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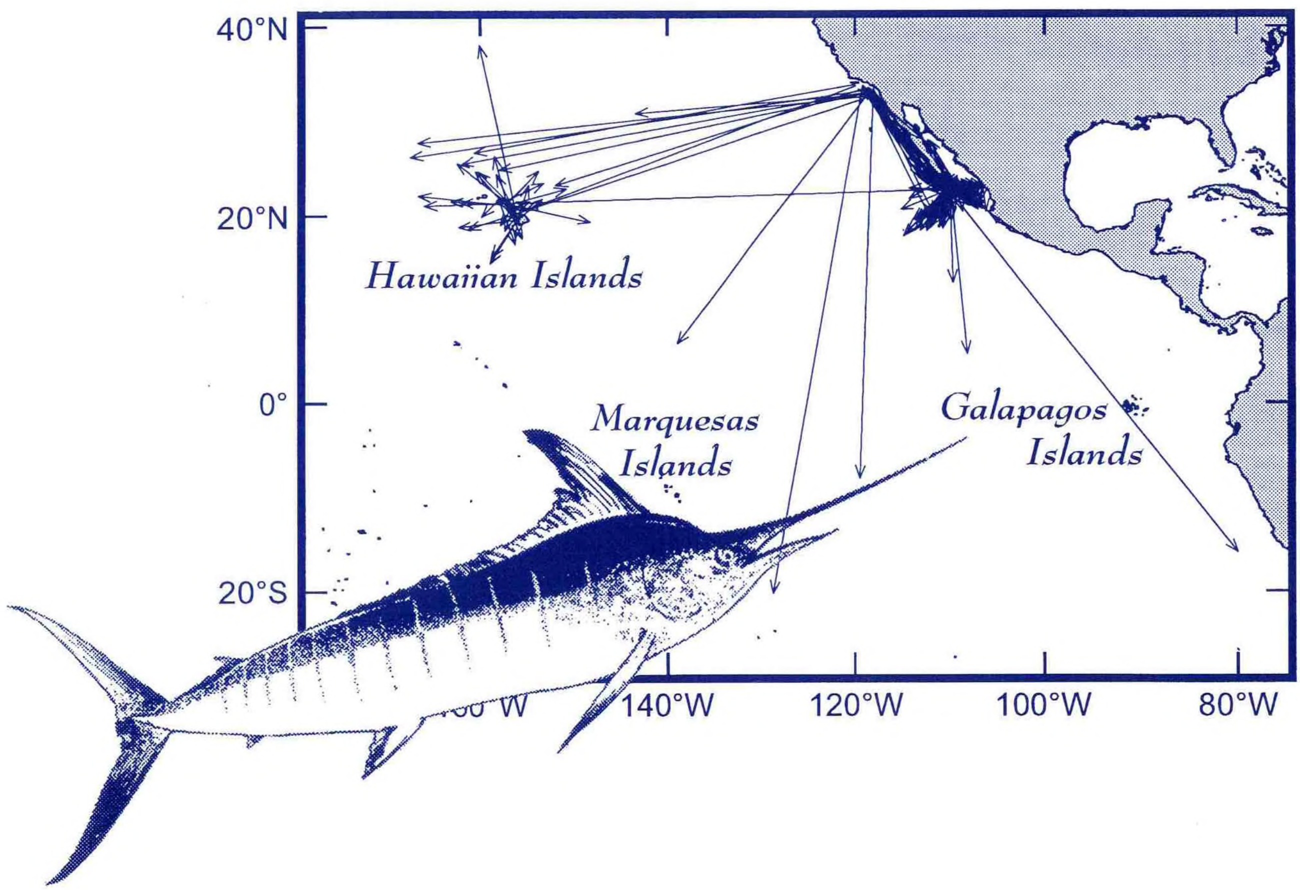
Pacific Federal Angler Affiliation for Billfish Plan and Workshop Report



John R. Hunter
David B. Holts
editors

Administrative Report LJ-99-11

DECEMBER 1999

PACIFIC FEDERAL ANGLER AFFILIATION FOR BILLFISH PLAN AND WORKSHOP REPORT

John R. Hunter
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editors

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ADMINISTRATIVE REPORT LJ-99-11

PREFACE

This is a report of a workshop and a plan on how to expand and enhance research collaboration between billfish anglers and the Southwest Fisheries Science Center (SWFSC), La Jolla to improve the information needed for fishery management. The workshop was held at the Balboa Angling Club of Southern California, Newport Beach California, August 11, 1999. Managing editors were John R. Hunter and David B. Holts; scientific writers were Norm Bartoo, Vincent Buonaccorsi, Pedro Ulloa, and Russell Vetter. The document may be cited as:

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Additional copies may be obtained from the scientific editors. See participant list for addresses and phone numbers or contact us from the PacFAAB Web site:

http://swfsc.ucsd.edu/frd/PacFAABa.htm

EXECUTIVE SUMMARY

A great opportunity exists to improve the management of swordfish, striped marlin, blue marlin and sailfish, because they will soon be included in an international fisheries convention and in two US fishery management plans. Presently, Pacific billfish are data-poor stocks that have not been assessed for a decade. Assessments are imprecise and possibly biased because of our ignorance of the vital rates, trends in abundance and stock boundaries. Without better biological information, international and federal initiatives to mange Pacific billfish resources will be ineffective. The rarity of billfish encounters and difficulties of capture dictate that an alliance between fishermen and scientists is the only way to improve knowledge of these stocks.

The consensus of the 1999 workshop, described in this Report, was that a cooperative program between California billfish anglers and their organizations, the US government (SWFSC) and the Mexican government (INP, Instituto Nacional de la Pesca) has a great potential for improving the level of knowledge on Pacific billfish and thereby reducing the risk of ineffective management. The report summarizes workshop presentations and recommendations and provides a draft research plan (Appendix A) based on this information. The plan describes how such a cooperative angler-based research program could improve Pacific billfish stock assessments by providing new information on vital rates, trends in abundance, stock boundaries, and tagging stress. The scientific approach would build upon and greatly expand the kinds of information collected by the SWFSC's successful angler tag and release program. Thus, knowledge is advanced to a new level while preserving the strong conservation ethic of the present program. A new level of information would be obtained through use of tissue biopsies, advanced tagging methodologies, and rigorous recording of recreational fishing effort and catch. Cooperation of anglers, vital to the success of this plan, would be sustained through a timely and effective communication system where the program data and analyses would be available on a Web site, and angler contributions would be clearly acknowledged. Communication would also be sustained through angler representation on a steering committee that would guide the development and implementation of this plan. The steering committee would consist of anglers, recreational industry representatives, and scientists from SWFSC and INP. Partnership with Mexico, particularly INP, is an important element of the plan because the majority of the west coast recreational catch of billfish is taken in Mexican waters. While present fiscal constraints do not allow full implementation of the plan, meeting participants identified a set of action items that could be undertaken with present resources as a demonstration of commitment to the more extensive program.

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PACIFIC FEDERAL ANGLER AFFILIATION FOR BILLFISH: WORKSHOP REPORT AND RESEARCH PLAN

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1. INTRODUCTION

Times are changing for management of Pacific billfishes resources. For the first time, Pacific billfishes will be covered under an international management treaty proposed to cover a vast area of the Pacific Ocean running from 42° north latitude to 4° south latitude and eastward to 150° west longitude (Figure 1). An international convention for effective management and long-term conservation of highly migratory stocks in this area is being drafted by the Multilateral High Level Conferences (MHLC) with an expected starting date of June 2000. Similarly, the Pacific Fishery Management Council (PFMC) is developing a fishery management plan (FMP) for highly migratory species (HMS) for the exclusive economic zone (EEZ) off the west coast of the US, and a Western Pacific Fishery Management Council FMP is in place for HMS in the EEZ of the Hawaiian archipelago. These HMS management groups will provide a new opportunity for effective long-term management of billfish stocks of the Pacific. To make future stock assessments more accurate and knowledge-based will require a major advance in knowledge of Pacific billfishes. In particular, the geographic limits of the stocks need better definition, our knowledge of age, growth and reproductive effort needs to be expanded, the effectiveness of tag and release needs to be evaluated, and better indices of abundance are required. Thus, the challenge of the future is how to obtain this knowledge and thereby improve the quality of the information used to make management decisions on Pacific billfish populations.

Anglers and their organizations are a key element in obtaining a baseline of information on billfish (swordfish, striped marlin, blue marlin, and sailfish) because they have access to the animals. The value of angler contributions to data collection on billfish has long been recognized. The SWFSC's Pacific billfish tag and release program, started over 30 years ago (Squire, 1987), has been a success. However, the major assessment and management tasks that lie ahead require a new kind of partnership that generates a broader range of information while sustaining the present system that delineates the movements of billfish and reduces their total take.

A research partnership for billfish between west coast anglers and federal scientists also must include Mexican fishery scientists. Cooperation with Mexico, and particularly the Instituto Nacional de la Pesca (INP), is vital because billfish stocks are transboundary and the west coast of Mexico is the center of the California recreational billfish fishery. Strong incentives exists for establishing a productive partnership between INP, SWFSC, and the west coast billfish angler community. Mexican fishery scientists and INP strongly support the recreational billfish fishery in Mexico and are

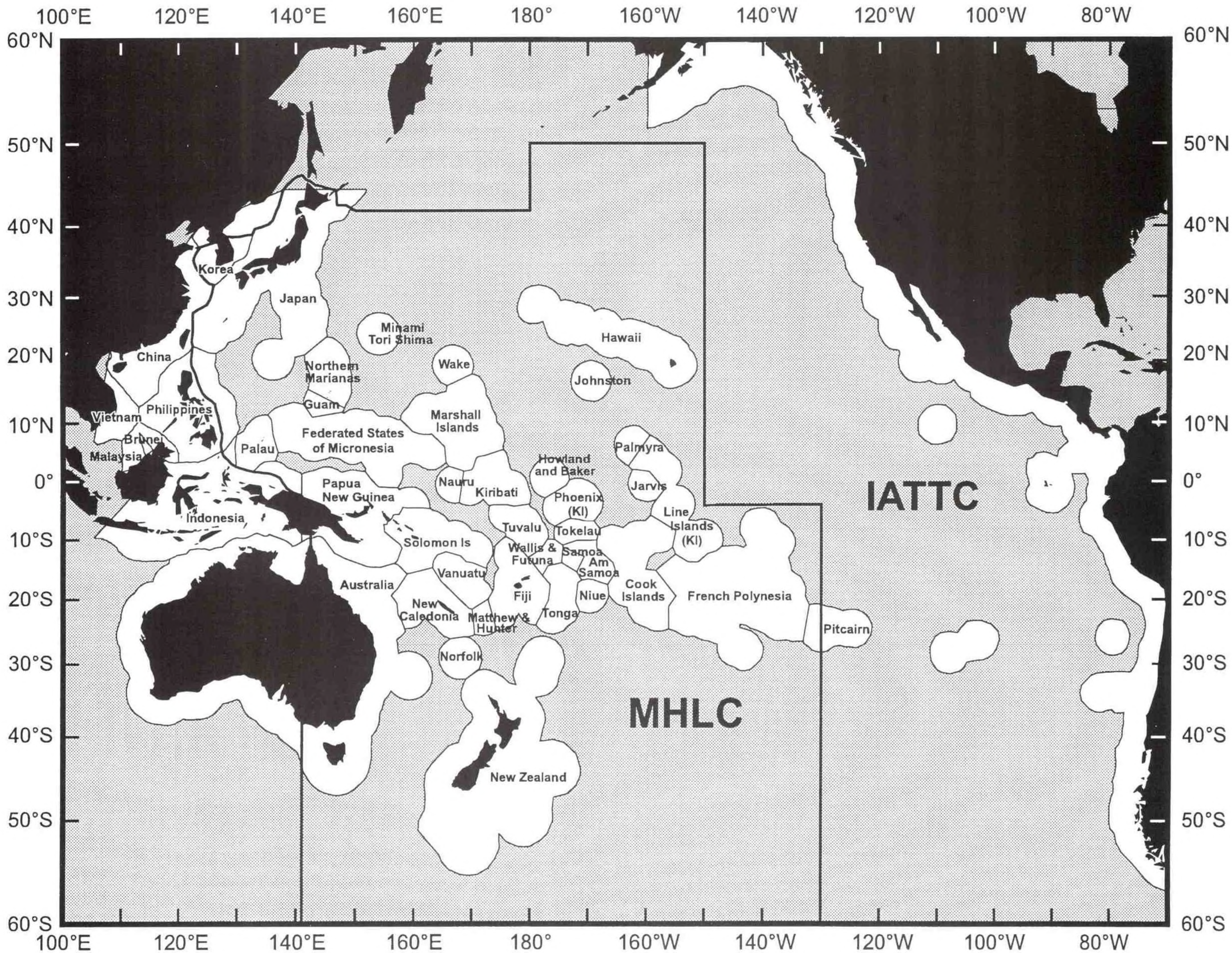

Figure 1. National and proposed international fishery management jurisdictions in the Pacific for highly migratory species (MHLC = Multilateral High-Level Conferences, IATTC = Inter-American Tropical Tuna Commission); and white areas are the Exclusive Economic Zone of each country.

deeply interested in increasing base-line information on these stocks.

