ECONOMIC AND MANAGEMENT IMPLICATIONS OF NO-TAKE RESERVES: AN APPLICATION TO *SEBASTES* ROCKFISH IN CALIFORNIA

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ABSTRACT

This paper presents some of the economic and management issues likely to arise if a no-take reserve is designed to protect and manage rockfish in California. These issues include equity matters associated with location of the reserve, implications for major sectors of the rockfish fishery, and possible external effects on fish stocks and fisheries outside the reserve area. These issues are described in the context of the current management regime and recent trends in the fishery. Particular attention is paid to two fishery sectors—groundfish trawlers and commercial passenger fishing vessels—whose logbook data provide detailed information about the area of harvest. Recommendations are made regarding the need to define objectives, address allocative issues and external effects, accommodate scientific uncertainties, and consider reserves in combination with more conventional management techniques.

INTRODUCTION

Permanent no-take marine reserves are being considered as a means of achieving a variety of resource management objectives, such as providing a hedge against collapse of fish stocks, or providing reference areas to facilitate the evaluation of natural versus human effects on fish populations (Bohnsack and Ault 1996). Economic benefits to fisheries outside a reserve may also arise: for instance, the stock enhancement that occurs within the reserve may eventually filter (via larval transport or export of adult fish) to outside areas (Rowley 1994). The extent to which such benefits are actually realized will vary, depending on the specifics of the particular reserve being considered.

This paper presents economic and management implications of reserves in the context of a specific hypothetical scenario—the establishment of a permanent no-take reserve to protect and manage rockfish (genus *Sebastes*) in California. Rockfish provide a plausible example for several reasons. As relatively sedentary stocks, they are considered amenable to enhancement by a reserve. Rockfish also have certain life-history characteristics (e.g., infrequent and variable recruitments) that lend considerable uncertainty to the stock assessments upon which management decisions are based (Ralston 1998). The current interest in rockfish reserves reflects an attempt to overcome the shortcomings of recent management in dealing with such uncertainty.

This paper provides information relevant to some of the fishery-related issues that are likely be raised with regard to rockfish reserves. This information is intended to be exploratory rather than conclusive and to encourage further discussion of real-world issues that must be addressed if reserves are to be considered as a rockfish management tool. Full development and evaluation of management options will require much more detailed iterations of the analysis provided here,[2] as well as extensive input from natural as well as social scientists, resource managers, enforcement and legal experts, the fishing industry, and the public at large.

ROCKFISH FISHERY MANAGEMENT

In 1982 the Pacific Fishery Management Council (PFMC) implemented a Fishery Management Plan (FMP) for the groundfish fishery in the Exclusive Economic Zone of California, Oregon, and Washington (PFMC 1982). The FMP covers a variety of finfishes, including 52 *Sebastes* stocks.

In 1994 the PFMC implemented a limited entry program (PFMC 1992) for the commercial fishery, and issued permits to vessels that met designated minimum groundfish landings requirements (MLRs) for trawl, longline, or fishpot gear. At the time of issuance, each permit was "endorsed" with the specific gear types for which the MLRs were met, with limited entry participation restricted to the gear types endorsed on the permit. Each permit, along with its particular gear endorsement(s), may be transferred to another vessel of similar or lesser length, and larger vessels may enter the fishery by consolidating permits held by smaller vessels. Other restrictions imposed on the limited entry fishery include quotas, limits on fish size, gear restrictions, and vessel landings limits.

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[2]A non–rockfish-specific but more comprehensive discussion of economic costs and benefits associated with reserves is provided in Thomson 1998.

The PFMC also manages an open access fishery, which is restricted to vessels that target non–PFMC-managed species (e.g., California halibut, sea cucumber) with trawl gear; vessels that land groundfish incidentally while participating in non-groundfish fisheries (e.g., shrimp trawlers); and vessels that use hook and line or fishpot gear without a limited entry permit to harvest small amounts of groundfish.

The PFMC annually establishes separate *Sebastes* quotas for the areas north and south of Cape Blanco, Oregon. The quota for the southern area (which includes California) is allocated 67% to the limited entry fishery and 33% to the open access fishery.

In 1997, 483 limited entry permit holders landed groundfish in California, Oregon, or Washington. Of these active permit holders, 234 landed groundfish in California, and 218 of those counted rockfish among their groundfish landings. Of the 218 rockfish harvesters, 83 possessed a longline endorsement, 130 had a trawl endorsement, and 5 had either a fishpot endorsement or multiple gear endorsements. Rockfish landings and revenue averaged 4.5 metric tons and $9,551 for the longliners, and 39.1 t and $29,563 for the trawlers, and accounted for about 10% of total landings and revenues from all species by both longliners and trawlers. Although the longliners make significant non-groundfish as well as groundfish landings and deliver most of their fish to California ports, the trawlers focus more exclusively on groundfish and are more likely to engage in interstate fishing (table 1).

In 1997, 1,111 vessels landed rockfish in California's open access fishery. Rockfish landings and revenues by these vessels averaged 1.6 t and $3,211. Four gear types accounted for 96% of these landings: hook and line, excluding troll (53%); troll (18%); trawl (14%); and non-trawl net (11%).

Although limited entry has been helpful in preventing the commercial groundfish fleet from expanding, the fishery remains significantly overcapitalized (pers. comm. between PFMC Chairman Jerry Mallet and U.S. Dep. Commerce Secretary William M. Daley, dated July 21, 1998). Growing concerns about the status of groundfish stocks have prompted the PFMC to reduce quotas and vessel landings limits (PFMC 1997). These decisions have been complicated by the need to minimize management-induced discards of fish and ensure that the conservation burden is equitably distributed among different segments of the fishery.

The 1996 Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA)[3] strengthened the responsibility of the PFMC and other regional councils to protect stocks from overfishing and rebuild overfished stocks. It also expanded the required scope of FMPs to include identification, conservation, and enhancement of essential fish habitat (NMFS 1996). Rockfish reserves, as well as other management measures, must be evaluated in the context of the new realities associated with the MSFCMA.

