COOPERATIVE STRATEGIES IN FISHERIES MANAGEMENT: INTEGRATING ACROSS SCALES

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ABSTRACT

Fisheries management at its core is concerned with the management of human behavior. Management institutions operating at different spatial scales create different kinds of hierarchies, relationships, and incentives. Hence the scale at which management decisions are made can strongly influence their effectiveness. In the United States, top-down coast-wide control rules can create perverse harvest incentives, impose adverse social impacts, and result in poor conservation and economic performance. Some large-scale institutional changes (e.g., individual fishing quotas) have effectively realigned economic incentives of individual harvesters, but fishermen respond to a diversity of factors in addition to economic incentives, including environmental and social factors that operate primarily in small-scale U.S. fisheries or within subunits of larger-scale fisheries. Failure to address scale issues has resulted in disputes over "best available science" and opposition to management perceived as threatening. Small-scale cooperative strategies that empower fishing communities to strengthen local monitoring efforts and social networks are practiced throughout the world, with often impressive success, but have yet to become integrated into mainstream U.S. fisheries management. We assessed potential barriers and bridges to using cooperative strategies to improve sustainability of small-scale U.S. fisheries. We selected California's nearshore fishery to demonstrate the methods, but the analytical framework we present can be applied to many others. Of course, successful implementation will require more than good analysis. People and institutions interested in cooperative strategies must continue to assemble resources and political will to overcome the barriers to progress that exist in the United States.

Fisheries management involves balancing competing goals with diverse objectives by means of a variety of biological, economic, and social criteria (Hilborn and Walters, 1992). U.S. fishery managers are charged with achieving many goals and objectives, including optimal yield, maintaining adequate spawning biomass to prevent recruitment overfishing, minimizing risk, maintaining year to year stability in the catch, and preserving jobs in the community. Because some of these objectives conflict with each other and because trade-offs exist, fisheries management has often been perceived as a failure by one stakeholder group or another.

Realization is growing that conventional approaches to fisheries management cannot fully address the needs and concerns of small-scale fisheries with limited data and spatially variable demographics. In the United States, stock-assessment models and the bureaucratic hierarchies that promulgate and enforce fishing regulations were designed to address industrial-scale pelagic fisheries such as those for anchovy, cod, and hake (Wilson et al., 1999), but recent high-profile collapses of many stocks and an increasing shift toward development of small-scale fisheries for sedentary species has stimulated interest in using decentralized cooperative management (Acheson, 2005; Chuenpagdee and Jentoft, 2007). Decentralized approaches such as cooperatives, comanagement arrangements, and collaborative research allow for

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broader community input into management and regulation. These decentralized approaches can improve management outcomes (ecological sustainability, social goals, and economic performance) by incorporating local knowledge, increasing responsiveness of management measures to local conditions, and rewarding stewardship behavior. Here, we focus on the potential for cooperative fishery-management strategies at smaller scales (relative to U.S. regional fisheries management) to achieve these goals. Cooperative strategies are based on the idea that parties involved in management—including for example fishermen, researchers, managers, and environmental organizations—can work together to achieve common fishery goals using participatory processes, in contrast to more adversarial or top-down strategies. To date, most examples of successful small-scale, cooperative strategies come from developing countries (Pomeroy et al., 2001; Satria and Matsuda, 2004; Soreng, 2006; Sverdrup-Jensen and Nielsen, 2008). These strategies are now gaining recognition in the United States as viable means of collecting data at smaller spatial scales and creating local incentives for stewardship in small-scale fisheries (Acheson, 2005; Table 1). Cooperative research is not a prerequisite for comanagement. It is regarded, however, as a transformational tool that provides a pathway by which fisherman can enter into the management arena. Hartley and Read (2006: 83) offer an example of this view on cooperative work from a U.S. lobster fisherman with over 20 yrs of cooperative-research experience:

"Before, it was government coming out and saying, 'This is what we are going to do, based on X.' Well, X was different from what fishermen thought they knew and different from what they saw on the water. Now, we participate in the deliberations of science. There is a natural transition from science and cooperative research in particular, to cooperative management. Once fishermen appreciate what science is and what scientists do, they will become better cooperative management partners. Likewise, once scientists appreciate what fishing is and what fishermen do, they will become better cooperative management partners. The result will be better, more effective management measures."—Pat D. White

Cooperative research and management arrangements can improve the transparency, understanding, and social structure of fishing communities, but a fundamental mismatch often exists between the data necessary for conventional stock assessments and the geographic scales at which cooperative management strategies operate. Concerns that conventional approaches have failed to manage small-scale fisheries sustainably have contributed to an increased interest in alternative assessment methods (Caddy and Mahon, 1995; McShane, 1995; Stephenson and Lane, 1995), but social, political, and economic barriers can limit the effective implementation of these approaches at different spatial and hierarchal scales of fisheries. Before the potential of cooperative strategies to improve U.S. fisheries management can be realized, these barriers must be identified and overcome.

Successful implementation of cooperative approaches involves the identification of the spatial scale at which complex social and fisheries dynamics can be most effectively addressed. For small-scale fisheries, implementing management strategies at these smaller scales may require alternatives to conventional stock assessments as well as appropriate incentives, allocation of catch, input controls, spatial refuges, simple quantitative metrics, and incorporation of fishermen's knowledge into the management doctrine (Ruddle, 2007). These techniques have been employed for centuries in other cultures and have proven successful in achieving social objectives

Table 1. Definitions of key terms and of metrics for which port clusters were ranked in Table 3.