A key preliminary step in the formation of such a partnership is for anglers and scientists to meet, discuss the issues and develop a plan of action. To this end, representatives from the SWFSC, the National Marine Fisheries Service (NMFS), Southwest Region (SWR), and a representative from INP met with representatives from southern California angler clubs, national angler organizations, and recreational fishing businesses on August 11, 1999, at the Balboa Angling Club in Newport Beach, California. The objective of the meeting was to develop a plan for PacFAAB (Pacific Federal Angler Affiliation for Billfish) that will provide information needed for Pacific billfish management by expanding and enhancing the collaboration between anglers, the SWFSC and the INP. This report documents the transactions of the first PacFAAB meeting and establishes a plan (Appendix A) for developing a cooperative program.

2. HISTORY OF COLLABORATION BETWEEN BILLFISH ANGLERS AND THE SWFSC

The present billfish program at the SWFSC was begun over 30 years ago in the Interior Department's Bureau of Sportfishing by Jim Squire (retired). The program consists of two primary elements: 1) support for tag and release of billfish, including providing tagging supplies, archiving records and production of a billfish newsletter, and 2) maintaining a postcard survey that now provides a 30-year-long time series of catch and effort information from the recreational fishery.

2.1 The Billfish Tagging Program:

The Billfish Tagging Program began as the Cooperative Marine Gamefish Tagging Program in 1963. Release and recapture data from tagged billfish are used to determine movement, distribution, and growth patterns of billfish. This angler-based tagging program depends on the participation and cooperation of recreational anglers, sportfishing organizations, and commercial fishers to tag and release billfish and to report recaptures of tagged fish (Holts and Prescott, 1999). The SWFSC has carried out these cooperative efforts for the tagging of all billfish at selected locations throughout the Pacific and Indian oceans. A similar program for Atlantic billfish stocks is conducted by the NMFS Southeast Fisheries Science Center in Miami, Florida.

Tagging supplies are provided for individual anglers, clubs, and other agencies for distribution to their respective membership. Those that recapture and report the recovery information from tagged fish receive the movement and time at liberty information from that fish along with a monogrammed baseball cap. Those who tag two or more billfish in a season are also recognized with their name printed in the annual Billfish Newsletter.

More than 46,100 sportfish representing 77 species have been tagged and released since the program's inception (Table 1). Billfish accounted for 89% (41,391) of all tags released resulting in 1.2% billfish recapture rate. Striped marlin accounted for 44% of all fish tagged while sailfish accounted for 17%, blue marlin 9% and black marlin 8%. Swordfish and black marlin have the highest rates of return (2.8% and 2.1%, respectively) while only 1.63% striped marlin and 0.96% blue marlin have been recaptured. None of the 692 tagged shortbill spearfish have ever been recaptured. Combined recaptures indicate that 29% of tagged billfish

Table 1. Billfish Tagging Program tag releases and recaptures 1963-1998.

SPECIES NAME	RELEASES TOTAL	RECOVERIES NUMBER	RATE %
Striped Marlin	20,059	326	1.63
Sailfish	7,559	34	0.45
Blue Marlin, Pacific	4,997	48	0.96
Billfish, Unidentified	4,273	4	0.09
Black Marlin	3,342	69	2.06
Shortfin Mako Shark	1,113	25	2.25
Roosterfish	920	29	3.15
Short-Billed Spearfish	693	0	0.00
Yellowtail	492	36	7.32
Broadbill Swordfish	494	14	2.83
Dolphinfish (Dorado)	407	3	0.74
Yellowfin Tuna	342	25	7.37
Blue Shark	313	5	1.61
Skipjack Tuna	97	2	2.06
Bat Ray	84	0	0.00
Albacore Tuna	79	0	0.00
Bigeye Tuna	76	2	2.63
Hammerhead Shark	52	2	3.85
White Sturgeon	50	1	2.00
Black Sea Bass	40	8	20.00
Leopard Shark	39	1	2.56
Bronze Whaler Shark	36	1	2.94
Wahoo	35	2	5.71
Whitetip Shark	36	0	0.00
Jack Cravelle	32	0	0.00
Blue Cravelle	30	1	3.33
Thresher Shark	62	3	4.84
Barracuda	23	2	8.70
Bluefin Tuna	19	1	5.26
Tiger Shark	17	2	11.76
Striped Bass	11	0	0.00
White Marlin	13	1	7.69
Whale Shark	5	1	20.00
All Others	287	8	2.78
TOTAL	46,127	656	1.42

are recaptured within the first month of liberty, 84% within one year, and only 2% are recaptured after 3 years.

2.2 Movements of Billfish:

Striped marlin are widely distributed in the Pacific, and move extensively. However, the tagging data indicate no regular patterns of movement. Striped marlin releases totaled 20,058 with 326 recaptures (Figure 2). The majority of tagged striped marlin were released from Hawaii, southern California, and Baja California Sur, Mexico. Recaptures indicate movement from southern California to Baja California Sur but show little or no movement in the reverse direction. Striped marlin tagged off southern California and Baja California have been recaptured after moving great distances with recaptures occurring in Hawaii, Peru, and near Pitcairn Island in the South Pacific. There is no indication of direct movement from Hawaii to the west coast.

A total of 4,993 blue marlin have been tagged with 48 recaptures resulting in a 0.96% recapture rate. Of those, 12 had missing or incorrect information and could not be used. Nearly half of the complete returns were released and recaptured within 200 nm of Hawaii, indicating considerable inter-island movement (Figures 3a and 3b). Others released off Hawaii moved west and offshore from 208 to 597 nm. A blue marlin was recaptured after traveling to the Marquesas Islands (2,357 nm), another to the South China Sea (4,450 nm), and a third to New Caledonia (3,508 nm). Blue marlin tagged off Baja California Sur, Mexico, also traveled west to Hawaii, and to the Marquesas in the South Pacific. Blue marlin are infrequent visitors to southern California and few releases and no recaptures exist. Blue marlin are often recaptured near the original tagging location after being free at approximately one-year intervals. Others are recaptured at some distance at half-yearly intervals, indicating movement away from and returning to the original tagging location (Figure 4).

A total of 494 broadbill swordfish have been tagged and released by cooperating billfish anglers and US commercial fishermen. Recaptures total 14 for a return rate of 2.8%. The SWFSC, along with cooperating southern California billfish anglers and commercial fishers, tagged 17 swordfish in 1978 in an effort to identify movement patterns in the Southern California Bight (SCB). Six of those swordfish were recaptured within 35 days and none had moved more than 30 nm. Swordfish tagged north of Hawaii on US longline vessels moved northeast toward the west coast of North America and were recaptured by other commercial fishing vessels (Figure 5). One swordfish was recovered near San Clemente Island, California; two others were recaptured by longline vessels fishing in international waters.

In summary, the recapture data indicate that blue marlin, striped marlin, and swordfish move extensively, but the data are insufficient to tell if these are merely nomadic wanderings or if the fish follow specific routes. The billfish make transpacific and equatorial crossings which expose them to foreign commercial and recreational fisheries. Fish taken by the high-seas fisheries in the North Pacific are being recaptured in the central and western South Pacific by vessels operating in coastal and international waters. Clearly, international management that recognizes recreational and commercial interests is needed for these highly migratory animals.

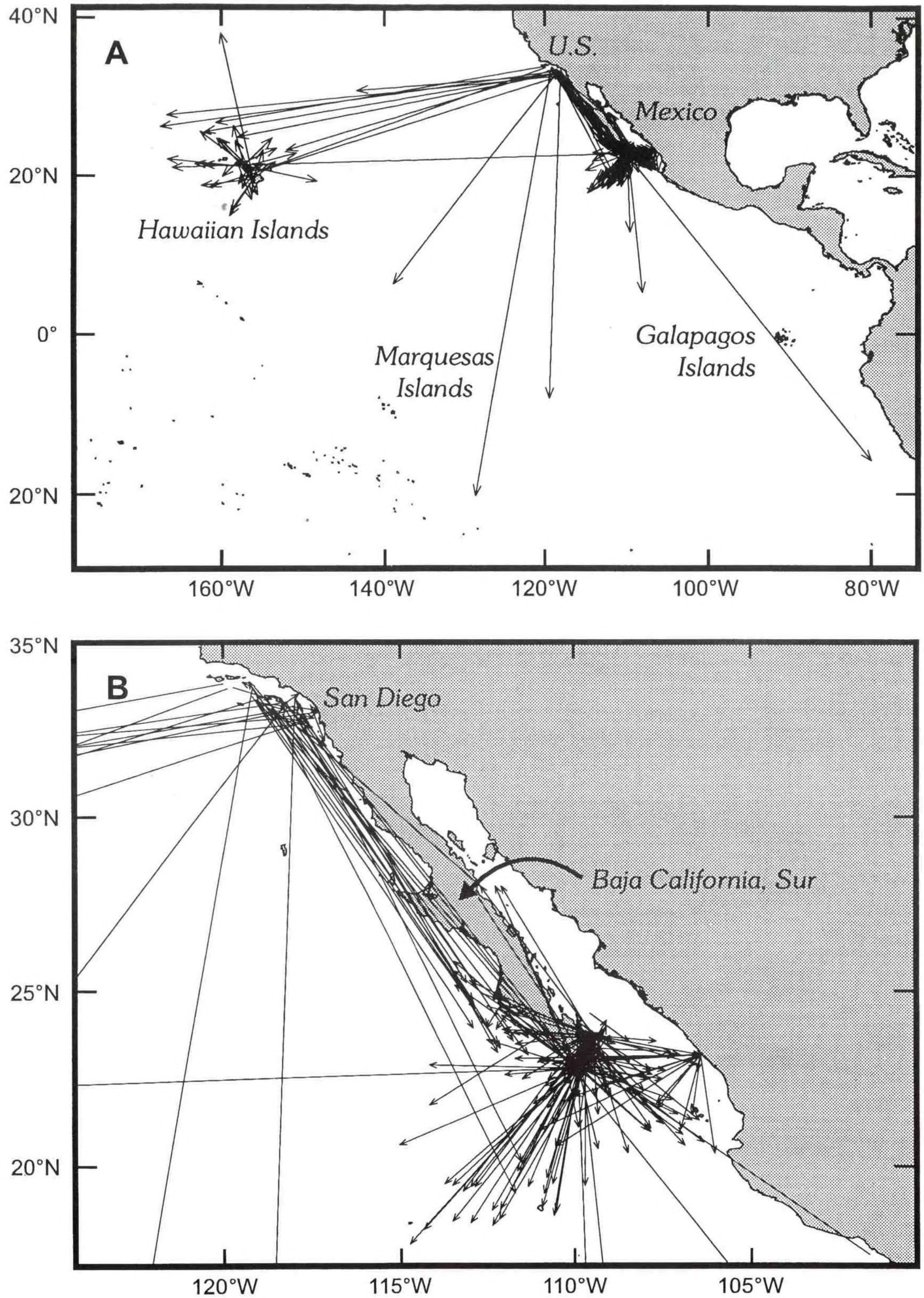

Figure 2. Striped marlin movements from tag recaptures in the north eastern Pacific (A) and detail of returns for southern California and Baja California, Mexico (B). Arrowheads indicate point of recapture and shaft point of release.

