below MSST, since strong recruitment supported those fishing levels, the equilibrium catch levels at those rates are not much different from MSY, and the stocks are being actively managed for average MSY by the IATTC. Thus no remedial actions are required by the Council. The criterion for being *overfished* is not met for bigeye and yellowfin tuna (and the other species as well), B/B_{MSY} being either substantially above MSST or there being other information not supporting that condition {Maunder, 2002 38 /id;Maunder, 2002 39 /id /pt "see Table 4–2 in the FMP, cols. 6, 7; also. Again, no management actions, even for the conservative limit B/B_{MSY} < Flag Ratio, are called for. That none of the species is presently in clear need of management action stems from two facts: 1) the widespread, extensively exploited species are productive species (see Table 4–1 in the FMP) long monitored by international organizations; 2) species of lower productivity are either not commercially targeted or have had adequate controls enforced by the states.

B.6 Summary of the Catch/Sustainability Status of Management Unit Species at the Time of FMP Adoption

[3.3.6 Summary of the Catch/Sustainability Status of Management Unit Species]

Stock-wide and regional (West Coast) catches of management unit species are summarized in Table 4–3 in the FMP, with estimates of regional catch fractions and their sustainability. All present West Coast catches of MUS are thought to be sustainable. Estimates of MSY or proxies are given, as are regional harvest guidelines where appropriate. The overfishing/overfished status of these MUS were summarized in Table 4–2 in the FMP.

Presently, there are stock-wide MSY estimates for only four MUS and no stock-wide OY estimates for any MUS of this FMP (see Table 4–3 in the FMP). The MSYs are for albacore, yellowfin and bigeye tuna whose fisheries have long been tracked, and for striped marlin (the MSY listed for blue shark is tentative, based on incomplete catches). For the other MUS, stock-wide, or local, recent average catch levels are used as MSY or LMSY proxies. For now and as described in section 3.2.3, the OY proxies are set by the formulae OY=MSY for non-vulnerable species and OY=0.75MSY for vulnerable species (here, for the sharks and for bluefin tuna and striped marlin). As better estimates of MSY become available, and if OY levels themselves are not estimated, the proxy OYs can be updated using the formulae.

Stock-wide catches for common, pelagic, and bigeye thresher sharks, shorfin mako shark, and for dorado are poorly known if at all. The MSY entries for the above sharks in Table 3-5 are actually local MSY proxies (LMSY proxies), and therefore minimal estimates of MSY. The pelagic and bigeye threshers are minor, incidentally caught species in West Coast fisheries. Distribution-wise, they are fringe species for the fisheries, especially the pelagic thresher shark. Even the maximum historical catch levels of these sharks could be misleading estimates of their stock-wide MSYs. The dorado is similarly a fringe species although it is targeted