Key terms, definitions, and metrics	
Cooperative research	Cooperative research is a joint venture between fishermen and scientists to perform research.
Comanagement	Comanagement arrangements represent a “shared responsibility” between fishermen or stakeholders and the government for resource use and management (Pomeroy and Berkes, 1997).
Organized communication	Number of fishing associations in commercial ports
Marketing organization	Number of fishing events in commercial ports
Level of interest	Number of full-time jobs supported by nearshore resources
Participation	Number of cooperative-research projects in port cluster with nearshore fishery
Leadership activity	Representative to participate in state or council process
Demand for reform	Expressed problems with access to or regulation of fishery
High-value resource	Average price per pound excluding trawl catch
Technical support	Number of marine research institutions
Monitoring support	Number of subtidal monitoring sites
Need for capacity reduction	Identified capacity reduction (number of permits minus capacity goal)
Oversight	Presence of regional California Department of Fish and Game office
Prior experience	Established cooperative working relationships between nongovernmental environmental groups and researchers
Positive history	Subjective assessment of the regional perception of prior cooperative experience: negative (–1), neutral (0), or positive (1)

(Johannes, 2002; Froese, 2004; Ruddle, 2007) and, in some cases, conservation outcomes (Cinner et al., 2005a,b).

Here, we discuss the potential for incorporation of cooperative strategies into fisheries on the U.S. Pacific Coast by means of an integrative framework of analytical tools that can be applied to other regions. We focus on California because legislative and administrative initiatives have given high priority to cooperative efforts and allocated funds for cooperative strategies (California Ocean Protection Trust Act, AB 1280, 2008). Within this political context, we identified the barriers to establishing cooperative approaches in fisheries management and evaluated fisheries using biological, social, and economic criteria with respect to their suitability for implementing cooperative approaches to management. We report here how these methods can be applied to the California nearshore fishery and suggest that the ports of Morro Bay and Santa Barbara are good candidates for cooperative fisheries management.

Methods

We adopted a cross-scale integrative approach to identify barriers to cooperative strategies, to determine whether these strategies can add value to existing management efforts, to determine characteristics of a fishery likely to influence the successful adoption of cooperative management, and to develop recommendations. Such an examination can illuminate barriers to implementation and provide guidance for managing stakeholder expectations.

The corresponding analyses fit within the Institutional Analysis and Development approach, developed by Ostrom and colleagues, as a means of defining the "action arena" in which policies are generated (Ostrom, 1986, 1990, 1999, 2005). Because we approached the assessment from a policy-making perspective, we focused heavily on three elements of the fishery's contextual setting: the physical setting of the fishery's execution, existing governance, and community attributes (Imperial and Yandle, 2005). We compared these elements to the literature on successes and failures of cooperative strategies to determine what barriers may arise in an action arena set in a cooperative management policy-making context. The integrative approach was intended to ensure that appropriate questions were asked and answered at relevant scales and that results were consistently integrated across scales. Our analysis included three steps: an opportunity assessment, an information synthesis, and the integration and implementation of cooperative approaches. Each step was inquiry-driven and included one or more subquestions, which we addressed to answer the overarching question, "How can comanagement and cooperative research be more fully realized?"

Step 1: Opportunity Assessment

What are the major fishery management challenges in small-scale fisheries, and how might cooperative strategies help overcome them? At what regulatory scales do California nearshore management systems operate, and where do redundancies and/or gaps exist in regulatory efforts?

Step 1 involved an assessment of the system of interest as a whole, intended to determine whether it offers a role for cooperative strategies. We defined our system as the management arena that encompasses California's nearshore finfish fishery. In Table 2, we list major fishery-management challenges with the performance and potential of cooperative strategies in meeting these challenges, based on a literature review of case studies. Not surprisingly, consistent management-design principles and trade-offs emerged (see for example Ostrom, 1990, 2005). Scale appears to affect incentives and accountability strongly; both are stronger at smaller scales. Level of bureaucracy influences the degree to which socially mediated incentives apply; highly developed large-scale bureaucracies that tend toward one-size-fits-all management measures may reduce the strength of incentives to cooperate.

Within Step 1, we developed a simple, three-axis schematic that describes a variety of fishery-management approaches (input controls, output controls, top-down controls, bottom-up controls, etc.). Our approach loosely parallels trade-off models used in life-history ecology. Such life-history models identify adaptive attributes of species, while accounting for functional constraints, to inform fisheries management generally (Winemiller and Rose, 1992). Instead of mapping life-history attributes, we used a triangular model to ordinate management attributes and design principles (Fig. 1).

We balanced a desire for accuracy with the need to keep the framework simple, so that the schematic would be an easy-to-use visual tool for categorizing and evaluating management strategies, alternatives, and opportunities. To represent these three axes (scale, hierarchy, and efficiency) visually, we mapped different management structures and control policies with respect to the nature of the incentives—i.e., whether they are primarily politically mediated (bureaucracy based), socially mediated (community based), or economically mediated (market based). The schematic shown in Figure 1 incorporates scale, equity, and efficiency axes. Other classifications and axis combinations failed to describe the full spectrum of fishery-management options and therefore lacked consistency and usefulness.

Table 2. Key fishery challenges facing traditional management regimes and the cooperative strategies necessary to overcome them.