TABLE 1
Average Landings (Metric Tons) and Ex-Vessel Revenue ($, Base Year = 1997) by Limited Entry Permit Holders Who Landed Rockfish in California in 1997, by Gear Type, Species Category, and State

	Longline		Trawl	
	t	$	t	$
California:				
Rockfish	4.5	9,551	39.1	29,563
Other groundfish	14.2	42,681	143.3	116,435
Non-groundfish species	25.5	26,130	42.9	56,430
Oregon/Washington:				
Rockfish	0.2	201	15.6	10,779
Other groundfish	1.3	6,311	179.3	43,465
Non-groundfish species	0.8	2,111	21.8	18,590
Total	46.5	86,985	442.0	275,262

Source: PacFIN data combined with limited entry permit information provided by Jim Hastie (NMFS, Alaska Fisheries Science Center, Seattle). In addition to 83 longliners and 120 trawlers, 5 permit holders with either a pot endorsement or endorsements for multiple gear types also landed rockfish in California. Mean landings and revenues for those five vessels are not reported here in order to protect data confidentiality.

THE CALIFORNIA ROCKFISH FISHERY

The fishery for *Sebastes* rockfish in California includes both commercial and recreational components. Commercial landings declined from about 11,900 metric tons in 1988 to 7,400 t in 1997 (table 2). Ex-vessel revenues—corrected for inflation to 1997 dollars—also declined from $13.4 million in 1988 to $8.7 million in 1997 (table 3). The rockfish sport fishery includes anglers who fish from commercial passenger fishing vessels (CPFVs), private boats, and shore. According to logbook data submitted by CPFV operators to the California Department of Fish and Game (CDFG), CPFV rockfish harvest increased from 1.7 million fish in 1987 to over 2 million in the early 1990s, then declined to around 1 million by 1996 (table 4). Although these numbers are conservative estimates of CPFV activity (not all CPFV operators participate in the logbook program), they are believed to indicate general trends in the fishery. Time series data on harvests by private boat and shore anglers are not as complete, but also suggest a decline in rockfish landings.

Although landings may be affected by nonbiological factors (e.g., effort shifts resulting from changes in ex-vessel prices), the recent decline in rockfish landings is more likely attributable mainly to declines in stock abundance, as evidenced by downtrends in biomass, catch per

[3]The Magnuson-Stevens Fishery Conservation and Management Act is the name given to the 1996 amendment to the 1976 Magnuson Fishery Conservation and Management Act, which established eight regional fishery management councils to manage fisheries in the Exclusive Economic Zone of the United States.

TABLE 2
Commercial Rockfish Landings in California by Gear Type, 1988–97 (Metric Tons)

Year	Trawl	Hook & line	Pot/trap	Nontrawl net	All else	Total
1988	6,104.4	1,893.0	39.2	2,420.2	1,485.5	11,942.3
1989	7,286.2	2,350.3	39.9	2,356.1	953.0	12,985.5
1990	7,836.0	2,731.3	31.8	2,288.4	1,046.6	13,934.1
1991	5,673.2	3,216.0	12.8	1,456.0	590.9	10,948.9
1992	4,057.8	4,140.9	17.3	1,464.4	524.8	10,205.2
1993	4,423.6	2,972.1	15.0	998.6	136.5	8,545.8
1994	4,236.8	2,135.4	18.2	582.5	531.7	7,504.8
1995	5,391.3	1,687.1	29.0	651.2	293.2	8,051.8
1996	5,457.4	1,599.2	23.2	240.2	224.5	7,544.5
1997	5,365.8	1,383.4	24.8	198.5	397.1	7,369.6
Avg.	5,583.3	2,410.9	25.1	1,265.6	618.4	9,903.2

Source: PacFIN database. "Trawl" pertains to the various types of groundfish trawl gear and "hook & line" to all hook and line gear except troll. "Nontrawl net" includes gill nets, trammel nets, dip nets, set nets, and seines. "All else" includes all gear types not covered elsewhere in the table (mainly troll and shrimp trawl).

TABLE 3
Ex-Vessel Value of Commercial Rockfish Landings in California by Gear Type, 1988–97 ($1,000s, Base Year = 1997)

Year	Trawl	Hook & line	Pot/trap	Nontrawl net	All else	Total
1988	5,352.3	3,535.0	49.2	2,933.9	1,502.6	13,372.6
1989	5,773.3	4,312.6	106.7	2,711.7	1,233.4	14,137.7
1990	6,019.1	4,714.3	44.3	2,770.4	1,262.3	14,810.4
1991	4,349.5	5,607.1	27.4	1,571.7	685.7	12,241.3
1992	3,087.5	6,450.2	42.7	1,579.3	630.4	11,790.0
1993	3,408.5	5,370.8	35.2	1,144.2	186.8	10,145.5
1994	3,554.0	4,351.5	66.4	681.5	652.9	9,306.3
1995	4,692.2	4,032.0	137.9	756.0	392.3	10,010.3
1996	4,403.8	3,946.9	101.3	314.4	285.4	9,051.8
1997	4,070.3	3,769.3	110.0	246.9	474.2	8,670.7
Avg.	4,471.0	4,609.0	72.1	1,471.0	730.5	11,353.7

Source: PacFIN database. Revenues corrected to 1997 dollars using GDP implicit price deflator. "Trawl" pertains to the various types of groundfish trawl gear and "hook & line" to all hook and line gear except troll. "Nontrawl net" includes gill nets, trammel nets, dip nets, set nets, and seines. "All else" includes all gear types not covered elsewhere in the table (mainly troll and shrimp trawl).

TABLE 4
Rockfish Landings by Commercial Passenger Fishing Vessels in California, in Numbers of Fish and as a Percentage of Total CPFV Landings in Each Area, 1987–96

Year	Southern California		Central California		Northern California		Total	
	No. fish	%	No. fish	%	No. fish	%	No. fish	%
1987	916,851	29%	744,348	81%	37,835	75%	1,699,034	41%
1988	1,053,906	32%	796,521	81%	41,850	79%	1,892,277	44%
1989	1,264,675	36%	853,021	83%	68,283	83%	2,185,979	48%
1990	1,265,471	35%	911,305	86%	98,880	90%	2,275,656	48%
1991	1,243,022	38%	759,554	90%	59,874	82%	2,062,450	49%
1992	1,110,692	36%	873,887	90%	66,997	96%	2,051,576	50%
1993	937,108	35%	721,038	87%	26,767	86%	1,684,913	47%
1994	812,361	33%	556,136	80%	26,795	89%	1,395,292	44%
1995	679,423	28%	460,624	74%	34,944	86%	1,174,991	38%
1996	645,802	24%	404,174	79%	26,134	84%	1,076,110	33%

Source: CPFV logbook summaries published by the California Department of Fish and Game. Estimates should be viewed as conservative, since not all CPFVs participate in the logbook program.

unit of effort (CPUE), and length frequency (Love et al. 1998; Ralston 1998; Mason, in press).