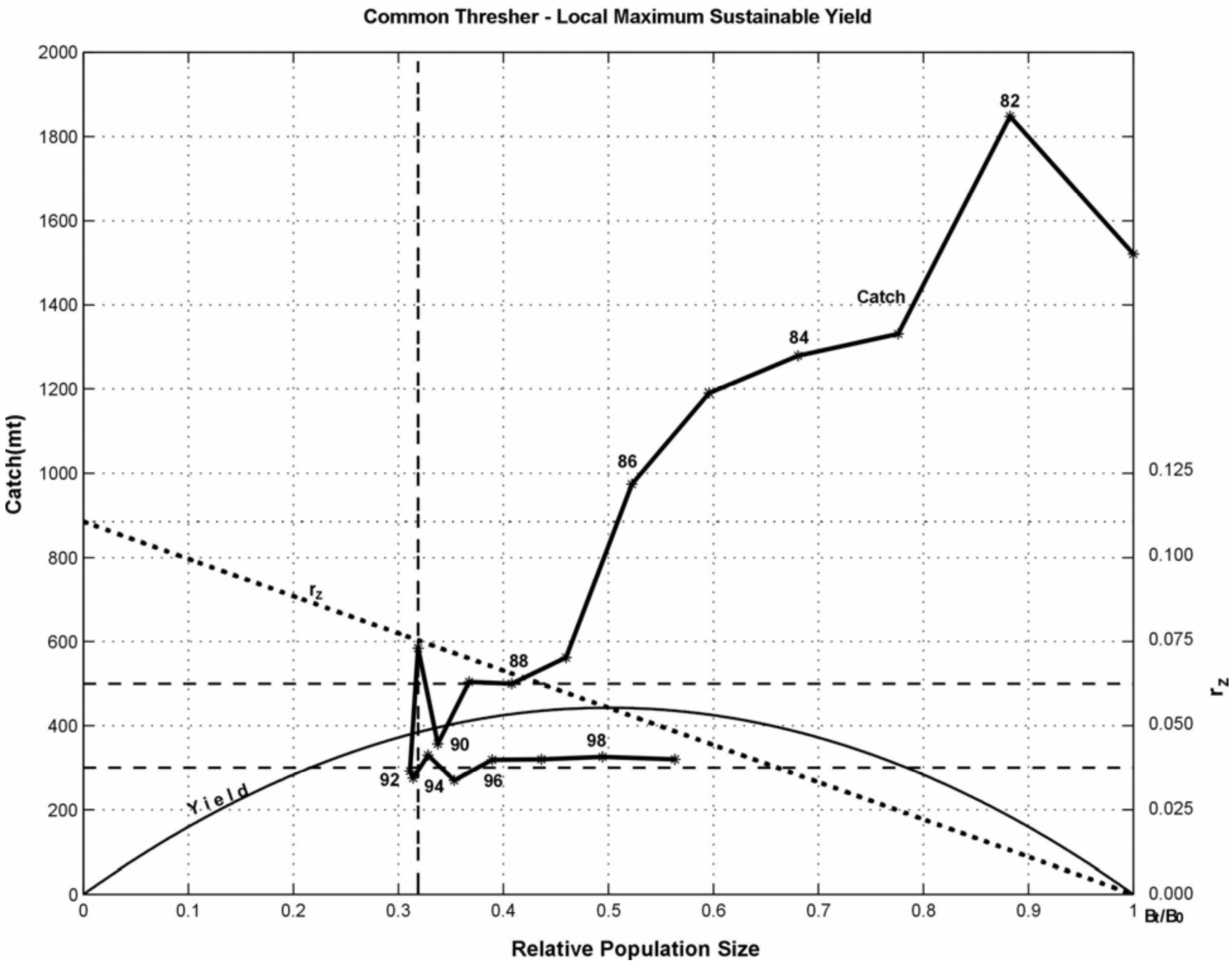

Figure B–1. A proxy estimate of local maximum sustainable yield (LMSY) for the common thresher shark.

The 1981-1999 catch vs. relative population size (B_t/B_0) trajectory show population recovery beginning at 1992-93 (trajectory moves to right) at a relative populations size of 0.32 (vertical line) and between sustainable catch levels (horizontal lines) that, along with productivity at the population size (r_z at the intersection with vertical line), together determine a production function as shown (parabola). In this example, the LMSY proxy estimate is 450 mt.

Table B–1. Formal HMS stock assessment protocols and status overview.

SPECIES/STOCK:	**Albacore**
ASSUMED STOCK:	North & South Pacific
ASSESSING ORGANIZATION/FORUM:	North Pacific Albacore Workshop. Informal international forum of Laboratories from 4 countries. Shared data. Individual/collaborative efforts reviewed/discussed at workshop. South - working group of Standing Committee on Tuna and Billfish (SCTB)
STOCK ASSESSED?	North - yes: South - yes

ASSESSMENT FREQUENCY?	North - one to two year intervals; South - intermittent
ASSESSMENT MODEL(S):	North - MSY, Biomass and F ratios for surplus production, others; South - variable.
RISK/UNCERTAINTY MODEL(S):	North - yes variable; South - yes variable
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	North: MSY, Overfishing, Overfished. South : None
SCIENTIFIC REVIEW:	North & South - Internal review at authors laboratories, group review at presentation.
REPORTING:	North Workshop - Published report, presentation to Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific (ISC) at BI-annual meetings. SCTB - annual report, working papers at meetings.
CURRENT CONSERVATION MANAGEMENT:	International: None. No international forum currently exists. Domestic: None. Western Pacific Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

SPECIES/STOCK:	**Yellowfin Tuna**
ASSUMED STOCK:	Eastern Pacific Ocean (EPO) east of 150 West Long. and Central-Western Pacific (CWP) west of 150 West Long.; Pacific-wide
ASSESSING ORGANIZATION/FORUM:	EPO - Inter-American Tropical Tuna Commission (IATTC). Analyses presented to Members annually. CWP - Standing Committee on Tuna and Billfish (SCTB). Annual meeting open to all scientists.
STOCK ASSESSED?	EPO - Yes ; CWP - Yes
ASSESSMENT FREQUENCY?	EPO - annually; CWP & Pacific- wide - intermittent
ASSESSMENT MODEL(S):	EPO - MSY, Yield-per-Recruit, cohort, others. CWP - MSY, tagging, CPUE; complex model in development.
RISK/UNCERTAINTY MODEL(S):	EPO - variable; CWP - variable
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	EPO: MSY, Overfishing, Overfished. CWP : MSY, Overfishing, Overfished.
SCIENTIFIC REVIEW:	EPO - Internal IATTC review. CWP - (SCTB) Internal review at authors laboratories, group review at presentation.
REPORTING:	Annual published report, available to public; documents presented at Members meeting. SCTB - annual report, working papers at meetings.
CURRENT CONSERVATION MANAGEMENT:	International: EPO - annual catch quota corresponding to MSY, implemented by member countries. CWP - none. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