Challenges of scale	Real-world example	Real-world experience	Performance and potential of cooperative strategies
To overcome constraints on data	U.S. Pacific Coast rockfishes (genus *Sebastes*)	Failure to account for spatial dynamics and/or recruitment variability of populations can result in the misspecification of important fishery reference points, including biomass thresholds and management targets.	Can be successful if management and/or stock assessments can incorporate data collected at smaller scales (Johnson and van Densen, 2007; Sverdrup-Jensen and Nielsen, 2008). Cooperative approaches can also improve survey-gear deployment and reduce costs (Pomeroy et al., 2001; NRC 2004; Johnson and van Densen, 2007).
To account for ecosystem complexity with nonlinear dynamics	Atlantic cod, especially in eastern Canada (Bundy et al., 2005; Frank et al., 2005; Savenkoff et al., 2007)	Fisheries are prosecuted within ecosystems that exhibit nonlinear dynamics, which can render management actions ineffective and skew projections.	Can help by collecting higher-resolution data (Johnson and van Densen, 2007) and reducing management response time. Some cooperative efforts have centered around meeting ecosystem-based management needs (e.g., a variety of projects in the northeastern United States, Johnson and van Densen, 2007, and Local Area Management Plans in Alaska, Gunderson et al., 2008).
To integrate information across social and geographic scales	Abalone fisheries (McShane, 1995).	Fishery collapses have resulted not only from a lack of scientific data needed for accurate stock assessments but also from the inability to reconcile spatial reference scales between relatively good data collection programs and population assessments.	Has helped in developing countries (Sutinen, 1999; Pomeroy et al., 2001; Sverdrup-Jensen and Nielsen, 2008) and in the United States, according to anecdotal information (NRC, 2004).
To reduce conflicts	Maine lobster (Acheson, 2005; Steneck, 2006)	Consequences of unsustainable fishing and regulatory changes are often unevenly and, arguably, inequitably distributed. Such inequities lead to conflict, unpopular management, distrust of science, higher management costs, and economic hardship.	Can help by increasing buy-in to research and assessment results (NRC, 2004) and perhaps by reducing the scale of management (reducing the number of stakeholders) and building trust (NRC, 2004; Johnson and van Densen, 2007; Shepherd et al., 2004).
To confront time lags resulting from changes in environmental or socioeconomic conditions	The "dead zone" off the U.S. Pacific coast, initially recognized by Oregon crab fishermen (Chan et al., 2008)	Top-down fisheries actions take time to be enacted through political and management systems, potentially creating policy that is ineffective or counter-productive in light of changed conditions. In addition, top-down actions through revised legislation, executive orders, and funding priorities can move the goalposts, creating more challenges for management.	Can help by supplying local data, detecting changes earlier, and reducing response times (Johnson and van Densen, 2007; Port Orford Ocean Research Team, 2008).

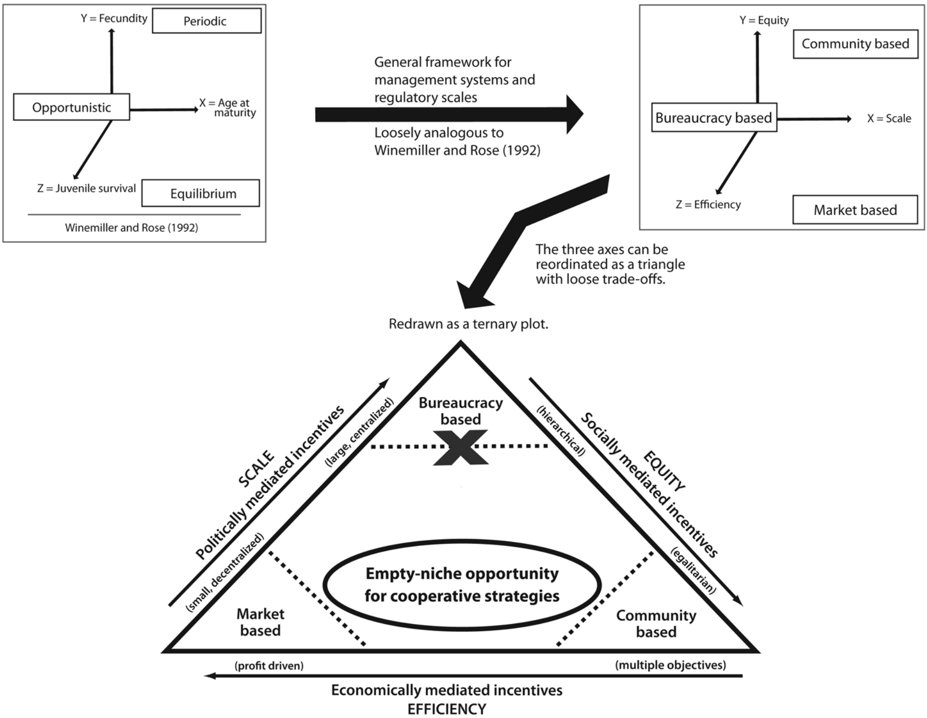

Figure 1. Management systems by control type. Management control types fall along various spectra of many different factors like effort/catch control, high/low bureaucracy, command-control/incentive-based, etc. We ordinated management strategies in this three-axis schematic, based on the indices of scale, equity, and efficiency. Conventional fishery management clusters near the top of this ordination diagram (large scale, multilayer hierarchies, balance of equity and efficiency). Sustainable fisheries frequently involve small-scale cooperative strategies that blend economically and socially mediated incentives. The conventional management emphasis in California and the United States, however, involves top-down management. The result is a relatively empty niche near the bottom (smaller scale, balance of community-based and market-based incentives; Charles, 1992; Yandle, 2003). We contend that cooperative management is most likely to succeed when implemented in this vacant niche (inside the oval). Within this vacant niche, small-scale efforts are most likely to complement large-scale efforts without overlapping jurisdictions to help leverage (not compete with) conventional management efforts (marked by the X).

The schematic in Figure 1 is robust but offers only a relative index that broadly describes management systems and clustered traits for management success. It comports with the results of other studies that have independently identified attributes of incentive scale, equity, and efficiency as appropriate characterizations for describing management systems (Charles, 1992; Yandle, 2003). To apply the general principles embodied within the schematic, we used information about the California nearshore fishery to define each of the three axes.