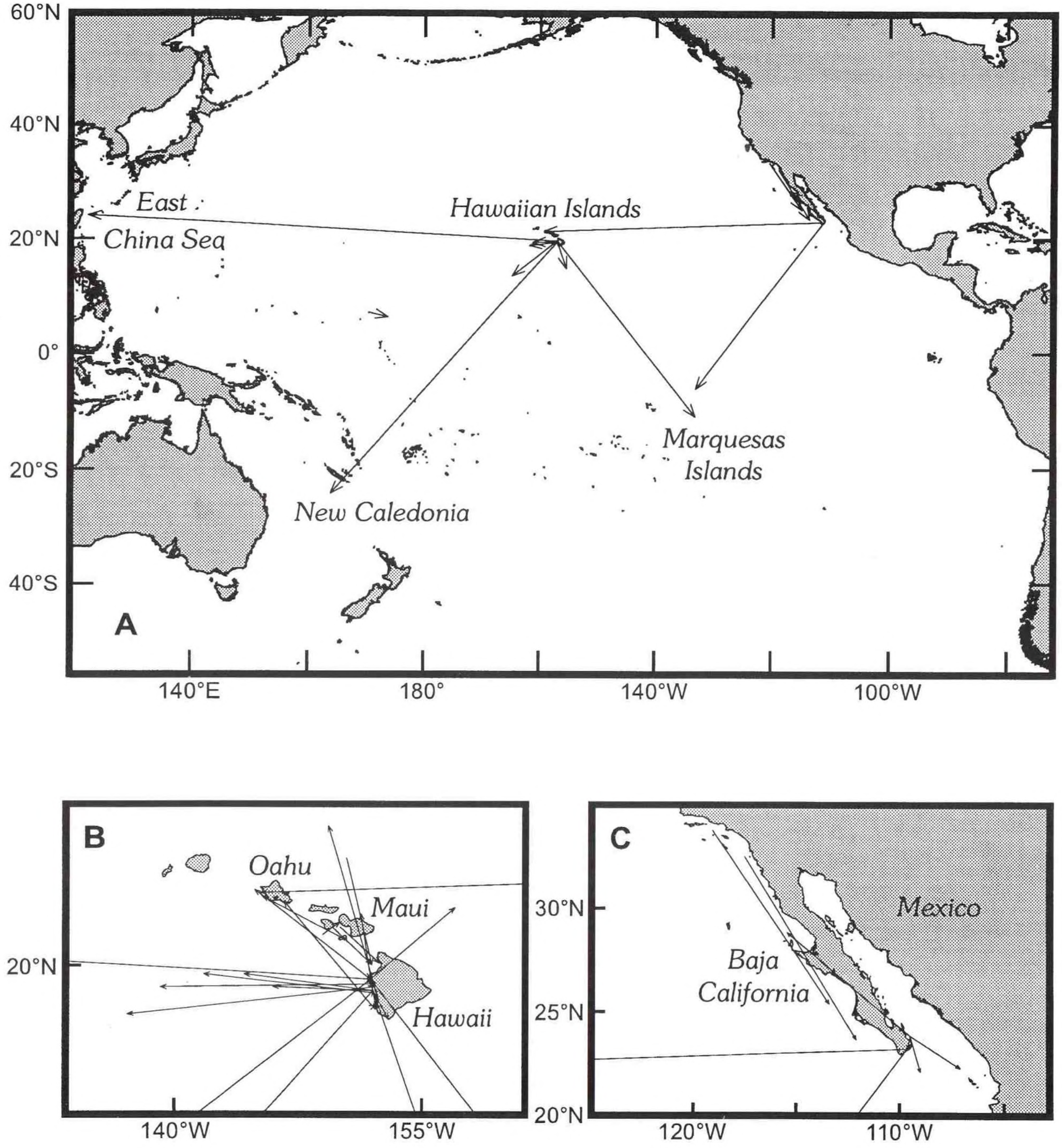

Figure 3. Blue marlin movements from tag recaptures in the North Pacific (A), in and around the Hawaiian archipelago (B), and detail of Southern California and Baja California, Mexico (C). Arrowheads indicate point of recapture and shaft point of release.

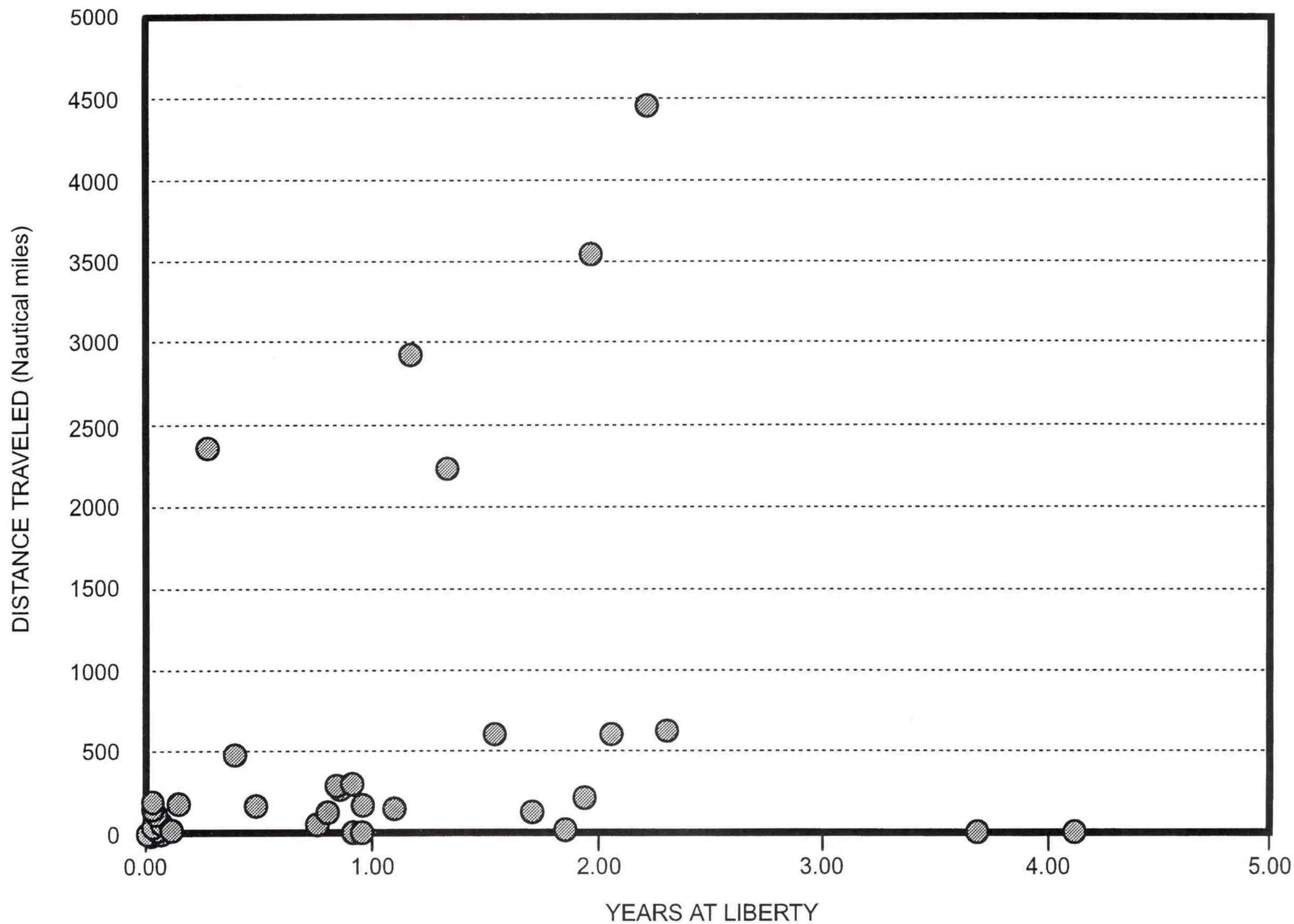

Figure 4. Blue marlin recaptured at half-yearly intervals indicate movement away from the original tagging location, while recaptures at yearly intervals show they return to about the same location.

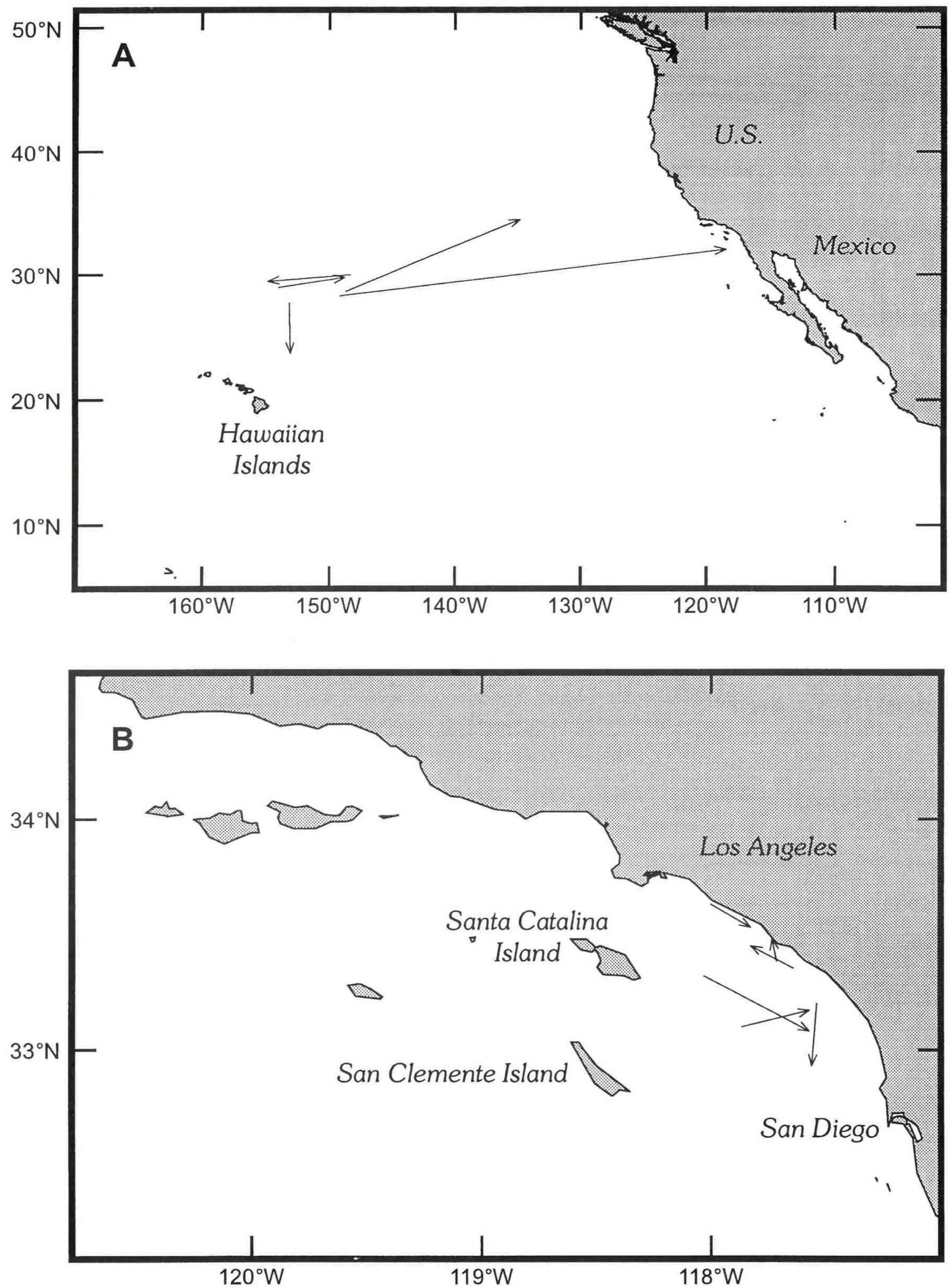

Figure 5. Broadbill swordfish movements from tag recaptures in the eastern North Pacific (A) and detail of southern California (B).

2.3 The International Billfish Angler Survey:

The International Billfish Angler Survey, began in 1969, provides a 30-year time series of area-specific angler catch and effort rates (Figure 6). Analysis of observed performance over time helps explain the effects of commercial harvests, weather patterns, and local economic changes.