Over the past 10 years, the major commercial gears used to harvest rockfish in California have included trawl, hook and line (excluding troll), pot/trap and nontrawl net (including gill and trammel nets). Rockfish landings with nontrawl net gear have declined significantly—particularly since 1994, when California voters passed Proposition 132, which banned gill and trammel nets in state waters. Landings by trawl and hook and line gear have also fallen, though less dramatically, and pot/trap landings fluctuate from year to year while their absolute numbers remain modest (table 2). Although trawl gear accounted for 71% and hook and line gear for 20% of statewide rockfish landings in 1995–97, these gear types each account for a similar share of statewide rockfish revenue—49% for trawl and 44% for hook and line. The disproportionate contribution of hook and line landings to revenues is due to the higher average price of hook and line rockfish relative to trawl-caught rockfish. Rockfish harvested with pot gear commands an even higher price than hook and line rockfish.[4]

Depending on how rockfish landings are distributed across areas and fishery sectors, the location of a reserve can have a significant effect on which sectors are most likely to be displaced by the reserve. During 1995–97, trawl landings were concentrated in north/central areas, and nontrawl net landings in south/central areas of the state, while hook and line landings were more evenly distributed throughout the state (table 5); revenues fol-

[4]Price differentials among gear types may be due to several factors, including differences in market quality associated with size or handling of the fish as well as differences among gear types in the composition of harvest between higher- and lower-priced rockfish species. Price is not necessarily a good indicator of economic value, since value is not determined by price but by the difference between price and harvesting cost.

TABLE 5
Average Annual Commercial Rockfish Landings in California, 1995–97, in Metric Tons and as a Percentage of Total Groundfish Landings Associated with Each Gear Type and Area

	Northern California		Central California		Southern California		Total	
Gear type	$	%	$	%	$	%	$	%
Trawl	2,462.1	17%	2,476.3	36%	466.5	18%	5,404.8	23%
Hook & line	402.3	47%	443.9	27%	710.3	72%	1,556.6	45%
Pot/trap	2.2	1%	3.8	13%	19.7	37%	25.7	8%
Nontrawl net	0.6	77%	191.3	82%	171.4	77%	363.3	80%
All else	49.1	49%	211.4	88%	44.4	49%	304.9	71%
Total	2,916.3	19%	3,326.8	36%	1,412.2	36%	7,655.3	27%

Source: PacFIN database.

TABLE 6
Average Annual Ex-Vessel Rockfish Revenue in California, 1995–97, in $1,000s (Base Year = 1997) and as a Percentage of Total Groundfish Revenue Associated with Each Gear Type and Area

	Northern California		Central California		Southern California		Total	
Gear type	$	%	$	%	$	%	$	%
Trawl	1,857.4	15%	2,118.1	30%	413.3	14%	4,388.8	19%
Hook & line	722.6	33%	949.8	28%	2,243.7	69%	3,916.0	44%
Pot/trap	3.9	1%	8.9	10%	103.6	30%	116.4	11%
Nontrawl net	0.7	65%	206.2	78%	232.2	79%	439.1	79%
All else	44.7	37%	242.3	86%	96.9	60%	384.0	68%
Total	2,629.4	17%	3,185.6	32%	3,089.5	44%	8,904.5	27%

Source: PacFIN database. Revenues corrected to 1997 dollars with GDP implicit price deflator.

lowed a similar pattern (table 6).[5] Although lack of complete data for the sport fishery makes it difficult to compare commercial and sport landings, rough extrapolations from available data[6] indicate that four fishery sectors account for most of the rockfish landed in recent years—trawlers 54%, hook and line vessels 16%, CPFVs 10%, and private boats 10%. The contributions of these sectors vary significantly by area (fig. 1), with landings in central/northern California skewed toward trawlers (64% trawl, 11% hook and line, 9% CPFV, 8% private boat), and landings in southern California somewhat more evenly distributed among sectors (32% hook and line, 21% trawl, 17% private boat, 13% CPFV).

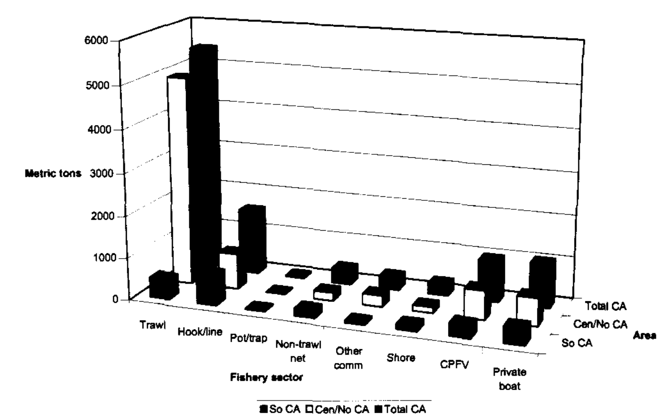

Figure 1. Recent annual rockfish landings in California, by fishery sector and area.

The discussion so far has focused on ports where the fish are landed rather than areas where the fishing occurs. Fishermen may base their choice of fishing areas on a variety of factors, including availability of target species, regulatory restrictions, distance from port, depth, and bottom terrain. To the extent that significant catches in an area reflect the presence of significant biomass or high-quality habitat, such an area may also be a good

[5] Areas of landing are defined for purposes of this paper as southern California—San Diego, Orange, Los Angeles, Santa Barbara, Ventura, and San Luis Obispo counties; central California—Monterey, Santa Cruz, San Mateo, San Francisco, Marin, and Sonoma counties; northern California—Mendocino, Humboldt, and Del Norte counties.

[6] Commercial rockfish landings are represented by mean annual landings for each gear type and area during 1995–97, as estimated from the PacFIN database. Sport landings were estimated by combining results from the Marine Recreational Fishery Statistics Survey (MRFSS) with trends reflected in CPFV logbook data, as follows: on the basis of results from the MRFSS (NMFS 1992), the average annual number of Type A and Type B1 rockfish landed by marine anglers during 1987–89 was calculated by area (southern and central/northern California) and fishing mode (shore, CPFV, private boat). Type A estimates pertain to fish that were available in whole form for the researcher to identify; Type B1 pertains to dead fish that were not available in whole form for identification (e.g., fish used for bait, filleted, discarded dead). Given the high retention rates for rockfish (Wilson-Vandenberg et al. 1996) and the fact that filleting of rockfish at sea is a common practice in California, Type B1 harvest was assumed to consist largely of fish that were landed rather than discarded; thus A + B1 was assumed to provide a reasonable estimate of total rockfish landings. Because MRFSS interviewers routinely weigh fish landed whole, Type A landings estimates were available by weight as well as by numbers of fish, but the weight of the Type B1 harvest had to be inferred. Numbers of Type B1 rockfish were converted to metric tons by applying the mean weight of Type A rockfish associated with each area and fishing mode to the Type B1 rockfish caught in the same area and mode. The resulting average A + B1 tonnage estimates for 1987–89 were then scaled back to reflect recent fishery declines, as documented in CPFV logbooks. On the assumption of a similar decline in all fishing modes, the 1987–89 A + B1 tonnage estimates for each mode were scaled back by the ratio of average 1994–96 to average 1987–89 CPFV rockfish landings from table 7.