Step 2: Information Synthesis

We evaluated three key elements of the fishery's contextual setting relevant to the success of cooperative strategies: *Step 2(a), Biophysical Resource Conditions, Catch, and Data.* What is the nature of the biological resource, and how is the fishery prosecuted? *Step 2(b), Fishery Governance and Privileges.* What governance structures exist, and how might the distribution of resource privileges support or hinder stakeholder incentives to cooperate and internalize conservation efforts? *Step 2(c), Port Cluster Community Attributes.* Which geographical locations, evaluated as groups of port clusters, might promote successful cooperative strategies?

To inform each step in the inquiry-driven integrative framework, we conducted a comprehensive evaluation of published literature, government reports, gray literature, interviews, and expert opinion. This work built on previous efforts to evaluate existing management institutions (Schlager and Ostrom, 1992; Yandle, 2007) and to define resource and community attributes that influence the success or failure of cooperative strategies (Ostrom and Becker, 1995; Noble, 2000; Pomeroy, 2000; Satria and Matsuda, 2004; Beem, 2006; Soreng, 2006; Chuenpagdee and Jentoft, 2007; Yandle, 2008).

Step 2 offers insight into the nature of the biological resource and catch patterns, the nature of governance and harvest privileges, and the relative distribution of different attributes across geographic regions. Different geographic regions have different community characteristics, some of which have important implications for cooperative management outcomes (e.g., level of organization, participation in fishery, leadership, amount of cooperative research, research capacity, demand for reform, value of the resource, government oversight, prior experience with cooperative strategies, and level of conflict; Table 3). From this multiattribute analysis, we mapped the distribution of critical attributes of cooperative management in California to illustrate where efforts to change to cooperative strategies may prove effective.

Step 3: Integration and Implementation

We developed recommendations for the implementation of cooperative strategies in the California nearshore fishery by assessing gaps and needs revealed in Step 1, by looking at barriers and opportunities revealed in Step 2, and finally by integrating the answers to the questions posed across scales.

Each step in the integrative framework feeds into the next to inform the decision-making process for establishing cooperative management strategies. The analysis of the California nearshore fishery incorporated three major realms of fisheries that are often evaluated in isolation rather than in integrated fashion: the resource and the science, the fleet and its management, and the socioeconomics of communities that support the fishery. These three domains appear to constitute the most influential aspects of the decision-making process. The framework is flexible and can be applied to fisheries that operate on many different scales.

Results

Step 1: Opportunity Assessment

Although empirical evaluations of the performance of cooperative strategies in meeting fishery challenges are rare, the literature indicates some success (Table 2).

Generally, federal and state regulation for the nearshore fishery uses top-down policy tools that operate on large scales. Even though the institutions are hierarchical, they include few feedback mechanisms that would facilitate the adaptation of large-scale policies to accommodate local concerns or interests. Conventional management therefore clusters at the top of the ordination triangle diagram in Figure 1.

Comanagement arrangements fall within the oval (depending on the specific fishery and its contextual setting). Examples of comanagement from other fisheries indicate smaller operational scales driven by individuals at local levels, involve flat hierarchies (minimal bureaucracy), and use input controls that restrict how and when fish are caught (rather than relying heavily on output controls, like quotas, already in use; Ruddle, 2007). The California nearshore fishery does not currently employ such bottom-up management efforts, although a need and opportunity exist (Fig. 1).

Comanagement can involve bottom-up decisions that flow through the bureaucratic chain of command before they are incorporated into the formal fisheries-management process—for example if management authority is not devolved to a local

Table 3. Port-cluster analysis. Of the wealth of community attributes listed in the literature as influencing the success or failure of cooperative strategies (Ostrom and Becker, 1995; Noble, 2000; Pomeroy et al., 2001; Satria and Matsuda, 2004; Beem, 2006; Soreng, 2006; Chuenpagdee and Jentoft, 2007; Yandle, 2008), we focused on those likely to have positive influences on planning the implementation of cooperative strategies. The characteristics and metrics used were chosen on the basis of availability of information on all or most of the port clusters. The nine port clusters were ranked for each characteristic (9 highest, 1 lowest). The number in parentheses after each rank is that port cluster's raw score for that characteristic; the metrics used are given in Table 1. Level of interest is "Level of interest in nearshore fishery." The rankings for characteristics designated "undefined" for the northern port clusters may have been unfairly discounted, but we removed those characteristics from the final score to minimize this effect. The final scores were scaled on an index from 1 through 100 and designated low, medium, or high on the basis of the scaled final scores. We believe the low, medium, and high ranks are more appropriate for the resolution of the analysis than specific port-cluster scores. Use of a state-wide scale limited a comparative analysis of the contextual and informal subtleties at work within each port cluster.