Current catch rates are 0.44 to 0.42 fish caught per angler fishing day (1997 and 1998), slightly lower than the prior four-year period rate of 0.47 (1994 - 1997). The highest reported catch rate (0.57) occurred during the first years of the survey (1969 - 1971) while the lowest catch rate occurred in the mid-1970s (0.34). Striped marlin enter southern California waters in the summer months where anglers average about 0.10 striped marlin per day of fishing. That catch rate is greatly improved off Baja California Sur, Mexico (0.67) where blue marlin and sailfish are also prime targets of recreational billfish anglers.

Baja California has always been a productive area for striped marlin, blue marlin, and sailfish (Figure 7). This survey showed the effect of commercial fishing on the recreational billfish fishery occurs near the tip of Mexico's Baja peninsula during the 1980s (Squire and Au, 1990). Declining catch rates for striped marlin were attributed to joint-venture longline fisheries operating near Baja California in the 1970s. Mexico enforced its EEZ in 1976 and restricted foreign longlines from fishing in its EEZ for two years. During that time, the angler catch rate for billfish in that area increased by almost 60%. A period of limited longlining that began in 1982 again was correlated with a decline in angler catch rates. Mexico canceled all longline permits to fish billfish and tuna within its EEZ in 1990.

2.4 Special Projects:

The SWFSC has worked with billfish anglers on a number of special projects designed to improve biological information on billfish. These projects are described below.

Southern California Swordfish Tagging. The SWFSC and cooperating southern California billfish anglers conducted an experiment to tag swordfish in an effort to identify swordfish movements in the eastern Pacific. Seventeen swordfish were tagged in the summer of 1978. Eight of these fish were recaptured within 30 days of release and none had moved more than 30 nm. There were no additional recaptures from this experiment (Figure 5b).

Movement Patterns of Striped Marlin. The SWFSC began a study utilizing acoustic telemetry to identify striped marlin movement patterns in the SCB. Former San Diego Marlin Club president (1980) Richard Johnson donated his time in this endeavor. This study resulted in the first acoustic tracking of a striped marlin and was expanded in 1986 with the cooperation of the California Department of Fish and Game. In all, 11 additional striped marlin were tracked for periods of up to 48 hours (Holts and Bedford, 1990). Eight of the striped marlin were donated to the project by southern California billfish anglers[1]. Marlin moved up to 57 nm during the tracking period. Maximum swimming speed was 1.5 kt with an average of 1.2 kt for all fish

[1]Those southern California billfish anglers donating their striped marlin catch were: J. Belus, D. Denholm, G. Jasper, R. Raftican, G. Stotesbury, H. Sutton, and W. Woodard.

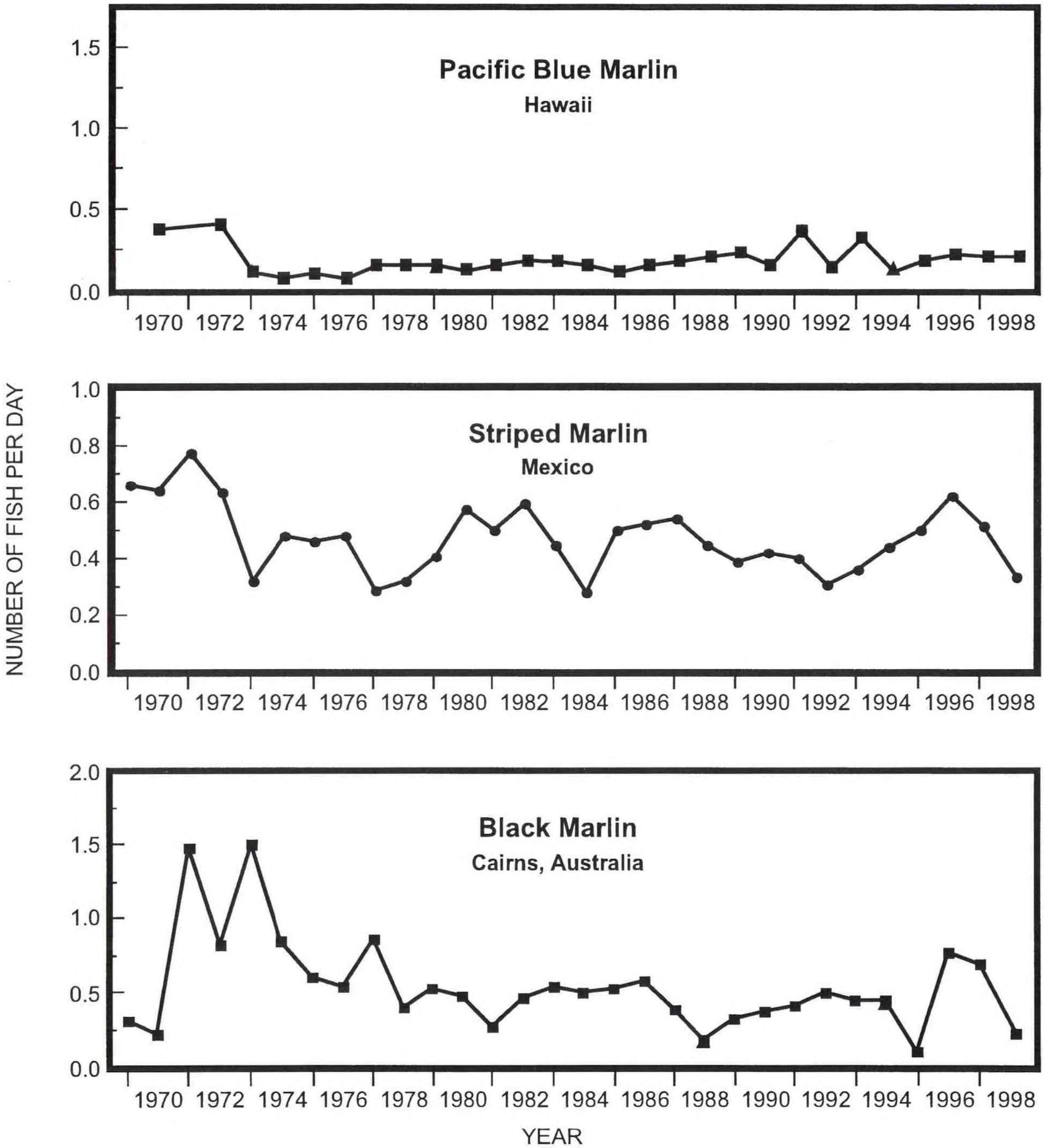

Figure 6. The SWFSC Billfish Angler Survey provides a 30-year index of catch and effort for recreational billfish fishing in the Pacific. The number of fish caught per angler day, are shown for blue marlin, striped marlin, and black marlin in principal sampling areas 1968 - 1998.

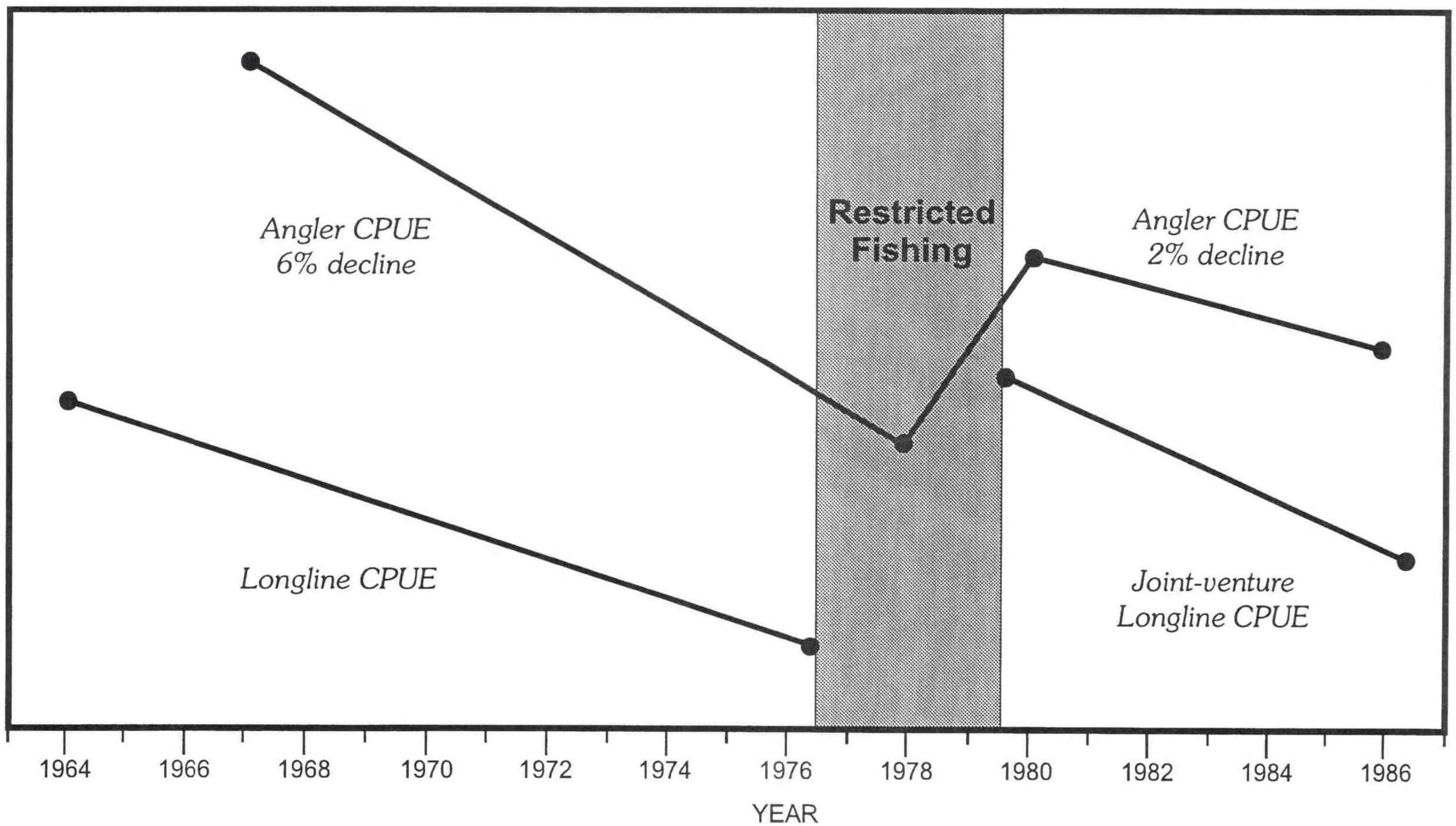

Figure 7. Catch per unit of effort for longline and angler catches for Baja California Sur declined around the tip of Baja during 1964 - 1976. Mexico began enforcing its Exclusive Economic Zone in 1976 and longline fishing effort was restricte until 1980. Angler catch rates increased during that period but declined after Mexico entered into joint-venture longline operations with Japan in 1980.

tracked (Figure 8). The greatest period of activity occurred during late afternoons, when some marlin swam rapidly down swell in a behavior known as "tailing." General level of activity slowed during the night. These behavior patterns clearly indicated that the trauma induced by capture and release can be short lived when adequate care is given to the condition of the fish.

AFTCO Tag Flag Tournament in the Pacific. This tournament, popular on the east coast, was conducted for the first time for the Pacific in 1998. The Tag Flag Tournament promotes the conservation of highly migratory species through tag and release programs and is supported by numerous sport and conservation organizations. The SWFSC supplied tagging supplies to participating anglers tagging billfish and bluefin tuna and provided AFTCO Tournament officials with the results of the 1998 billfish tag results.

3. STATUS OF RECREATIONAL BILLFISH STOCKS

Current assessments of Pacific billfishes are needed for almost every major species. The last inclusive peer-reviewed assessments were presented in 1988 at the Second International Billfish Symposium (Stroud, 1989). The recommendations for assessments and data needs from that symposium, in great measure, stand today. Most recently, the Standing Committee on Tuna and Billfish (SCTB) 12th meeting in 1999 produced a set of recommendations that were essentially the same as those from the billfish symposium (SCTB, 1999). Thus, over the last ten years, billfish assessments have progressed very little.