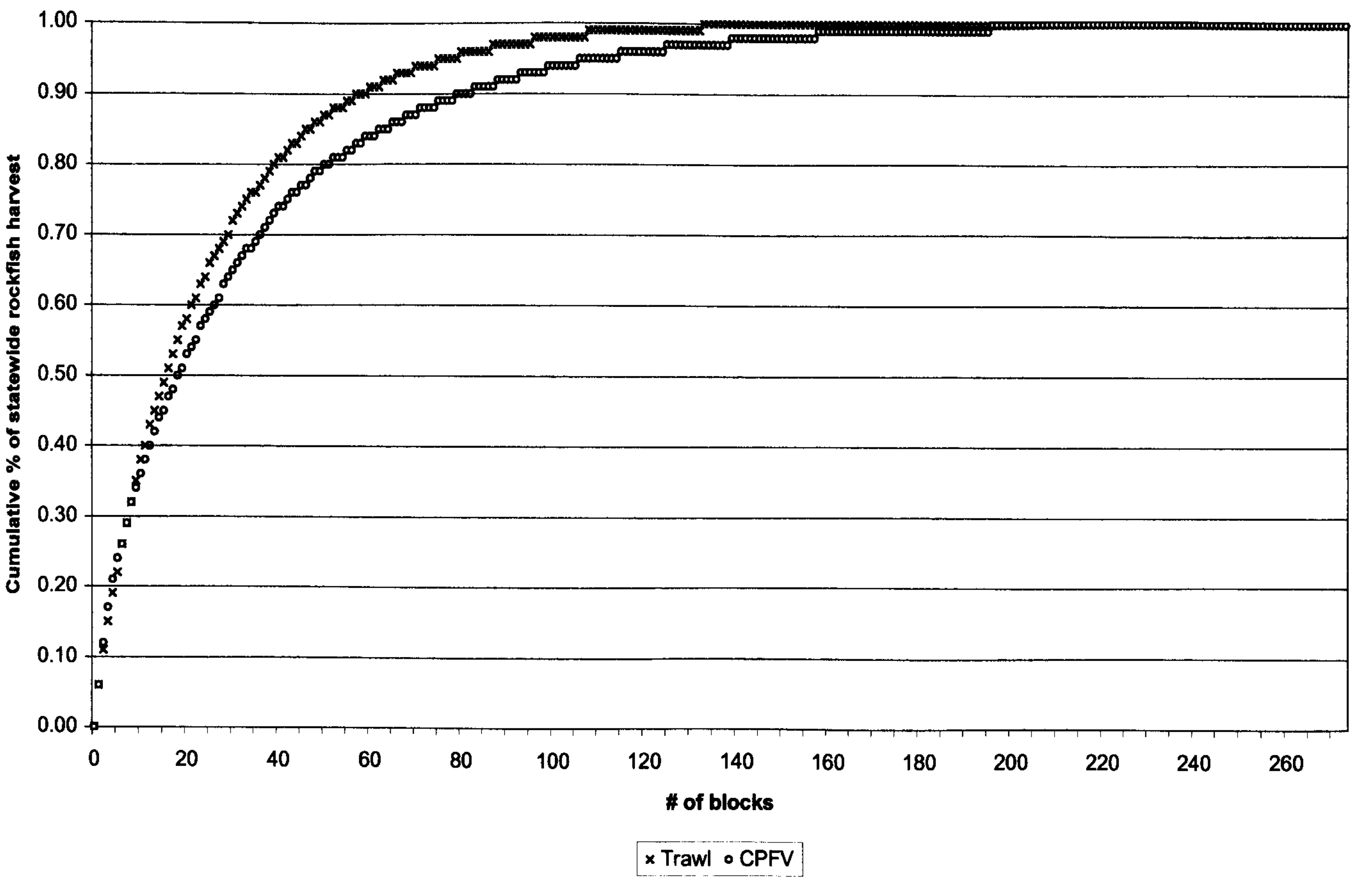

Figure 2. Extent of geographic concentration of trawl and CPFV rockfish harvest among blocks in California.

location for a reserve. The remainder of this section focuses on issues associated with placement of a no-take reserve in an area of high rockfish harvest.

Logbooks provided by trawlers and CPFVs include information on harvest by area fished. The fishing areas reported in these logbooks correspond to standardized 10 × 10 nmi blocks that have been mapped and numbered by the CDFG.[7] Because the representativeness of logbook data is uncertain (for instance, some fishermen are reluctant to disclose "hot" fishing spots), the data as used in this paper are intended to suggest rather than definitively identify areas of concentrated rockfish harvest.

For this discussion, the block areas reported in the 1994–96 trawl logbooks were sorted in descending order of average annual rockfish harvest, and—proceeding from the top to the bottom of the order—the cumulative number of blocks was plotted against the corresponding cumulative percentage of statewide rockfish harvest accounted for by those blocks. The same procedure was applied to 1995–97 CPFV logbook data to estimate the cumulative harvest distribution for CPFVs. The results (fig. 2) indicate a high degree of rockfish harvest concentration for both sectors of the fishery.

For figures 3, 4, and 5, I used the CDFG block maps for southern, central, and northern California to depict the geographic distribution of trawl and CPFV fishing activity. The filled and unfilled triangles denote major rockfish and non-rockfish areas for trawlers, while the filled and unfilled diamonds denote major rockfish and non-rockfish areas for CPFVs. Major trawl rockfish blocks are defined to include the 16 blocks that ranked highest in terms of average annual 1994–96 trawl rockfish harvest and that together accounted for 50% of statewide trawl rockfish harvest during 1994–96. Major CPFV rockfish blocks are similarly defined to include the 19 blocks that ranked highest in terms of average annual 1995–97 CPFV rockfish harvest and that together accounted for 50% of statewide CPFV rockfish harvest during 1995–97. I identified major non-rockfish blocks by applying a similar ranking procedure to the non-

[7]Although, in recent years, fishing area information has been reported in the trawl logbooks on a finer scale (i.e., latitude-longitude coordinates), areas of trawl activity are reported here in terms of blocks, in order to be consistent with the block areas reported in the CPFV logbooks.