SPECIES/STOCK:	**Skipjack Tuna**
ASSUMED STOCK:	Eastern Pacific Ocean (EPO) east of 150 West Long. and Central-Western Pacific (CWP) west of 150 West Long.; Pacific-wide
ASSESSING ORGANIZATION/FORUM:	EPO - Inter-American Tropical Tuna Commission (IATTC). Analyses presented to Members annually. Pacific-wide and CWP - Standing Committee on Tuna and Billfish (SCTB). Annual meeting open to all scientists.
STOCK ASSESSED?	EPO - Yes; CWP - Yes
ASSESSMENT FREQUENCY?	EPO - annually; CWP & Pacific- wide - intermittent.
ASSESSMENT MODEL(S):	EPO - Yield-per-Recruit, CPUE, others. CWP - tagging, CPUE.
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	EPO: Overfished. CWP: Overfishing, Overfished.
SCIENTIFIC REVIEW:	EPO - Internal IATTC review. CWP - (SCTB) Internal review at authors laboratories, group review at presentation.
REPORTING:	IATTC - Annual published report, available to public; documents presented at Members meeting. SCTB - annual report, working papers at meetings.
CURRENT CONSERVATION MANAGEMENT:	International: EPO - None. CWP - none; Pacific-wide - none. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

SPECIES/STOCK:	**Bigeye Tuna**
ASSUMED STOCK:	Eastern Pacific Ocean east of 150 West Long.; Pacific-wide
ASSESSING ORGANIZATION/FORUM:	EPO - Inter-American Tropical Tuna Commission (IATTC). Analyses presented to Members annually. Pacific-wide - Standing Committee on Tuna and Billfish (SCTB) and Bigeye Working Group of ISC. Annual meeting open to all scientists.
STOCK ASSESSED?	EPO - Yes: Pacific-wide - Yes.
ASSESSMENT FREQUENCY?	EPO - annually; Pacific- wide - intermittent.
ASSESSMENT MODEL(S):	EPO: Age-structured cohort, Yield-per-Recruit; Pacific-wide: age-structured cohort, Yield-per-Recruit, others under development.
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	EPO: Overfished. Pacific-wide: Overfishing, Overfished.
SCIENTIFIC REVIEW:	EPO - Internal IATTC review. CWP and Pacific-wide - (SCTB & ISC) Internal review at authors laboratories, group review at presentation

REPORTING:	IATTC - Annual published report, available to public; documents presented at Members meeting. SCTB - annual report, working papers at meetings. ISC - Working papers at Bi-annual meeting.
CURRENT CONSERVATION MANAGEMENT:	International: EPO - quota by IATTC with restrictions on area and method of fishing for Y/R management, implemented by member countries. Stock-wide - none, no forum exists. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

SPECIES/STOCK:	**Northern Bluefin Tuna**
ASSUMED STOCK:	Pacific-wide
ASSESSING ORGANIZATION/FORUM:	IATTC. Bluefin Working Group of ISC.
STOCK ASSESSED?	Yes, intermittently
ASSESSMENT FREQUENCY?	Intermittent (1999 most recent)
ASSESSMENT MODEL(S):	Models in development
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	Pacific-wide: None
SCIENTIFIC REVIEW:	Pacific-wide - IATTC - Internal review; ISC - Internal review at authors laboratories, group review at presentation.
REPORTING:	IATTC: Annual published report, available to public; documents presented at Members meeting. ISC: Working papers at Bi-annual meeting.
CURRENT CONSERVATION MANAGEMENT:	International: none, no forum exists. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

SPECIES/STOCK:	**Swordfish**
ASSUMED STOCK:	North Pacific-wide (uncertain)
ASSESSING ORGANIZATION/FORUM:	Pacific-wide: Swordfish Working Group of ISC.
STOCK ASSESSED?	Yes, not current (new assessment underway)
ASSESSMENT FREQUENCY?	Intermittent (last published - 1989 stock-wide); currently underway (ISC).
ASSESSMENT MODEL(S):	CPUE, surplus production
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	Pacific-wide: Overfishing, Overfished.
SCIENTIFIC REVIEW:	Pacific-wide - (ISC) Internal review at authors laboratories, group review at presentation.
REPORTING:	ISC: Working papers at Bi-annual meeting. IATTC.