Billfish assessments are hampered because billfish catches (with the exception of swordfish) are usually bycatch in major industrial fisheries (i.e., longline and purse seine). Effort measures (CPUE statistics), because of the bycatch nature of these fisheries, are very difficult to apply in generating abundance indices yet they are the basis of the simplest class of assessment models. Other, more sophisticated models are unreliable at present because of lack of biological information. They require age structure of the catch as well as estimates of some of the most basic life history parameters, natural mortality, or maturity and fecundity measures. Unfortunately, estimates of these parameters for most Pacific billfishes are lacking, imprecise, or inaccurate at best (Table 2).

The following quote from the SCTB 12th meeting report on a review of problems with stock assessment of marlins summarizes the current problem:

"Landings and catch/effort were reviewed with respect to their utility for future stock assessments on marlins. It was noted that the FAO statistics, which are the only statistics that cover the whole Pacific, are probably unreliable as few countries report marlin catches and species identification is likely to be poor. Furthermore, although efforts are being made to improve marlin statistics, the historical change of coverage in the landing statistics will need to be taken into account in any stock assessment analysis. An abundance index has been derived from logbook information from the longline fishery. However, interpretation of this index is problematic as marlins are not generally targeted by longliners. In particular, horizontal coverage is limited because of limited overlap in the distribution of marlins and tunas (which are the target species). Vertical coverage is limited as commercial longlines are set in the water column starting at about 100 m depth, and this depth is near the lower end of marlin distribution."

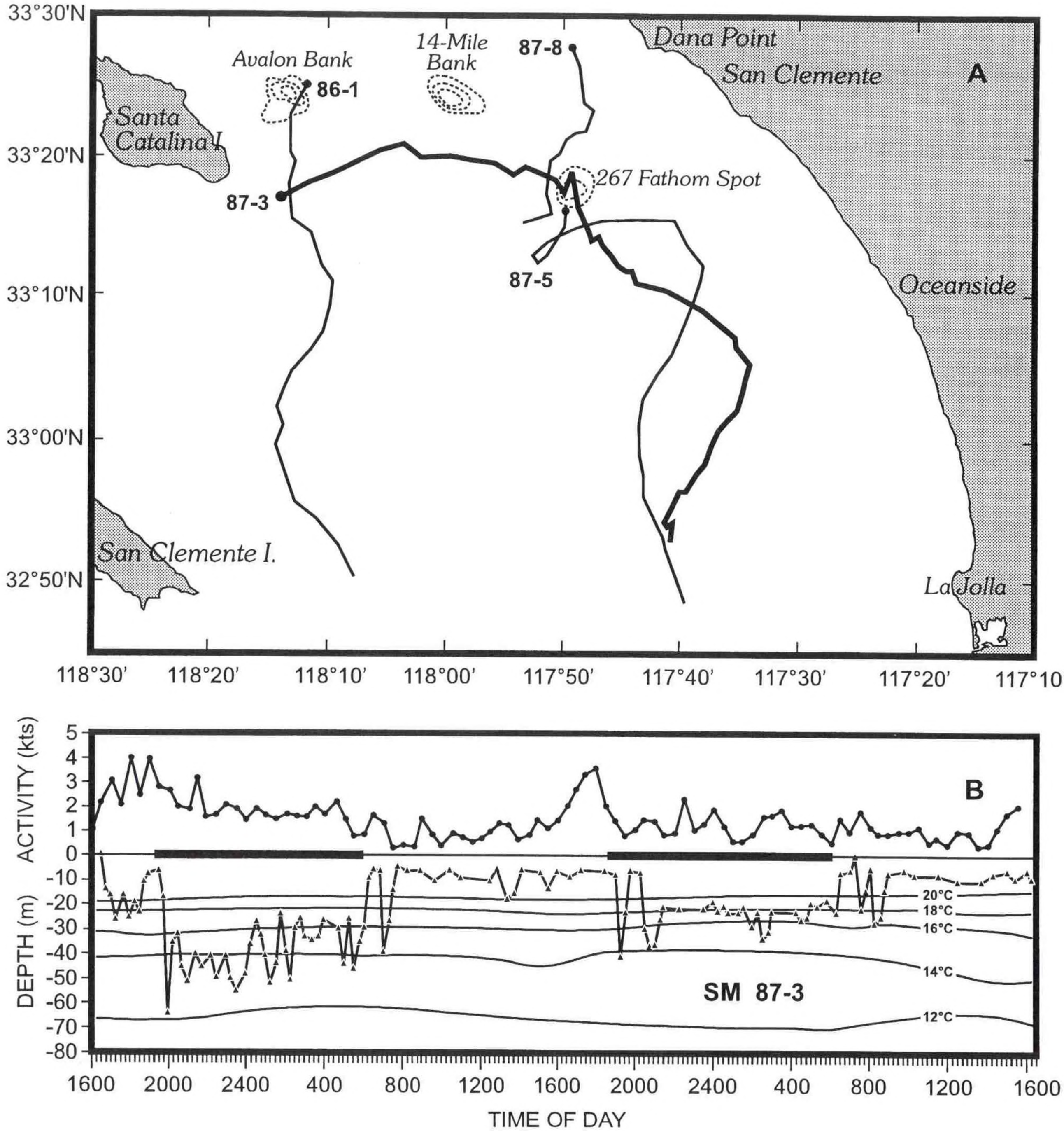

Figure 8. Activity and swimming patterns for striped marlin (No. 87-3; highlighted) tracked with acoustic telemetry over a 48-hour period. Tracks of three additional striped marlin are also shown. Swimming activity and depth shown on a 24 hour clock, night time periods indicated by a dark horizontal bar (from Holts and Bedford 1990).

Table 2. Status of life history parameters of Pacific billfish.

PACIFIC BILLFISH LIFE HISTORY

SPECIES		MAXIMUM SIZE LENGTH TL, CM	MAXIMUM SIZE WEIGHT WHOLE, KG	ANNUAL FUCUNDITY MILLION EGGS	AGE AT MATURITY YEARS	LENGTH AT MATURITY CM EFL	WEIGHT AT MATURITY	LIFE SPAN YEARS	STOCK STRUCTURE	SOURCE
Striped Marlin	Male	206	?	-	?	137	27-40	?	H1: N.Pac & S.Pac.	1,3,4
	Female	350	200	?	?	137	23-36	?	H2: Pac. Wide	
Blue Marlin	Male		170	-	2	130-140	31	30	Single Stock	1,2,4
	Female	447	906	?	4	200	80	30	Pacific Wide	
Black Marlin	Male		?	-	3-4	?	60	20	H1: SW Pac, H2: SW Pac, H3: Indian Ocean	1,2,3,4
	Female	448	707	?	4.5	?	70	20		
Sailfish	Male	340	100	-	?	?	?	15	Pacific Wide	1
	Female			?	?	160	?	?		
Swordfish	Male	309	140	-	?	150	21	?	H1: Pacific Wide	1
	Female	445	537	?	5-6	170	74	?	H2: 3 Pac. Stocks	

References:
1. Nakamura, 1985
2. Hinton, 1999
3. Suzuki, 1989
4. SCTB 1999

The stock boundaries of individual billfish species are based on limited tagging data, genetic information, known spawning areas, and distribution of catches. Often multiple hypotheses of stock boundaries exist resulting in alternate assessment scenarios. For example, striped marlin stock structure is unclear. Hypotheses include a single Pacific-wide stock, north and south stocks, and east and west stocks. Spawning was recently observed in the coastal water of central Mexico. (Gonzalez-Armas et al., 1999). Based on larval distribution and catch rates in the Japanese longline fishery, blue marlins are thought to be a single Pacific stock extending into southeast Asia. Black marlin is assumed to be a single Pacific-wide stock although distinct spawning areas exist. Clearly, a more authoritative definition of stocks is needed in order to apply any class of assessment models.

The current status of marlins was reported at the 12th meeting of the SCTB (Table 3). The relationship between catch and fishing effort (CPUE) for striped marlin, measured by the Japanese longline fishery, showed sustained catches over a wide range of fishing intensity without any clear trend, suggesting that this species was not overfished (Figure 9). For blue marlin the relationship between catch and effort indicated a range of catches between 12,000 to 24,000 metric tons annually over widely fluctuating fishing effort (Figure 10). This suggests increased fishing did not result in greater catches, a sign that the stock may be overfished. These examples highlight the difficulty in using catch and effort data to assess non-target species. Perhaps the best way to deal with this problem is to improve the effort computation using the specific habitat characteristic of marlins as shown by Hinton (1999). Unfortunately marlin habitat is not sufficiently characterized to make such an approach practical but this is an information need that could be addressed using advanced tagging methodologies.

4. THE PACIFIC RECREATIONAL BILLFISH FISHERY IN MEXICO

In 1983 the government of Mexico restricted the use of longlines in the Pacific Ocean by limiting the catch of billfish within 50 miles of the coastline exclusively to the sport fishery, a regulation which remains in force to this day. As a result, the total catch of billfish has declined. Another contributing factor to changes in catch is the great sensitivity of this species to environmental changes, such as the presence of an El Niño event, which cause the resource to move northward and render it inaccessible to the Mexican fleet. Another important factor is the fishing effort of foreign fleets outside the Mexican EEZ, which could affect the abundance of the resource in the Mexican fleet's fishing area.

The majority of management measures applied to swordfish and striped marlin in the northeastern Pacific waters of Mexico have been driven by recreational fishing groups interested in limiting the take of commercial fisheries. These measures may have improved the recreational catch, but they probably had little effect on the status of the billfish of the Pacific.

The primary sportfishing sites for billfish in Mexico are located near La Paz and Los Cabos, Baja California Sur (BCS); Mazatlán, Sinaloa, and Manzanillo, Colima. Billfish catch and effort at Mazatlán (Table 4) is mostly targeted for sailfish and to a lesser degree striped marlin. Catches of striped marlin have been steady since 1989 but in fewer numbers in prior years. In Baja California Sur (Table 5), striped marlin are the dominant billfish followed by blue marlin and sailfish. The combined mean number average marlin taken in these two areas from

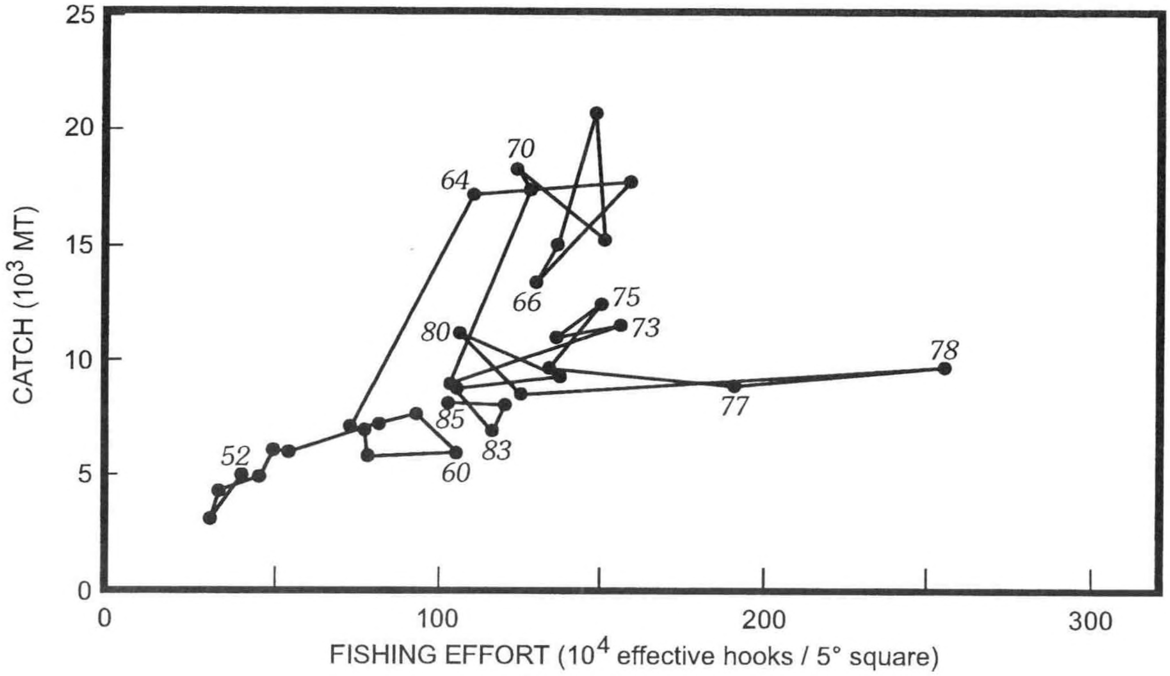

Figure 9. Catch and fishing effort relationship for the north stock of Pacific striped marlin indicating increased catch and effort through about 1970 but decreasing thereafter. Numbers denote the fishing year (from the Japanese longline fishery, Suzuki, 1989).