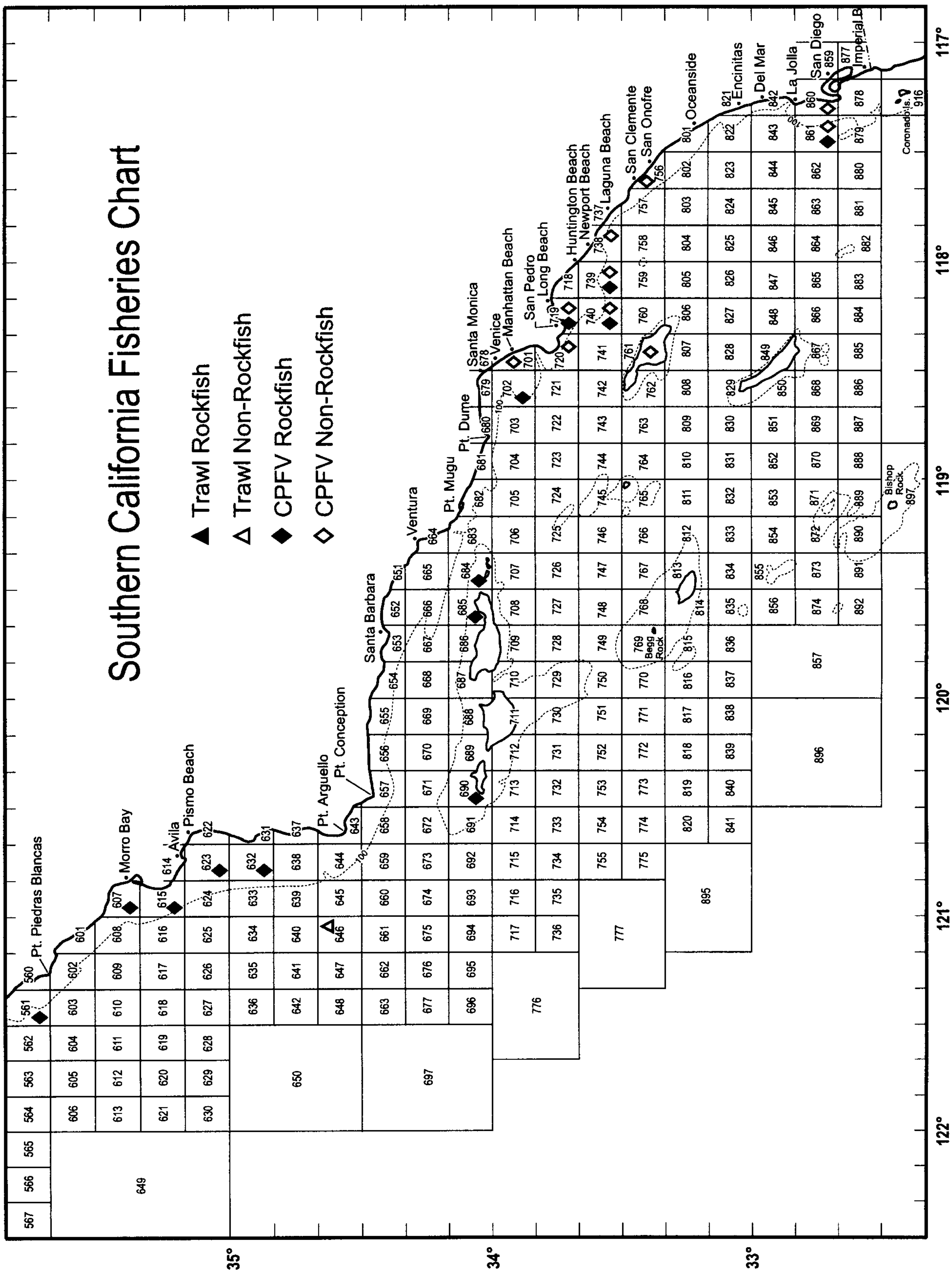

Figure 3. Distribution of major rockfish and non-rockfish blocks for trawlers and CPFVs in southern California.