	Port cluster								
Characteristic	Eureka	Fort Bragg	Bodega	San Francisco	Monterey	Morro Bay	Santa Barbara	San Pedro	San Diego
Organized communication[a]	4 (0)	5 (1)	5 (1)	8 (5)	7 (4)	6 (3)	9 (9)	6 (3)	6 (3)
Marketing organization[a]	4 (0)	5 (1)	5 (1)	9 (9)	7 (4)	6 (2)	8 (6)	6 (2)	6 (2)
Level of interest[b]	1 (1.1)	4 (2.1)	3 (1.9)	2 (1.7)	6 (3.4)	8 (8.7)	9 (8.8)	7 (3.8)	5 (2.9)
Participation[c]	6 (0.5)	6 (0.5)	6 (0.5)	6 (0.5)	7 (1.5)	8 (2.5)	9 (4.5)	7 (1.5)	7 (1.5)
Leadership activity[d]	7 (7)	5 (5)	2 (2)	7 (7)	7 (7)	9 (9)	8 (8)	6 (6)	9 (9)
Demand for reform[d,e]	5 (5)	5 (5)	7 (7)	8 (8)	8 (8)	9 (9)	8 (8)	3 (3)	7 (7)
High-value resource[b]	1 (0.47)	5 (1.09)	3 (0.72)	4 (0.84)	2 (0.68)	8 (1.51)	6 (1.34)	9 (1.57)	7 (1.39)
Technical support[f]	undefined	undefined	8 (10)	6 (3)	9 (13)	5 (2)	5 (2)	6 (3)	7 (6)
Monitoring support[f]	undefined	undefined	6 (43)	8 (53)	7 (45)	5 (17)	9 (65)	4 (10)	3 (5)
Need for capacity reduction[g]	6 (12)	7 (19)	7 (19)	7 (19)	9 (38)	9 (38)	8 (32)	8 (32)	8 (32)
Oversight[b]	yes	yes	yes	yes	yes	yes	yes	yes	yes
Prior experience[d]	7 (0)	7 (0)	7 (0)	9 (2)	7 (0)	9 (2)	8 (1)	7 (0)	8 (1)
Positive history[d]	7 (–1)	8 (0)	9 (1)	8 (0)	8 (0)	9 (1)	8 (0)	7 (–1)	8 (0)
Total of ranks	48	57	54	68	68	81	81	66	71
Total/number scored	4.36	5.18	4.15	5.23	5.23	6.23	6.23	5.08	5.46
Index, scale of 1–100	10	49	1	52	52	100	100	44	63
Qualitative index	Low	Medium	Low	Medium	Medium	High	High	Medium	Medium

[a] NMFS (2007); [b] CDFG (2002); [c] WCCRAHWG (2005); [d] R. Fujita; [e] Culver et al. (2007); [f] CDFG (2005, 2007b, 2008b); [g] CDFG (2007a)

management entity—but current institutions provide little or no support for such a process and information flow. Data collected through cooperative research programs is typically referenced to small spatial scales and therefore cannot be used in stock-assessment models currently used to determine total allowable catch (TAC) for larger stocks of fish (Gunderson et al., 2008). Too often, cooperative efforts "bounce off" the large-scale regulatory structure, disenfranchising fishermen, who view these efforts as wasted.

Figure 1 shows the relatively large opportunity area for implementing cooperative strategies in the California nearshore fishery. In California, most management regulation comes from the top down in the form of state or federal mandates, complicating development of cooperative strategies at small scales but at the same time leaving plenty of opportunity for cooperative approaches to complement existing regulations at the other end of the triangle. Potential exists for cooperative programs to emerge and work in tandem with existing regulatory structures.

Step 2: Biophysical Resource Conditions, Catch, and Data

California's nearshore fishery is largely composed of individual fishermen operating small vessels in shallow water using set hook and line and trap gear. Limited access was established in 1999, and 1184 permits were issued. Because of overcapacity concerns, regional capacity goals were established, and a permit-attrition program was implemented. As of 2007, 185 nearshore permits and 239 deeper nearshore permits existed (CDFG, 2008c).

Fishermen operate close to port, and many keep fish alive upon return to port. Distributors pay premium prices for these live fish in order to deliver the freshest product to market. Most species harvested in this fishery are sedentary, reef-dwelling fish with high demographic variability through space and time.

Given the multispecies nature of the fishery, the spatial variation in life history parameters, and the lack of historical catch and effort data, many of these species are poorly suited for assessments based on statistical catch-at-age models (Orensanz et al., 2005). Because some nearshore species have small home ranges and may exhibit substock structure, an assessment at a large spatial scale may misspecify productivity and sustainable yield at more local scales (Gunderson et al., 2008). Most of the 19 species managed under the Nearshore Fishery Management Plan (CDFG, 2002) have yet to be assessed and are managed by a precautionary approach (Restrepo et al., 1998). For these species, TACs are set at a fraction of historically stable landings. These strict limits on catch are perceived by managers as necessary for the rebuilding and conservation of depleted fish stocks. From an economic perspective, these limits are unviable, as fishermen can often land their entire two-month quota in a single trip (J. Colgate, commercial fisherman, pers. comm.). Trip limits, intended to extend the season, aggravate the effect of small TACs when they fall below a threshold defined by the ratio of fishing costs to potential revenue from the trip.

In addition to the limitations of the reduced two-month quota, the fishery includes considerable latent capacity; dozens of permits are left unused. As of 2007, only 74% of the shallow- and 71% of the deeper-water permits were active (CDFG, 2008c). Fishermen who regularly make landings cannot be assured that the two-month quota will be guaranteed to them if these unused permits are fished in a given season. When they are, the yearly TAC may be met before the end of the season, and the two-month quotas are severely reduced or the fishery is closed altogether.

One of the most important constraints on catch and opportunity in this fishery is the large recreational sector, which is managed with bag limits and seasons and is often given a higher percentage of the overall TAC than the commercial sector.

Step 2: Fishery Governance and Privileges

This part of our analysis characterized the formal institutional arrangements of the nearshore fishery. It incorporated Ostrom and Schlager's (1996) concept of property-rights bundles as a means of categorizing fishery permit structures into operational-level rights: access, withdrawal, exclusion, management, and alienation (Table 4). Yandle's (2007) approach added temporal, spatial, and quantitative dimensions to assess the quality of the property rights and interactions between competing interests. For our analysis, we modified the language of the original Yandle (2007) matrix from "property rights" to "fishery privileges," recognizing that inalienable property rights over public resources cannot be legally granted to fishermen in the United States (Parma et al., 2006). The term "privilege" accurately captures the ever-present possibility of revocation. In addition, the "withdrawal" and "alienation" privileges have been renamed allocation and transfer privileges, for consistency with the fisheries literature.