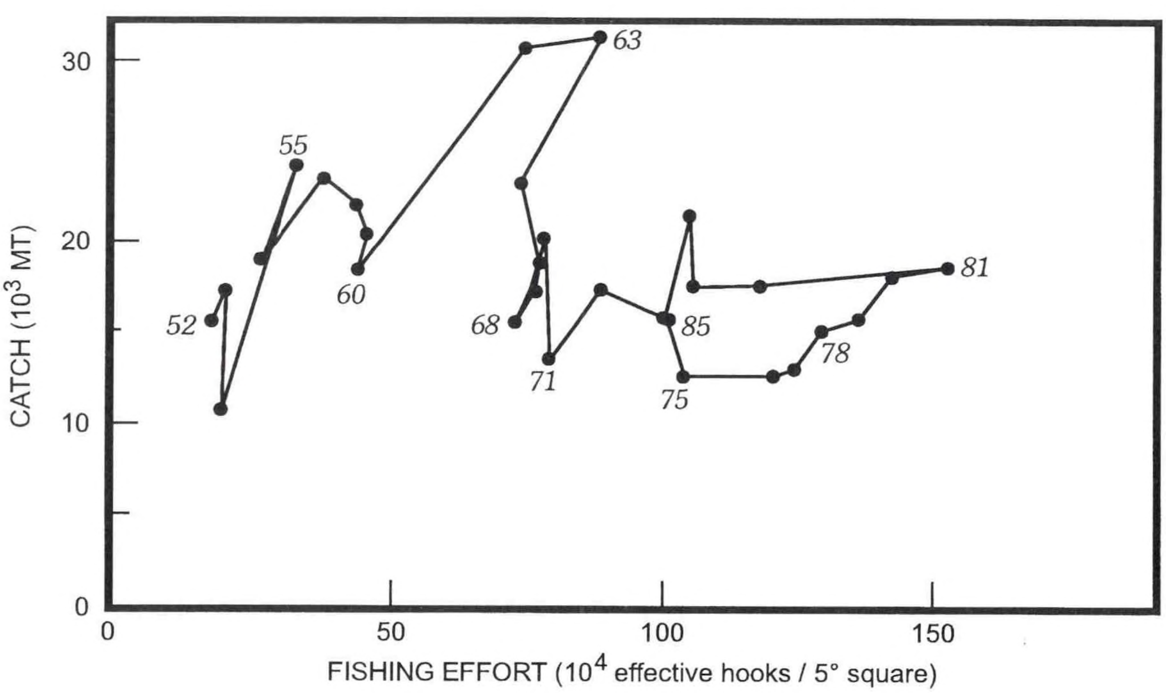

Figure 10. Catch and fishing effort relationship for the Pacific blue marlin stock indicating little or no increased catch with increased fishing effort after 1964 (from the Japanese longline fishery; Suzuki, 1989).

Table 3. Current status of Pacific-wide marlin stocks. Striped marlin are currently considered healthy as reported catches are well below maximum sustained yield (MSY). Both blue and black marlin were over fished in the 1960s and may be recovering from that condition. Uncertainty in stock structure and possible under reporting of catch numbers make estimates of MSY questionable. Data extracted from SCTB 1999.

	Usable Model	Estimated MSY	Catch Level	Stock Condition
Striped Marlin	No	24,000 mt	11,746 mt	Healthy, not over-fished
Blue Marlin	Yes	18,000 mt	16,000 mt	Over-fished Recovering?
Black Marlin	No	??	1,500 mt	Recovering?

Table 4. Catch and effort of the sport-fishing industry in Mazatlán, Sinaloa, Mexico (1986-1995).

Year	Striped Marlin	Other Billfishes	Effort (Trips)
1986	1,056	3,858	4,122
1987	2,072	3,974	9,316
1988	1,637	4,651	9,639
1989	204	5,776	6,728
1990	461	6,641	8,649
1991	432	6,236	5,715
1992	140	4,035	4,320
1993	132	2,797	4,545
1994	220	2,443	4,421
1995	360	1,995	3,216

Table 5. Catch and effort from the sport fishing industry in Los Cabos, BCS, Mexico (1990-1996).

Year	Striped Marlin	Blue Marlin	Other Billfishes	Yellowfin Tuna	Boats	Trips
1990	10,239	1,684	4,016	6,218	256	22,863
1991	14,873	1,492	4,225	13,110	288	29,619
1992	10,831	4,084	2,874	12,025	294	25,972
1993	10,651	2,355	3,282	15,069	284	23,970
1994	10,397	1,831	2,837	23,468	n.a.	24,786
1995	11,562	1,180	2,828	13,145	n.a.	22,090
1996	16,412	1,096	1,058	17,327	n.a.	23,577

1990 to 1995 is 11,763 individuals. Total estimated sport catch for BCS in 1996 was about 20,000 individuals.

The Mexican Fishery Agency (INP) began a monthly sampling program in primary sport fishing sites in the Mazatlan area in 1986, and in La Paz and Los Cabos in 1991. Tournaments are also sampled. About 1,000 vessels in the sport fishery actively participate in tournaments, but effort has not been estimated. The fishery is monitored using information obtained from a required logbook system. An observer program began in 1999. The information collected from these programs comprises data on effort (fishing trips), weight, length, species composition, and fishing areas. Catch-and-release has become common practice in recent years and only billfish of record sizes are landed.

A new data collection system is envisioned for Mexico's sport fishery, and several research projects based on the observer program began in 1999. An experimental fishing survey to estimate abundance was conducted by two commercial longline vessels from September 1997 through May 1998. A total of 471,952 hooks were deployed catching 11,743 striped marlins (77.5%), 758 sailfish and swordfish (5%), and 2,652 of other fish (17.5%). More surveys with the participation of the private sector are being planned. The primary objective is to provide the best scientific information on billfish stocks outside the 50 nm closed area.

5. GENETIC STRUCTURE OF BILLFISH POPULATIONS[2]

In recent years, genetic markers have been developed for billfishes to be used as tools to identify stocks and infer migratory patterns. Once a genetic marker is available for a species, fish from different locations are randomly sampled, surveyed for genetic variation, and compared. Statistical tests are performed to determine whether samples from different locations are genetically distinguishable, and population subdivision and migration patterns are inferred. In highly migratory billfishes, the degree of similarity among populations relates to the amount of migration and interbreeding between them.

5.1 Atlantic vs. Pacific:

Initial genetic studies focused on relationships of Atlantic and Pacific groups of billfishes. Based on conventional morphological and life history data, opinion has varied concerning whether Atlantic and Pacific blue marlin, Atlantic and Pacific sailfish, and white and striped marlin represent distinct species, different populations of one species, or a single population of one species. Genetic data support the hypothesis that each of these Atlantic-Pacific pairs actually represent species with distinct Atlantic and Pacific populations. A range of 10% to 40% of the genetic variance surveyed was attributable to differences among oceans, corresponding to an average of less than a single successful migrant per generation between oceans. Differences between striped and white marlin and between Atlantic and Pacific sailfish were more pronounced than inter-ocean divergence in blue marlin, as befits the more migratory nature of blue marlin.

5.2 Atlantic:

Hypotheses of billfish stocks in the Atlantic are varied. Based largely on disjunct larval

[2]Recent Progress in Genetic Analysis of Billfish Population Structure and Migratory Patterns, contributed by Vincent Buonaccorsi, Jan McDowell, Brett Falterman, and John Graves.

distributions and presumed separation of spawning areas, separate northern and southern stocks of blue marlin and white marlin have been proposed. Based on slight morphological differences and tagging data, separate eastern and western Atlantic stocks of sailfish have been proposed. Preliminary genetic data do not provide evidence that blue marlin, white marlin, or sailfish are composed of more than a single spawning stock within the Atlantic.

5.3 Pacific:

Within the Pacific, stock hypotheses are also varied among species. For blue marlin, researchers have suggested a single intermingling stock based on a continuous distribution of larvae and seasonally varying locations of high catch rates. Although Pacific basin stocks appear to be well mixed, genetic data show some preliminary evidence that Australian fish may be distinct from groups in the eastern Pacific. Black marlin exhibit discrete spawning locations, raising the possibility that distinct spawning stocks exist. However, ongoing efforts have not detected differences among fish sampled from eastern and western Pacific locations.

5.4 Striped Marlin:

Separate northern and southern Pacific stocks of striped marlin have been proposed based on several lines of evidence: a zone of low hook rate along the equatorial western Pacific (Figure 11), temporally and geographically separated spawning zones, a much larger maximum size in southern fish, and differences in distribution of pectoral fin length. A competing hypothesis states that the entire Pacific represents a single stock. Based on seasonal shifts in CPUE, tagging, and length frequency modes, it was concluded that striped marlin movements tend to be diffusive throughout the Pacific. Genetic data revealed a great deal of population structuring in Pacific striped marlin, implying discrete spawning areas for fish from Hawaii, Australia, and Mexico-Ecuador regions. Restricted dispersal among Pacific locations was also detected in preliminary studies of Pacific sailfish.

The precise definition and causes of population subdivision within striped marlin requires further investigation. Extant data fail to adequately address whether Ecuador and Mexico represent distinct stocks, largely due to small sample sizes. Also, striped marlin tagging data revealed that numerous individuals tagged off Mexico and southern California were recaptured off Hawaii, despite the presence of genetic differences among fish from the two locations. It may be the case that striped marlin stocks from Mexico mix with Hawaiian fish during the northern winter before returning east to spawn in summer months. Information on season of catch, age, and sex are necessary to infer how each of these factors influences the genetic and tagging patterns detected. No genetic data are available from other spawning areas of striped marlin, including Japan, the Indian Ocean, and the south-central Pacific.

The degree of population structure in billfishes depends on basin size and migratory tendency. Less population structure was detected in the Atlantic Ocean, where distances are less than half those of the Pacific Ocean basin. Relative to blue and black marlin, enhanced population structure in striped marlin and sailfish likely results from a less migratory nature, with fewer individuals straying to distant locations. With sustained effort, genetic studies will continue to reshape our understanding of billfish population structure and life history.