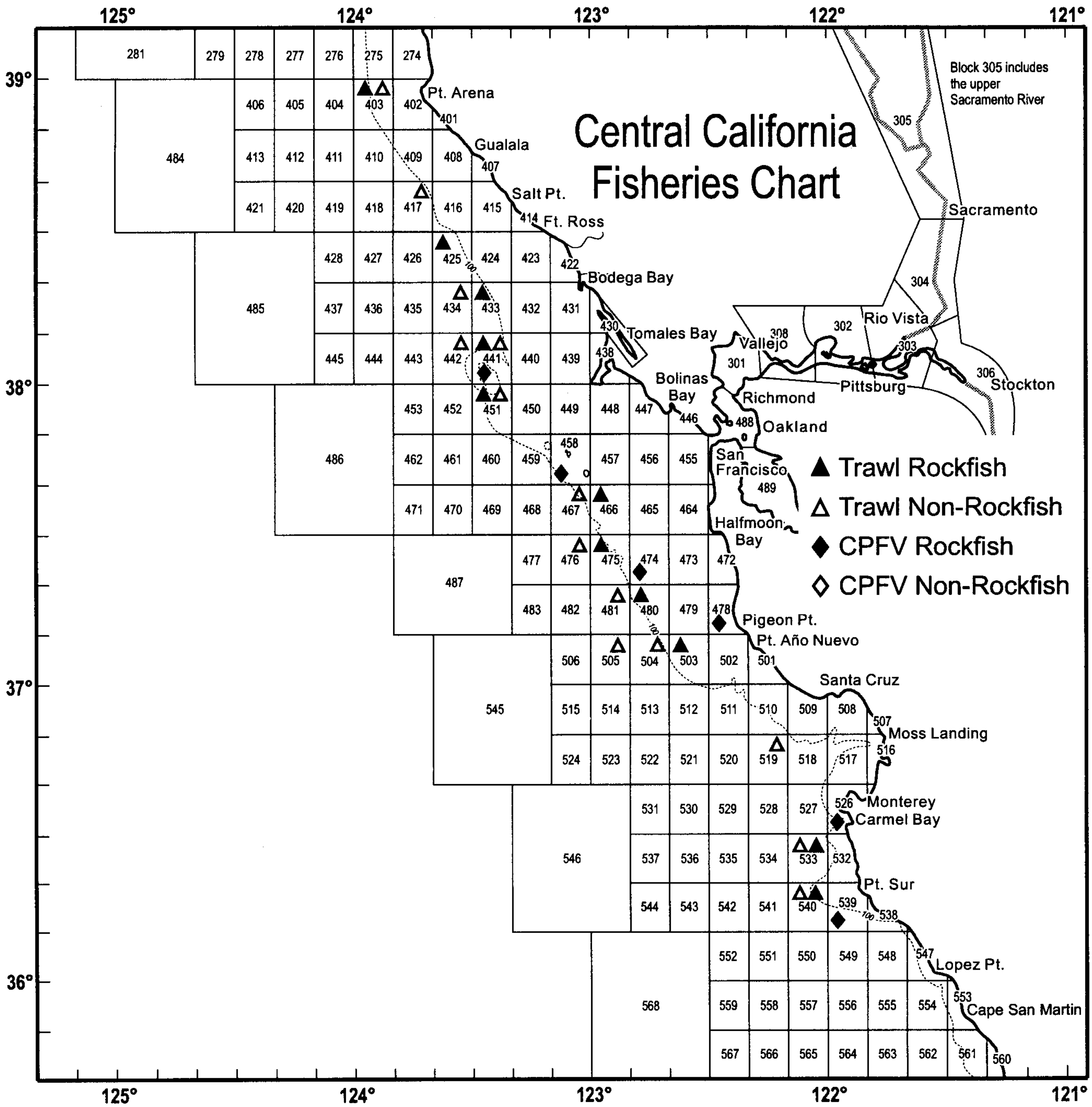

Figure 4. Distribution of major rockfish and non-rockfish blocks for trawlers and CPFVs in central California.

rockfish harvest data contained in the 1994–96 trawl logbooks and the 1995–97 CPFV logbooks.

Five of the 16 major trawl rockfish blocks are located in northern California (fig. 5) and 11 in central California (fig. 4). Of the 19 major CPFV rockfish blocks, 6 are located in central California (fig. 4) and 13 in southern California (fig. 3). Although there are some major trawl and CPFV rockfish blocks in central California, there are no major trawl blocks in southern California and no major CPFV blocks in northern California. Geographic differences such as these highlight the difficulty of ensuring that decisions about locating reserves are equitable.

In evaluating the effects of a reserve, it is important to consider how participants in both the commercial and recreational rockfish fisheries rely on non-rockfish species, the extent to which their non-rockfish as well as rockfish harvest would be directly precluded by closure of

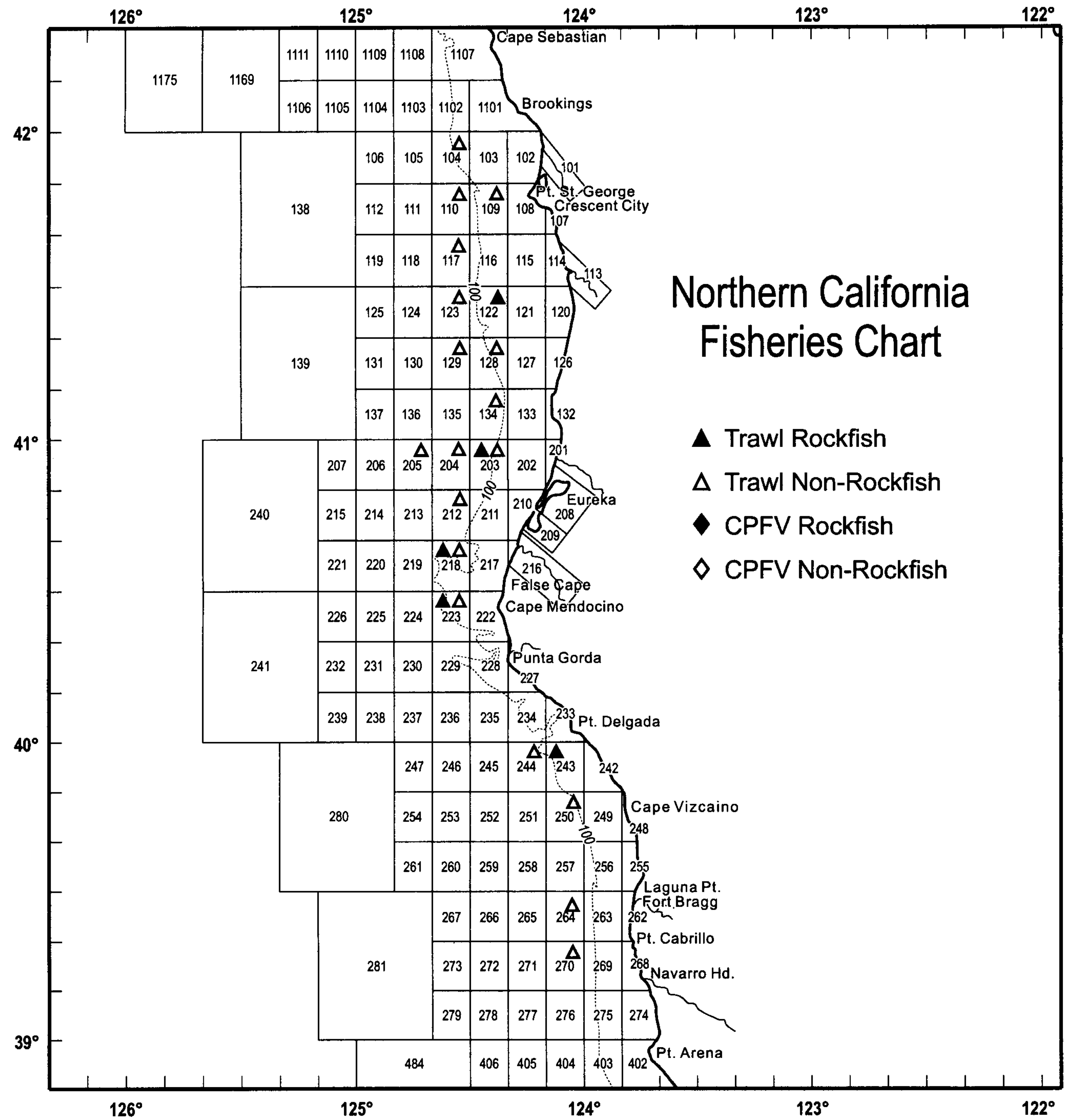

Figure 5. Distribution of major rockfish and non-rockfish blocks for trawlers and CPFVs in northern California.

the reserve area to all fishing, and the availability of rockfish and non-rockfish stocks outside the reserve.[8] Other fishing activities which customarily occur in the reserve area but are unrelated to rockfish—that is, which do not involve targeted or incidental harvest of rockfish—would also be displaced. Evaluating the effects on these latter types of fisheries, though beyond the scope of this paper, is also an important consideration for reserve design.