The five fishery privileges included in our analysis represent controls that governments or stakeholders may have over fisheries. Table 4 presents the five fishery privileges and California nearshore fishery permit and conservation regulations. Below, we first define the temporal, spatial, and quantitative dimensions of the fishery privileges, and then how they are secured, whether by fishermen or by the government. Fishery privileges must be secure if fishermen are to internalize conservation efforts (Wilen, 2006). The privileges observed to create incentives for sustainable harvest when held by fishermen are access, withdrawal, and management (Ostrom and Schlager, 1996).

Secure Fishery Privileges.—In general, the California nearshore fishery permit holders have not secured enough fishery privileges to have a sufficient incentive to internalize conservation efforts. They hold only access and allocation privileges, whereas exclusion, management, and transfer privileges are primarily held by the government (Table 4). For fishermen to feel secure about the fishery privileges that they currently hold, which must be renewed annually, they must trust that they will be able to secure them in the future and that the government is taking the appropriate management actions to improve the quality of their fishery privileges into the future. The instability in the two-month quota and the potential for the TAC to be met before the end of the season and to result in loss of fishing opportunity instills distrust, reduces the transparency of the management process, and reduces the quality and value of fishing privileges.

Transferability.—Permit holders with transfer privileges have greater incentive to conserve the resource, because the permit can be leased at higher prices when resource conditions are good. Such privileges can be argued to confer limited exclusion privileges, in that the holders can choose whether or not to transfer or lease their access and allocation privileges. Therefore, transferable permits can lead to greater harvester security, but the strength and value of these privileges remain low because the permits must be renewed annually.

Limited Entry, Restricted Access, Limited Access Privileges.—Exercise of the exclusion privilege has very important implications for the security of privileges in a

Table 4. Characteristics of and privileges conferred by permits in the California nearshore fishery (CDFG, 2008a). Privileges are defined as follows: access, the privilege of entering the fishing ground or area; allocation (withdrawal), that of extracting the resource; exclusion, that of determining allocation and preventing others from fishing; management, that of making regulatory changes or improvements; transfer (alienation), that of leasing or selling management and exclusion privileges. Ostrom and Schlager (1996) observe that resource users, such as fishermen, will only have sufficient incentive to harvest sustainably if and when (at minimum) the resource users themselves hold certain key privileges, namely, access, withdrawal, and management, which are necessary, but not always sufficient, conditions for sustainable bottom-up management without external rules or top-down controls.

	Permit sector				
	Deeper nearshore fishery (nontransferable permits)	Nearshore fishery (transferable permits)	Nearshore fishery (by-catch permits)	Recreational permits	Protected areas
Privilege dimensions					
Time scale	Yearly, held until death	Yearly	Yearly, held until death	Presumed held in perpetuity	Variable (held in perpetuity or short-term)
Spatial scale	Regional, superseded by by-catch limits or other interests	Regional, superseded by by-catch limits or other interests	Not defined; anywhere not explicitly forbidden	Not defined; anywhere not explicitly forbidden	Well defined small areas
Quantitative metric	Metric tons	Metric tons	Metric tons	Individual limits make enforcement of collective limit difficulty; metric-ton limit	No-take zone; zero fishing mortality
Fishery privileges					
Access	Implicitly held by permit owner	Implicitly held by permit owner	Implicitly held by permit owner	Implicitly held by recreational-permit holders	Held by general public
Allocation (withdrawal)	Well defined; held by permit owner	Well defined for some species and not defined for others; held by permit owner	Well defined for some species and not defined for others; held by permit owner	Poorly defined collectively; explicitly held by recreational fishers	Held by government
Exclusion	Strictly exercised; held by government	Strictly exercised; government is primary holder; owners hold limited privileges collectively	Strictly exercised; held by government	Loosely exercised; held by government	Strictly exercised; held by government
Management	Held by government	Held by government	Held by government	Held by government	Held by government
Transfer (alienation)	Held by government	Government is primary holder; permit owner holds limited privileges	Government is primary holder	Held by government	Held by government

fishery. Exclusion of users from fisheries is especially difficult and usually requires expensive enforcement, but carefully constructed rules and sanctions that include a legal basis for exclusion can reduce competition for scarce resources, eliminate free-riding behavior that increases costs to those who conserve, and incorporate incentives for cooperation (Ostrom and Becker, 1995; Sutinen, 1999; Cohen, 2000; Beem, 2006). When the exclusion privilege is not, or is only loosely, exercised, the fishery is vulnerable to overcapitalization. In the nearshore fishery, limited entry has been established for the commercial fishery, making the commercial harvest capacity more manageable (CDFG, 2008c).

Exclusion privileges such as territorial use privileges, area-based quotas, or individual fishing quotas can create strong incentives for conservation and improve fishery performance (Costello et al., 2008), but the government's only loose exercise of its exclusion privilege over the recreational fishery may adversely affect improvements to the management privileges for the commercial sector. Without limits on the recreational sector, benefits expected to accrue through voluntary conservation efforts of the commercial sector may be dissipated as the commercial quota is affected by the take of the recreational sector.