CURRENT CONSERVATION MANAGEMENT:	International: Stock-wide - none, no forum exists. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.
SPECIES/STOCK:	**Striped Marlin**
ASSUMED STOCK:	Pacific-wide (uncertain)
ASSESSING ORGANIZATION/FORUM:	Pacific-wide: Marlin Working Group of ISC. EPO: IATTC
STOCK ASSESSED?	Yes, not current
ASSESSMENT FREQUENCY?	Intermittent
ASSESSMENT MODEL(S):	MSY, CPUE, others
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	Pacific-wide: Overfishing, Overfished.
SCIENTIFIC REVIEW:	Pacific-wide - IATTC - Internal review; ISC - Internal review at authors laboratories, group review at presentation.
REPORTING:	ISC: Working papers at Bi-annual meeting.
CURRENT CONSERVATION MANAGEMENT:	International: Stock-wide - none, no forum exists. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.
SPECIES/STOCK:	**Common Thresher Shark**
ASSUMED STOCK:	Eastern Pacific Ocean, U.S. EEZ.
ASSESSING ORGANIZATION/FORUM:	EPO - none; U.S. EEZ - NMFS
STOCK ASSESSED?	EPO - no; U.S. EEZ - yes.
ASSESSMENT FREQUENCY?	EPO - none; U.S. EEZ - intermittent
ASSESSMENT MODEL(S):	Demographic; models in development
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	EPO: None; U.S. EEZ: MSY, Overfishing, Overfished.
SCIENTIFIC REVIEW:	PFMC
REPORTING:	FMP
CURRENT CONSERVATION MANAGEMENT:	International: none, no forum exists. Domestic: None. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.
SPECIES/STOCK:	**Pelagic Thresher Shark**
ASSUMED STOCK:	Eastern Pacific Ocean

ASSESSING ORGANIZATION/FORUM:	None
STOCK ASSESSED?	No
ASSESSMENT FREQUENCY?	None
ASSESSMENT MODEL(S):	Demographic; models in development
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	EPO: None
SCIENTIFIC REVIEW:	Unknown
REPORTING:	None
CURRENT CONSERVATION MANAGEMENT:	International: none, no forum exists. Domestic: None. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.
SPECIES/STOCK:	**Bigeye Thresher Shark**
ASSUMED STOCK:	Eastern Pacific Ocean
ASSESSING ORGANIZATION/FORUM:	None
STOCK ASSESSED?	No
ASSESSMENT FREQUENCY?	None
ASSESSMENT MODEL(S):	Demographic; models in development
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	EPO: None
SCIENTIFIC REVIEW:	Unknown
REPORTING:	None
CURRENT CONSERVATION MANAGEMENT:	International: none, no forum exists. Domestic: None. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.
SPECIES/STOCK:	**Shortfin Mako Shark**
ASSUMED STOCK:	Eastern Pacific Ocean
ASSESSING ORGANIZATION/FORUM:	NMFS
STOCK ASSESSED?	Partially
ASSESSMENT FREQUENCY?	None
ASSESSMENT MODEL(S):	Demographic; survey; models in development
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	EPO: Overfishing, Overfished.
SCIENTIFIC REVIEW:	PFMC
REPORTING:	FMP
CURRENT CONSERVATION MANAGEMENT:	International: none, no forum exists. Domestic: None. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

SPECIES/STOCK:	**Blue Shark**
ASSUMED STOCK:	Pacific-wide; north Pacific
ASSESSING ORGANIZATION/FORUM:	Cooperative NMFS-Japan Working Group
STOCK ASSESSED?	No
ASSESSMENT FREQUENCY?	In process
ASSESSMENT MODEL(S):	Models in development
RISK/UNCERTAINTY MODEL(S):	Unknown
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	Unknown
SCIENTIFIC REVIEW:	Center of Independent Experts (U of Miami)
REPORTING:	Through WPRFMC.
CURRENT CONSERVATION MANAGEMENT:	International: none, no forum exists. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

SPECIES/STOCK:	**Dorado (Dolphinfish)**
ASSUMED STOCK:	Pacific-wide
ASSESSING ORGANIZATION/FORUM:	NMFS
STOCK ASSESSED?	No
ASSESSMENT FREQUENCY?	None
ASSESSMENT MODEL(S):	None
RISK/UNCERTAINTY MODEL(S):	None
MODELS SUITABLE TO ESTIMATE CONTROL RULES:	Unknown
SCIENTIFIC REVIEW:	PFMC
REPORTING:	FMP
CURRENT CONSERVATION MANAGEMENT:	International: none, no forum exists. Domestic: None. Western Pacific Region Fishery Management Council lists species in Pelagics FMP. Pacific Fishery Management Council considering species in Highly Migratory Species FMP.

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