During 1995–97, the contribution of rockfish to total groundfish landings made by each commercial gear type varied significantly (8% for pot/trap, 23% for groundfish trawl, 45% for hook and line, and 80% for nontrawl

[8]Included among the major non-rockfish species targeted by commercial rockfish fishermen in California are sablefish, Pacific whiting, Dover/English/petrale sole, thornyheads (a non-*Sebastes* rockfish), and Dungeness crab. Included among the major non-rockfish species targeted by sport fishermen are salmon, sturgeon, and striped bass in central/northern California, and sea basses, tunas, California halibut, and Pacific bonito in southern California.

net gear), and also varied across areas within each gear type (table 5). Revenues showed a fairly similar pattern (table 6). According to the 1994–96 trawl logbooks, 19% of statewide non-rockfish groundfish harvest by trawlers occurred in the 16 major trawl rockfish blocks, indicating the extent to which non-rockfish groundfish harvest would be directly precluded by including those blocks in a reserve. Eight of the 33 major non-rockfish groundfish blocks are also major rockfish blocks, and the other 25 (except for block 646 in southern California) generally occur near major rockfish blocks, though somewhat farther offshore and deeper (figs. 3–5).

According to CPFV logbooks, 32% of statewide CPFV non-rockfish harvest during 1995–97 occurred in the 19 major CPFV rockfish blocks, 3 of which are also major non-rockfish blocks. All 10 of the major non-rockfish blocks are located between Los Angeles and San Diego (figs. 3–5), reflecting the relatively high volume of CPFV fishing in southern California (table 7) and the tendency for CPUE to be higher for non-rockfish species taken in southern California (e.g., sea basses) than for those taken father north (e.g., salmon).

For CPFVs, evaluating dependence on rockfish and the effect of a rockfish reserve is complicated by several factors. In southern California, rockfish constitute 33% of total CPFV landings (table 7). According to the CPFV logbook data, 60% of southern California rockfish landings are made on the 10% of CPFV angler trips that are specifically targeted at rockfish. However, the majority of southern California angler trips (75%) are characterized simply as "coast" or "offshore" trips on which rockfish is one of several important components of catch; 31% of southern California rockfish landings are made on generic trips of this type. Thus the effects of a reserve will depend not only on the number of CPFV trips (rockfish and non-rockfish) customarily made in the reserve area but also on whether the species abundance and mix outside the reserve are sufficient to sustain the generic trips that constitute most CPFV activity in southern California.

In central and northern California, rockfish and salmon are the two major CPFV target species. Since CPUE is much higher for rockfish than for salmon, the rockfish share of harvest does not accurately reflect the proportion of angler trips attributable to rockfish. For instance, although rockfish make up 81% of total landings in central California (table 7), CPFV logbook data indicate that 24% of angler trips are targeted at rockfish and 52% at salmon. In northern California, where rockfish make up 80% of CPFV landings (table 7), the proportion of trips targeting rockfish and salmon is the same (43%). Closure of major rockfish areas in central/northern California would likely compound existing economic difficulties associated with recent declines in CPFV fishing activity (table 7) and with increasingly restrictive salmon regulations (PFMC 1998).

TABLE 7
Average Annual Rockfish Landings (Number of Fish), Total Landings (Number of Fish), Number of Angler Trips, and Number of Vessels in the CPFV Fishery in California, 1987–89 and 1994–96, by Area

	Southern California	Central California	Northern California	Total
1987–89 average:				
Rockfish landings	1,078,477	797,963	49,323	1,925,763
Total landings	3,297,546	979,361	61,850	4,338,757
Total angler trips	516,299	177,300	13,614	707,213
Total vessels	195	142	31	368
1994–96 average:				
Rockfish landings	712,529	473,645	29,291	1,215,464
Total landings	2,567,350	609,157	34,041	3,210,548
Total angler trips	481,609	126,812	5,894	614,314
Total vessels	203	96	12	311

Source: CPFV logbook summaries published by the California Department of Fish and Game. Estimates should be viewed as conservative, since not all CPFVs participate in the logbook program.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Given the nonuniform geographic distribution of rockfish landings by different sectors of the fishery, a system of reserves strategically distributed up and down the coast rather than concentrated in a single area would help ensure that short-term displacement costs associated with the reserve do not fall disproportionately on any particular sector. Given the importance of biological and enforcement considerations in the placement of the reserve, as well as equity, it will not be possible to achieve complete consensus about an acceptable distribution of reserves. Nevertheless, it is critical that allocative implications be recognized and addressed as much as possible. Ignoring this issue will not make it go away; it will merely appear in different guises as disputes over other, seemingly unrelated issues.

In recent years the California rockfish fishery has displayed a downward trend in abundance and landings of many stocks. Regardless of what combination of reserves and more conventional management measures might be used to rebuild these stocks, the short-term economic costs are likely to be significant and to have implications beyond the rockfish fishery. For instance, because of the multispecies nature of the groundfish fishery, rebuilding rockfish stocks via conventional management measures could involve reducing quotas for relatively healthy groundfish stocks that are caught concurrently with weak rockfish stocks; and non-groundfish fisheries that incidentally take rockfish might also have to be restricted. A no-take reserve would also involve direct restrictions on non-rockfish as well as rockfish fishing activities, though of a different type (i.e., displacement due to area closure). A reserve might affect an even broader range of non-rockfish fisheries than conventional management measures if fishing activities that have no bearing on rockfish are also displaced from the reserve.

Diverting fishing effort to areas outside a rockfish reserve might cause a variety of external effects, including higher exploitation rates for outside fish stocks and higher vessel operating costs and increased social conflict in outside areas. Management problems outside the reserve might be magnified if fisheries for outside stocks are already fully subscribed. Effects of this type are not unique to reserves and could also occur, for instance, if effort were diverted to other fisheries as a result of conventional management measures such as rockfish quota reductions or restrictions on the harvest of non-rockfish species caught with rockfish. But external effects might be broader in scope for reserves, depending on how much of fishing effort displaced from the reserve involved vessels that had targeted non-rockfish species in the reserve and whether the fishing subsequently undertaken by those vessels outside the reserve differed significantly from the activities undertaken by displaced rockfish vessels.