Area-Based Approaches.—The fishing privileges of the commercial sector are limited to subregional rather than coast-wide scales, so tailoring of catch adjustments to subregional differences in ecosystem dynamics and changes in conditions may be possible. This scaling down of the management units can increase the incentives of commercial fishermen to cooperate and promote regional solutions, but the mismatch in spatial scales between the fishing privileges of the commercial and recreational sectors may counter such incentives. The coast-wide scope of recreational fishing privileges enable that sector to concentrate disproportionally on some areas.

In 1999 the state of California concurrently passed two laws, the Marine Life Management Act and the Marine Life Protection Act. The former provided a sustainability mandate and requirements to account for the effects of ecosystems on fisheries and vice versa; the latter initiated efforts to establish a network of marine protected areas (MPAs) along the entire coast of California. MPAs are an effective area-based tool for protecting biodiversity and allowing fish stocks to recover within their borders, but their current management presents some institutional barriers to achieving optimal conservation, social, and economic outcomes. All of the resource privileges for these areas are held by the state government, and the regulations override the fishery privileges of the fishermen. These measures reduce spatial access to the fishery and can potentially reduce fishing opportunity, thus reducing the value of fishing permits.

Mandates and Jurisdictions.—Sixteen species of the nearshore fishery are cross-listed with federal and state management plans and therefore complicate cooperative management options. Because the nearshore fishery is nested in the federal groundfish fishery, the state imposed a by-catch permit to track and limit take of nearshore species (regarded as by-catch in the federal fishery). These permits are nontransferable and expire upon death of the holder, but they must be reissued if future catches of nearshore species are to be tracked accurately, unless management of nearshore species is devolved entirely to the state. The federal groundfish sectors were not presented in Table 4 because the federal restrictions are not to supersede the more restrictive state regulations (NMFS, 2008).

In conclusion, our Step 2 top-down analysis suggests that significant barriers to cooperative strategies in the nearshore fishery exist, including insecure fishery privileges, temporal limitations on fishery privileges and their transferability, spatial mismatches in privileges between the recreational and commercial sectors, and regulatory complexity.

Step 2: Port Cluster Community Attributes

As Step 1 revealed, a niche may exist for cooperative strategies within the context of California fisheries management. California port regions differ significantly, however, so we examined the distribution of attributes identified by social scientists as likely to contribute to successful cooperative strategies. These are defined in Table 1.

We divided the coast into geographic areas based on the nine largest fishing ports along the west coast of California. Each of these nine regions contains a major port and smaller, surrounding ports that we grouped together as one port cluster (see Table 3 for full port cluster analysis). We drew on available literature, expert opinions, and stakeholder interviews to complete a matrix of community attributes, management attributes, and context within which each port cluster operates.

The state-wide scale imposed limits on the resolution of the analysis, so the matrix-assessment results are presented in a low-resolution fashion in Figure 2, to reflect the confidence in our assessment as an accurate depiction of a given port cluster's aptitude for implementation success. Larger circles represent more favorable community attributes, according to our metrics. The Santa Barbara and Morro Bay port clusters seem the most opportune locations for initiation and further investigation of place-based cooperative strategies.

Step 3: Integration and Implementation

The major results from Steps 1 and 2 are that (a) a niche exists for cooperative strategies in California and (b) the small-scale nearshore fishery centered in Santa Barbara has many attributes thought to be conducive to cooperative management. Given existing regulatory structures, bottom-up and community-based management systems are likely to be difficult to implement in California, as minimal legal authority currently exists for fishery management at local scales, but the history of cooperative research in the nearshore fishery, together with the emergence of new stock assessment methods that can make use of data collected at local scales and the existence of fishery regions for the nearshore fishery, creates a window of opportunity.

Strengthen Stakeholder Privileges.—From our Step 2 analysis, we conclude that incentives exist for commercial fishermen to design cooperative strategies voluntarily within the current formal institutional structures of the California nearshore fishery, but these incentives are weak. Aggregating stakeholder input across the full spatial extent of the fishery is likely to produce confusion and gridlock in making rule changes.

Devolving authority over fishery management privileges to stakeholder organizations, while the government sets performance standards and requires adherence to them, is one way to strengthen stewardship and cooperation incentives (Yandle, 2008). To have sufficient incentive to conserve and make decisions collectively, stakeholders must enjoy secure access, management, and exclusion privileges (Ostrom and Schlager, 1996). Therefore, government-imposed performance standards must