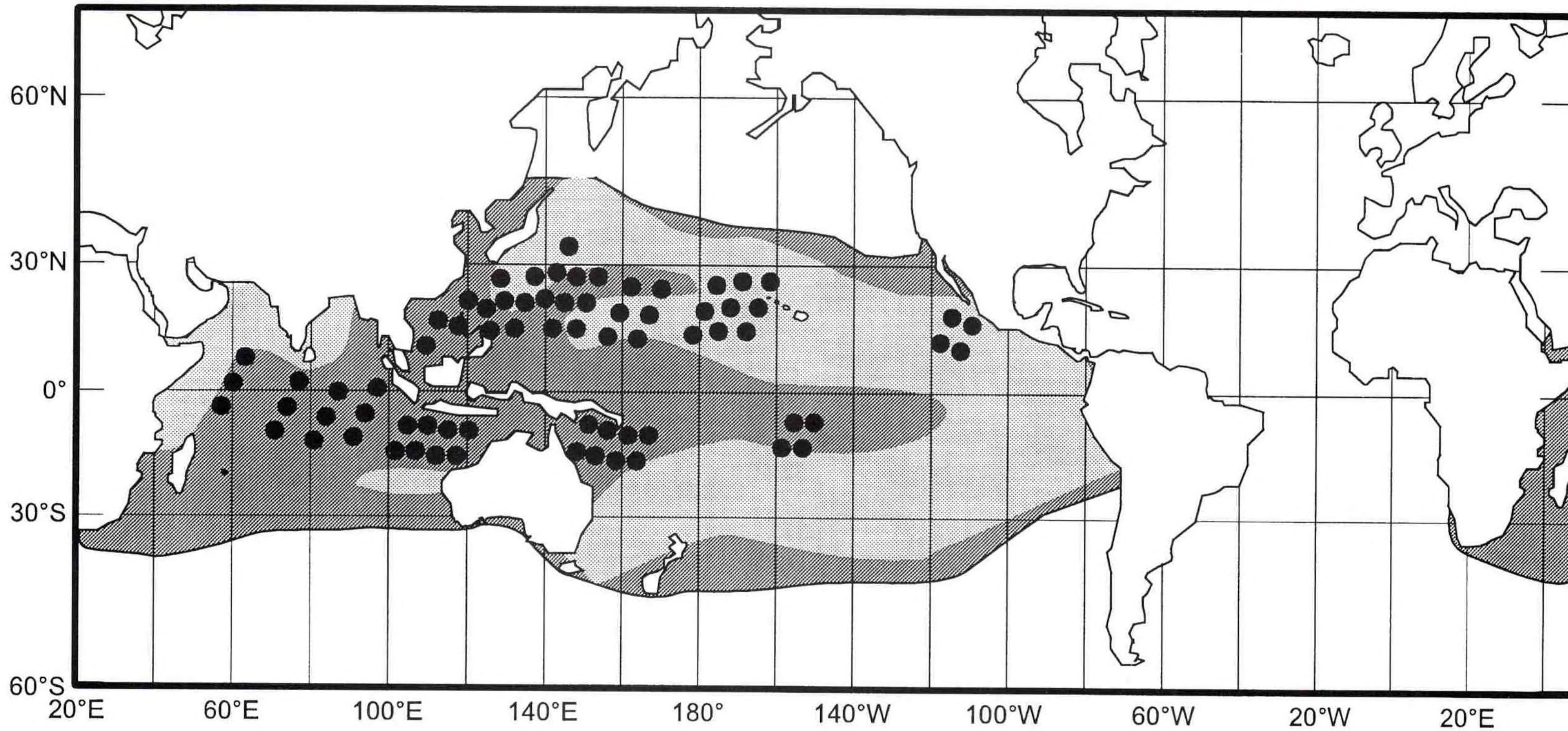

Figure 11. Striped marlin fishery and larval distribution. Dark shaded area indicates distribution (Nakamura, 1985), light shaded area indicates zones of high hook rate in the Pacific (Nakamura, 1974; Suzuki, 1989), and black circles indicate areas where larvae are sampled (Matsumoto and Kazama, 1974; Nishikawa et al., 1985; Gonzalez Armas et al., 1999; Ueyanagi and Wares, 1975).

6. POTENTIAL JOINT RESEARCH PROJECTS

6.1 Enhancement of the tag and release program:

Recreational billfish anglers have taken the lead in good conservation practices by moving to tag-and-release tournaments. This change in thinking is a great help to the resource but one consequence is that large numbers of specimens are no longer landed and available for detailed morphological and physiological examination. Fortunately modern technology such as laser measurement devices, archival tags, and molecular diagnostic assays can potentially get more and better information from the brief contact period when the fish is brought to the boat for tagging.

Presently when a fish is tagged, crude estimates of size, location, and date of capture are recorded. Information on growth rate and movement are obtained when the fish is recaptured. Ultimately we would like to know something about the stress of capture, the survival rate after release, the population structure and migration patterns, growth rate, age, nutritional condition, sex, and reproductive state of the tagged fish. All of these variables can theoretically be measured by using advanced tagging methodologies, better photographic documentation of the fish, and the collection of a small tissue biopsy taken at the time of capture. Only experience will tell us which of these methods are practical in the real world.

Archival tags. Tags that continuously record environmental and physiological data such as location, water temperature, depth, and body temperature and report the data to orbiting communication satellites are now used routinely to track whales, sea turtles, penguins, and whale sharks. For animals that breath air or bask at the surface, there is sufficient time for the tag to transmit to a satellite. The technology is more difficult for fishes. So called "pop-up" tags record data but do not transmit continuously. Rather they are released from the animal at a set time (days to months after attachment) and transmit the archived data to satellites when the tags float to the surface at the end of the deployment. Such tags are already being used in pilot studies of tunas, sharks, and billfishes. They are presently quite expensive but will continue to come down in price and size and increase in capability. Such tags will answer the important question "Do marlin survive after the stress of capture and release?" In addition they will provide valuable information on the depths of feeding, day-night activity, preferred temperature, and long-distance movements of billfish.

Advanced Imaging. Digital photography is becoming an inexpensive way to record, transmit, and quantify images by computer. Paired lasers (which project two red spots a known distance apart onto the object being photographed) allow for accurate measurements of the objects that appear in a photograph. Paired laser imaging is commonly used for underwater video surveys of fish where size needs to be recorded. Digital photographs with a paired laser sight would be a relatively inexpensive and easy way to record the length, girth, and physical appearance of the billfish at the time of capture.

Tissue Biopsy. In the realm of human medical diagnostics, there is a constant push to get more and better information from a small blood or tissue sample by exploiting the revolution in molecular biology. The same can be true for understanding the genetic history and physiological condition of billfishes. Previously the need for large tissue samples that were kept on ice and transported immediately to the laboratory limited the practicality of physiological and genetic studies except when whole fish were landed. However, with DNA-based methods we can derive vast amounts of information from very small bits of fin, skin, or muscle taken during the tagging procedure. These samples can be kept for months in suitable preservative, and sent through the mail for later analysis. Population genetics are discussed in Section 5. Below is a brief summary of the approaches that might be used to derive condition information from a tissue biopsy or blood sample. Some are practical now and some would require additional development and testing.

Sex. Salmon, sturgeon, and other fishes in aquaculture facilities are routinely sexed by genetic markers found on the sex-determining chromosome. These techniques could immediately be applied to billfish.

Age. Chronological age has never been measured with absolute precision by biochemical means. However, relative age can be approximated by the accumulation of age pigments (lipofuscin), or by the loss of telomeres in cells that are programmed to undergo a finite number of cell divisions in their lifetime.

Growth. Growth state can be determined by measuring the proportion of cells that are undergoing cell division at the time of sampling. In the past this was done by careful examination of tissue slides in which the number of cells undergoing mitosis were counted. Today it is possible to measure the activity of proteins such as cyclins that are only expressed during the brief period in a cell's life when it is actively dividing. The amounts of some cyclins or cyclin-dependent kinases have been shown to correlate quite well with growth rate in larval fishes. Their application to a billfish biopsy measure of growth remains to be investigated.

Reproductive Condition. Different hormones and hormone receptors are expressed during the reproductive cycle. In addition, proteins such as vitelogenin (which forms the bulk of the egg yolk protein) are transported to the ovary via the blood stream. Assays for these components already exist for many fishes. It remains to be examined how we can modify them for use with alcohol preserved tissues or blood samples from billfishes.

Stress Responses. Stress can apply to immediate factors such as the exertion of capture as well as longer term responses such as encountering pollutants in the water or diet. A vast amount of information is known on how fishes respond to various environmental stresses. During the stress of capture, oxygen supplies become depleted, lactate accumulates, and hormones (e.g., adrenaline and corticosteriods) are released into the blood. None of this requires the activation of genes or the synthesis of specific proteins and so is best measured by the presence of the levels of the actual compounds in the blood. Exposure to environmental stresses such as El Niño warming conditions, organic pollutants, increased UV radiation, or disease does elicit the expression of specific genes for defense and repair pathways. These can often be detected even in small samples. The incorporation of various metals, both natural and anthropogenic, as well as organic compounds such as pesticides has been used to describe the body of water that defines a fishes home range. This has traditionally been done for estuarine fishes but could be applied to billfishes.

In summary, technological advances in photography, communications, and biotechnology have opened up a range of new approaches to long-standing problems in understanding the biology of highly migratory fishes. We can expect further technological advances in the future. It is time to begin the practical work of determining which methods are most useful in the context of recreational tag and release fishing for billfishes.

7. INCENTIVES FOR SUSTAINED COOPERATION

For an expanded cooperative program to succeed strong incentives must exist for government and anglers. Acquisition of new information on the stocks is a strong incentive for federal scientists as management is difficult on information poor stocks. Anglers also recognize the value of increased knowledge for stock assessments, and wish to contribute, but are concerned that data from a joint program will not be analyzed or available. Thus, the key incentive for anglers is access to the data and conclusions drawn from it. A secondary incentive for anglers is recognition of their contributions such as posting names of those who tagged and released fish. Thus, our workshop discussions indicated that a cooperative program that focuses on these issues will be more successful than one using more traditional incentives (prizes, cash awards, badges, etc.). Therefore, the key ingredients in a cooperative federal-angler research plan are a process that assures the effective use and communication of the information collected by angler volunteers and identification of their contributions.

8. RECOMMENDATIONS AND ACTION ITEMS

Participants in the PacFAAB workshop agreed to work together to develop a full scientific cooperative research program. Such a program would include all Pacific billfishes including swordfish, striped marlin, blue marlin, and sailfish. Recommendations for an enhanced cooperative program that could be implemented in the longer term or immediately (action items) were identified. Longer term recommendations included joint venture pop-up satellite tag deployment for tracing of moments of billfish; development of a laser digital camera apparatus for shipboard measurements of tagged and released fish; development of a biopsy tagging harpoon for billfish; improved environmental monitoring from fishing boats; posting on web composite satellite images of sea surface temperature with recreational fishing data for the season; development of exhaustion physiology studies; use of pop-up archival tags; integrating all Pacific tagging information; and, importantly, maintaining close working relationship with Mexico.

All workshop participants agreed that the best way to meet the information needs of the future begins with expanding the existing level of cooperation to the extent present resources permit, recognizing that the SWFSC lacks the resources for the full program envisioned in this report. Seven action items were identified that could expand the existing level of cooperation using existing resources and serve as measures of good faith. This would catalyze the development of a more complete future program.

1) *Volunteer bridge log:* Club members agreed to implement a volunteer bridge log for recreational billfish fishing. The objective of such a log would be to establish a time series of catch per unit of effort index for southern California recreational billfish fishing which would be used as a tool to detect trends in abundance in billfish in southern California waters. The SWFSC agreed to develop a draft version of the log for club members to review prior to implementing for the 2000 fishing season.

2) *PacFAAB Web site:* SWFSC agreed to establish a Web site where information collected by joint efforts of anglers and SWFSC scientific staff will be available to all interested groups.

3) *Record nominal lengths of released fish:* Club members agreed to adopt a nominal length classification system for estimating the length of released fish. SWFSC shall recommend the length classes to be used.

4) *Rescue historic time series information from angler club records:* One of the most valuable kinds of information needed for fishery management are time series of abundance. Club members agreed to assist the SWFSC in obtaining copies of these records, the SWFSC agreed to summarize the data and post it on PacFAAB Web site.

5) *Upgrade tournament data recording:* Club members agreed to work with SWFSC in upgrading the "fishery quality" of the records taking during billfish tournaments. In particular, making sure that some measure of total fishing effort is recorded for each tournament so that catch per unit of effort (CPUE) can be estimated for both the numbers of sighted, hooked, caught, and released fish. SWFSC agreed to post results on the Web site.

6) *Implement tissue sampling for genetics and physiological studies:* SWFSC shall provide sampling kits with instructions to club members present at the meeting who will distribute them among members. At this time, this is a tissue archiving activity as SWFSC lacks resources to process the materials. Building a tissue bank is an essential preliminary step for future analysis.

7) *Develop a draft plan for a cooperative angler-SWFSC program on Pacific billfish:* A draft plan is contained in this report (Appendix A).

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APPENDIX A: PACIFIC FEDERAL ANGLER AFFILIATION FOR BILLFISH (PacFAAB) PLAN

DRAFT

1. GOAL

Improve stock assessments of Pacific billfish by increasing baseline data on movements, growth, reproduction, and tagging mortality through a research collaboration between Pacific recreational billfish anglers, Mexican fishery scientists, and the Southwest Fisheries Science Center (SWFSC).