Good science is critical to the design of a reserve and the implementation of appropriate protocols for evaluating its long-term potential for enhancing fish stocks, fish habitat, and fisheries (Carr and Reed 1993). These are ambitious research goals. It is also important that science not be asked to provide more than it is capable of delivering. Just as questions are being raised about the desirability of basing rockfish quotas on highly uncertain stock assessments, it is also important to evaluate (1) the uncertainties associated with predicting and validating the biological benefits of reserves, (2) the extent to which such uncertainties could be reduced within a reasonable time frame and with reasonable funding, and (3) how management should proceed in the face of such uncertainties.

Reasonable predictions about the nature, extent, and timing of benefits to be generated from the reserve would be important not only for evaluating the reserve but for determining how to best regulate the rockfish fishery outside the reserve. Such predictions would also be of interest to the fishing industry, which would probably be concerned about its ability to absorb displacement costs while awaiting whatever fishery benefits might be generated by the reserve over the long term. Management, monitoring, and enforcement costs would be important considerations as well. It is important that reserves not be oversold as a panacea for the limitations and costs of current rockfish management. There are no easy fixes for rockfish.

Management objectives should be defined at the outset (Yoklavich 1998, p. 154). Objectives would provide guidance for the design of management options (e.g., size and location of the reserve) and the issues relevant to evaluating the options. The process of defining objectives might also be useful for clarifying the extent to which the reserve is intended as a species-specific management tool or as a tool for providing broader benefits—such as protection of essential fish habitat—more consistent with "ecologically based management units" (Davis 1989).

Since reserves are likely to supplement rather than replace more conventional management measures, it would be useful to explore whether and how the two approaches might be coordinated to achieve the desired objectives. This exploration should include a reevaluation of current regulations, including the groundfish limited entry program. Additional reductions in the limited entry fleet (perhaps via a vessel buyback program), combined with new restrictions on the open access fishery, might alleviate the economic costs associated with displacement from a reserve more immediately (and perhaps more definitively) than any fishery enhancement benefits that the reserve might provide over the long term. Capacity reduction might also alleviate the economic hardships associated with more conventional management measures such as vessel landings limits, which are becoming untenable as a way to maintain an extended fishing season in the face of declining quotas. Regardless of how reserves fare as a rockfish management tool, the current interest in them might provide a catalyst for looking "outside the box" to devise more effective ways to manage rockfish stocks.

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SOCIAL CONSIDERATIONS FOR MARINE RESOURCE MANAGEMENT: EVIDENCE FROM BIG CREEK ECOLOGICAL RESERVE

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ABSTRACT

Growing interest in no-take marine protected areas (MPAs) as a complement to traditional fishery management has led to increased attention to biophysical considerations for MPA design, implementation, management, and evaluation. Considerably less attention has been directed, however, toward social, cultural, and economic considerations for MPAs. Information on and understanding of the relationship between MPAs and local fisheries in social, cultural, and economic, as well as biophysical, terms is especially important. At the same time, there is growing interest in collaboration between fishers and scientists to provide more complete and accurate information on fisheries and marine ecosystems. Such collaboration is one element of cooperative (or co-) management of local fisheries, which is gaining recognition as potentially more effective, appropriate, and equitable than traditional, top-down resource management. These two themes—social considerations for MPAs and co-management of local fisheries—are central to a study being conducted at central California's Big Creek Ecological Reserve. This paper provides an overview of the local skiff fishery and the cooperative arrangement at Big Creek; discusses that arrangement as a form of co-management, and as it has played an integral role in the history of the marine reserve; and concludes with observations and emerging questions about the social aspects of establishing and maintaining no-take marine reserves in the context of local fisheries.

INTRODUCTION

Concerns about the shortcomings of traditional fishery management tools and approaches have prompted interest in two alternatives: no-take marine protected areas (MPAs; i.e., marine reserves) and cooperative (or co-) management of local fisheries. The interest in MPAs has led to increased attention to ecological considerations associated with the components of the MPA process, namely their design, implementation, management, and evaluation (see, e.g., Carr and Reed 1993). Much less attention has been directed, however, to social, cultural, and economic considerations for MPAs (Fiske 1992; Wolfenden et al. 1994; Suman 1998). Both sets of considerations are especially germane to the relationship between MPAs and local fisheries because of the diverse ways they affect one another, in sociocultural and economic as well as ecological terms. The interest in co-management has focused largely on its potential for fostering information gains, especially through fishing industry collaboration in the collection of scientific data. This is only one element of full-fledged co-management, however, in which government agencies and resource users share responsibility and authority for resource management (Jentoft 1989; Pinkerton 1989).

At California's Big Creek Ecological Reserve, a small group of local skiff fishers and the manager of the University of California, Santa Cruz (UCSC) Landels-Hill Big Creek (LHBC) Reserve established a cooperative arrangement with two key features: a no-take zone and a fishery-dependent data collection system, *before* the reserve's legal designation in 1994. The Big Creek case is an example of co-management in an MPA context that provides an opportunity for exploring the social, cultural, and economic aspects of these two alternatives or complements to traditional fishery management. This paper explores these themes, based on research the author has been conducting at Big Creek since 1996.[1]

The first two sections briefly discuss fisheries co-management and social considerations associated with MPAs. The third section focuses on the local fishery and the development of co-management at Big Creek. The final section presents emerging questions about the sociocultural and economic aspects of the Big Creek reserve and its co-management that are being pursued as the research continues. I conclude that these questions and considerations are critical not only to the Big Creek situation, but to MPAs and fishery management more generally.

FISHERIES CO-MANAGEMENT AND MPAS

Much of fishery management is based on the assumption that fisheries, as common pool resources

[1]This research has included two studies: a demonstration project, sponsored by UCSC's Monterey Bay Regional Studies (MBRS) Program, conducted in 1996 to explore the cooperative arrangement; and a subsequent three-year (June 1997–May 2000) in-depth study, sponsored by the California Marine Ecological Reserves Research Program (MERRP, Grant no. R/BC-2). The goals of the latter study are to document the fishery adjacent to the reserve, analyze the cooperative arrangement between local fishers and the reserve manager, and evaluate their cooperative data collection system.