2. BACKGROUND

Pacific billfish will soon be managed under a west coast fishery management plan (FMP) and under an international treaty. On the west coast of the US, a FMP is being developed by the Pacific Fishery Management Council for highly migratory species (tunas, billfish, and sharks). Starting in 2000, stocks will also be managed over a vast area of the Pacific (excluding exclusive economic zones) under an international convention. While these changes in policy make possible effective management of Pacific billfishes, the lack of baseline data on these stocks makes management both difficult and risky. In short, not enough data exist for adequate stock assessments on most species.

The SWFSC for the last 35 years has carried out an angler-based tagging program on marlins, sailfish, and swordfish; and conducted an annual mail census of fishing effort in the Pacific. Interest in angler-based programs has intensified greatly in recent years, with reported angler fishing days for Pacific billfish increasing from about 6,000 days in 1996 to 11,500 days in 1997, and tagging has expanded throughout the Pacific. With the increasing interest in tag and release programs and increasing information needs for the 2000's, now is the time to strengthen and broaden the SWFSC cooperative billfish program.

Baseline data on age structure, growth, genetic structure, reproduction, habitat characteristics and indices of abundance are needed for improved stock assessments. The tagging data program needs to be strengthened by determining post-release mortality and the effects of hooking injury, tackle weight, and other tagging trauma. All of these data would feed into an assessment of the status of billfish stocks in the Pacific. A thorough assessment of the Pacific Istiophorid stock(s) has not been done since the study of Skillman 1989.

This plan is based on the ideas and concepts developed during a workshop convened by the SWFSC and held at the Balboa Angling Club of Southern California, Newport Beach California, August 11, 1999. This first PacFAAB meeting, hosted by the Balboa Angling Club and United Anglers of Southern California, was attended by SWFSC and Southwest Region staff, representatives from 9 southern California angling clubs, various non government organizations and angling related businesses.

3. SCIENCE APPROACH AND INCENTIVES

A salient feature of this plan is that it depends upon a partnership between 2,500 anglers who regularly participate in the current SWFSC Pacific billfish program, their regional and international fishing organizations, the US government (SWFSC), and the Mexican federal fisheries agency Instituto Nacional de la Pesca (INP). The sustained cooperation of anglers and their organizations is vital to the success of this plan because they shall provide the research platforms for collecting data, tagging the fish, logging the observations, and obtaining the biological samples. The scientific approach builds upon the successful billfish tag and release approach thereby supporting the strong conservation ethic inherent in recreational billfish tagging programs. The INP is an important partner because the billfish populations are shared with Mexico and INP is strongly interested in cooperation in billfish stock assessment.

In this plan, anglers shall tag and release billfish and participate in billfish tournaments as before, but in a way that will greatly increase the kinds and quality of scientific information derived from their fishing trips. Guided by SWFSC and Mexican fishery scientists, billfish anglers shall add to and improve the kinds of information obtained from tagged and released fish by measuring fish size and by taking tissue biopsies that provide measures of stress, age, growth, reproductive states, sex, and genetic structure. In addition, tournaments and other fishing records shall be improved to include measures of fishing effort as well as catch, and thereby provide indices of abundance. Special billfish tournaments having fishery objectives as well as fishing objectives shall also be considered.

3.1 Enhancement of the tag and release program

The measurements itemized below are to be implemented by PacFAAB as an enhancement of the tag and release program. These measurements contribute directly to the understanding of vital billfish population rates and also contribute to better management by enhancing our knowledge of billfish movements. The present tag and release program illustrates the extensive movements of billfish throughout the Pacific, and hints that some patterns may be repeated annually. However, further advances require the delivery of more information per tagged animal. This information includes the biological traits of the tagged animal (sex, size, age, reproductive state), the likelihood that the tagged animal will survive (stress level, fishing method, etc.) and the immediate and long-term movement patterns of the animal (archival tags).

Fish size. Movements of fishes often vary with life stage, hence fish size is an essential ingredient for interpreting movements and a critical missing element of the present tag and release program. Two approaches will be used, a three length class classification system implemented using a marked line and a precise method based on a digital camera equipped with laser markers. The latter is the preferred approach once the equipment is developed and calibrated (points on the body from which such measurements could easily be recorded on film would be calibrated against standard measurements of body length and weight).

Sex. Fish sex is essential for interpreting movements and assessing reproductive effort of tagged and released fish. Sex can be determined by applying molecular methods to a tissue biopsy. A tag application device that also provides a tissue biopsy shall be used.

Age. Age determination in billfish is fraught with analytical problems, and obtaining suitable spines for analysis in a tag and release program may be a formidable barrier. On the other hand, use of age-based assessment models would be a major advance in billfish stock assessment. Thus, age determination shall be included initially as a pilot study to determine the extent such measurements might be practical in PacFAAB.

Stress level. The effectiveness of an angler-based tag and release program depends upon the condition of the animals at the time of release and the likelihood that they will survive. That only about 1% of tagged fish are recaptured indicates that some problems may exist. Two approaches are needed: 1) an analysis of the ways that different fishing processes, such as heavy vs. light tackle, affect the condition or stress level of the animal, and 2) an independent assessment of the survival rate using pop-up satellite tags. Stress level and metabolic state can be assessed using chemical analysis of tissue biopsies.

Reproductive activity. When and where billfish reproduce is poorly understood yet essential management information. For example, age and size at first maturity drives all estimates of stock productivity. While obtaining freshly preserved gonads of animals with active ovaries is extremely valuable, some important information can also be obtained from a tissue biopsy. The level of the precursor to yolk in the blood clearly identifies the fish as reproductively active as well as hormones.

Growth potential. Rates of somatic growth is essential baseline information for any stock assessment, yet it is poorly known in billfish. While analysis of skeletal hard parts of fishes (spines, otoliths) shall be studied in this project, age determination is difficult and uncertain and in need of supplementation by other information sources. It is practical to use enzyme-based bioassays from a tissue biopsy to estimate recent rates of somatic growth. Such information would be extremely useful as a supplement to skeletal based rates or as a way of validating them, thereby increasing their accuracy.

3.2 Advanced Tagging Methodologies

Application of pop-up satellite tags is becoming widespread throughout the world for highly migratory species because the approach guarantees a recovery and in the archival version records movements and environmental information. The potential value of such information for fishery management is without question. Barriers to full implementation by PacFAAB are the risk of tag loss due to inexperience of anglers, the need for development of movement models to interpret the data in a way that would be useful for management of billfish stocks, and the unit cost of the tags (from $2,900 to $4,900 US dollars in 1999). While the first two barriers can be overcome by training and acquiring scientific personnel, the unit cost of the tag is a constraint for an angler-based program such as PacFAAB. A solution posed by participants in the first PacFAAB workshop was to consider adding satellite pop-up tagging to billfish tournaments. All participating boats would be equipped with tags, fishermen trained in their application, and PacFAAB would be reimbursed by tournament fees for the expected number of tags used in the tournament. PacFAAB would post the tracks of the fish on the PacFAAB Web site, and identify successful fisherman and participants.

3.3 Indices of abundance

Perhaps the most valuable measurements for a stock assessment, other than the fishery landings, are abundance index time series. Since each index suffers from its own biases and imprecision, the more of these one has for an assessment the better. Even the crudest abundance index tracked for enough years is valuable. Billfish tournaments and other billfish fishing provide an opportunity to begin such time series if fishing effort data are recorded along with the catch. As club records from southern California may extend back in time for decades, it is important that such records be rescued and entered into a fishery data base and a crude index of abundance developed. In some regions, mandatory or voluntary bridge logs are maintained by recreational fishermen, but none are used in southern California or Mexico. Thus, an important first step for PacFAAB shall be to enter all data from clubs with longtime series to develop indices of abundance, to begin a voluntary log book program, and to improve tournament data recording so that future records will include a precise measure of catch and effort.

3.4 Direct Biological Measurements from Whole Specimens

Because we strongly support the conservation merit of tag and release recreational fishing, the principal focus of PacFAAB is on non-destructive sources of information from tagged and released billfishes. On the other hand, certain critical measurements exist which can only be obtained by destructive means. These include: collecting a variety of skeletal parts for age determination, assessment of the annual reproductive output of the stock through detailed histological analysis of gonads and fecundity determinations, calibrating shipboard indices of total length, and validating the non-destructive (biopsy) measures of physiological state and age. Therefore, the PacFAAB program shall require the collection of such material and measurements from some fishing tournaments. Cooperation with anglers to provide access to specimens would be needed but data collection would be more conventional as SWFSC staff would be used. A key role could be played by the clubs in the initiation of tournaments with the objectives of obtaining whole specimens for certain kinds of measurements for which a shortage exists. This is now the case for assessment of reproductive rates where freshly preserved active gonads are needed.

3.5 Data Synthesis and Support for Stock Assessment

A critical step in delivering this information to stock assessment specialists and mangers is that it must be analyzed and summarized into a form that would be useful for stock assessment models. These synthetic activities are a vital function of PacFAAB. Synthetic analyses to be included in PacFAAB include: develop a new synthesis of billfish tagging and genetics data to establish movement patterns and identify stock units; develop abundance indices from bridge logbook and tournament data; develop indices of abundance from historic club records; develop an algorithm for converting from a shipboard measurement of a portion of a fish to a whole body measurement and estimate statistical precision; incorporate mitotic growth data with skeletal part increments to improve precision of age determination; and others.

4. COMMUNICATION AND ANGLER INCENTIVES

The key to the success of the angler-based data collection system of PacFAAB is communication. The primary incentive for anglers to continue their support is the understanding that the results will be made available to them and used effectively in the management of billfish stocks. The annual Pacific billfish tagging newsletter, which gives tag and release information for the year, has supported the communication objectives of the existing program for many years. However, a new level of communication is needed if PacFAAB is to develop into the extensive information gathering cooperative described in this plan. To insure that all collected information is available to anglers, we propose to post such information on a Web site specifically designed for PacFAAB. This will include abundance indices based on input from anglers, records of tag recoveries, PacFAAB research updates, the year's tag and release data, and other features. As a contribution to the development of PacFAAB, and in response to suggestions of anglers at the first PacFAAB meeting, a PacFAAB Web site is currently being developed. If PacFAAB fails to become an extensive data gathering organization, it will not be practical for SWFSC to maintain the site.

If PacFAAB were developed, a steering committee would be formed with representatives from the SWFSC, southern California recreational billfishing anglers and supporting industry, and INP, Mexico. The committee would meet regularly, steer the development of the program, and guide information collecting activities.

5. PARTNERSHIP WITH MEXICO

A partnership with Mexican colleagues is essential to PacFAAB as eastern Pacific billfish stocks are transboundary and taken in the recreational and commercial fisheries of both Mexico and the US. PacFAAB would coordinate with the INP through the MEXUS-Pacifico forum to identify research associates to participate in joint research activities. Several research areas important to PacFAAB include but are not limited to the following:

a. rescue of historical billfish catch data from sportfishing fleets, fishing resorts, and tournaments conducted in Baja California Sur, Mexico,
b. examine literature in local universities for unpublished life history studies of billfish,
c. define the economic influence of sportfishing for billfish versus recreational fishing for non-billfish species, and
d. monitor commercial fisheries that target billfish.

6. BUDGETARY CONSIDERATIONS

Southern California anglers and the SWFSC, as a measure of their good faith in the future of PacFAAB, are implementing some of the most basic and lower cost elements described in this plan (as of September 1999). These include: implementation of a bridge log system by anglers; rescue by club and SWFSC representatives of club angling records, and the entry of this information by SWFSC in a data base; collection of tissue samples by anglers for archiving by SWFSC; and development by the SWFSC of a Web site where the data obtained from these cooperative activities will be displayed.

The SWFSC does not have the funds to advance the billfish work to the new level as advocated by this plan, and some doubt exists that even the present level (annual billfishing newsletter, management of the tag and release data base, the postcard billfish angler survey, and distribution of tagging kits) can be continued indefinitely because of competing requirements for baseline data and stock assessments for many other pelagic and groundfishes. In short, additional financial support is required for PacFAAB to become a reality. Funds are needed for chemical and genetics analysis to work with anglers in developing the special equipment needed for measurements on tag and released animals, to coordinate sampling in Mexico and the US and, importantly, to analyze and transform the data so that it will find immediate use in billfish stock assessment and management.

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