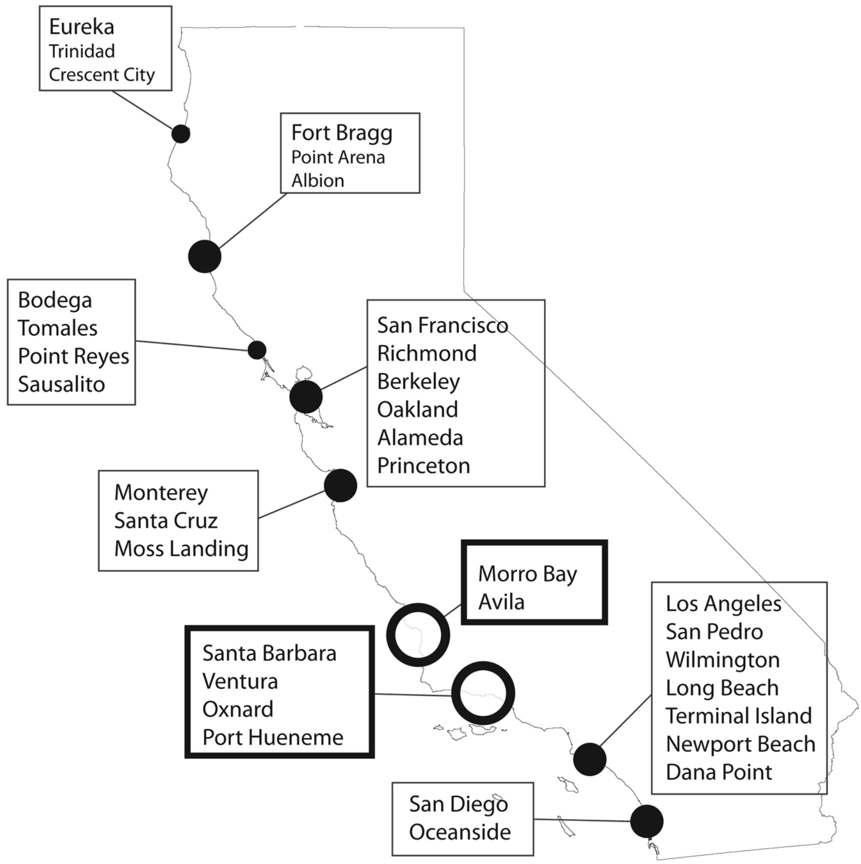

Figure 2. Ranking of the nine California port clusters by their relative potential for achieving successful cooperative management strategies. The rankings were based on an integrated analysis examining social, biological, and political characteristics of the port cluster (Table 3). Larger circles indicate higher potential for success.

provide flexibility for variations in operational rules at local levels for decentralized, cooperative approaches to influence harvester incentives effectively (Agrawal and Ostrom, 2001).

The California Nearshore Fishery Management Plan authorizes the management of regions, providing a clear way to match the scales of fish subpopulations, stock assessments, fishing communities, and management measures (CDFG, 2002). Creation of formal comanagement institutions nested within the state's regional management system would give permit holders considerably greater access to management by reducing competition for time (to express concerns and offer solutions) at meetings and the travel costs to attend, but such institutions must provide a means for officials to support informal rules that address local issues rather than waiting until conditions warrant formal rule changes for the management areas at large.

Extending the duration of existing stakeholder fishery privileges presents another means of providing stewardship incentive. Because the current one-year term is too short to allow nearshore populations to replenish themselves, permit holder cannot necessarily benefit from their own conservation actions. Allocation privileges held in perpetuity or until transferred have been identified as providing greater incentives to sustain fishery resources over time (Costello et al., 2008). These types of privileges are often administered as catch shares and are defined as a proportion of the TAC. Catch shares could be allocated either to individuals or to cooperatives fishing under subregional TACs. Strengthening allocation privileges without devolving management and exclusion privileges requires stringent oversight mechanisms to ensure that fishermen are accountable to the state. In most catch-share systems, observer coverage, port sampling, and catch-accounting efforts are all greater than those needed in open-access or limited-access systems (Sutinen, 1999; Agrawal and Ostrom, 2001; Townsend et al., 2006).

Integrate MPA Management with Fishery Management.—Cooperative strategies that allow fishermen to benefit directly from MPA spillover (for example spatially restricted licenses or TURFs near MPAs) may increase fisherman support for MPAs and create incentives for MPA stewardship. In addition, extending the temporal limit on stakeholder fishery privileges (catch shares are one example) could reduce the perceived impact of conservation areas on access and allocation privileges, as the long-term benefits would become incorporated into the asset value of the permit or quota. Greater involvement of fishermen in the management of conservation areas could offset incentives to poach there. MPAs may become useful for establishing reference conditions against which stock status can be measured, but their direct use in setting harvest guidelines has only recently been addressed (Wilson et al., in press). Because MPAs are located in the nearshore environment, novel approaches to setting harvest levels at local scales for the nearshore fishery may in fact be possible through the use of MPAs as proxies for unfished populations. Comparison of the density of fish and other metrics in the fished population to those inside MPAs can allow managers to increase or decrease effort or harvest to achieve a reference point set at some fraction of the MPA indicator (A. MacCall, National Marine Fisheries Service, pers. comm.). These types of methods provide simple approaches to assessing fish populations and managing fishing effort while increasing the transparency and understanding of the stock-assessment process. Moreover, local MPA-based assessments and management can result in smaller-scale infrastructure, potentially increasing management's responsiveness to environmental variations and threats to sustainability of smaller-scale metapopulations of the resource.

Reduce Regulatory Mismatches and Complexity.—Mismatches in the spatial qualities of subregional commercial and coast-wide recreational fishery privileges can contribute to conflicts over fishery resources (Yandle, 2007). Currently, the nearshore recreational catch limits can be adjusted by region, but without any limits on the number of participants, aggregate recreational catches are difficult to project and track. The current coast-wide extent of recreational fishery privileges allows the recreational sector of the fishery to move freely from one region into another, and if it concentrates on narrowly distributed species and is not accurately monitored, as is the case in the nearshore fishery, serial depletion could result (Berkes et al., 2006). Such an occurrence or window of opportunity may reduce a regionally based commercial sector's willingness to conserve or make improvements on regional fishing grounds because the rewards might not be realized. Requiring recreational fishers to obtain regional stamps would allow better predictions of fishing pressure on regional resources and catch adjustments during the season tailored to regional conditions.

Matching spatial scales by strengthening regional controls will lead to stronger feedback between conservation and management actions (Wilson, 2006).

The federal west-coast groundfish fishery and the California nearshore fishery are also spatially mismatched. Regionalizing the groundfish fishery catch limits or devolving authority over the nearshore species to regional or subregional comanagement entities of the state are recommended strategies for reducing conflicts between sectors and improving opportunities for fishermen to cooperate and capture benefits of local conservation efforts.

Next Steps

We recommend first encouraging cooperative efforts where they are most likely to be favorably received and therefore effective. Our results (Fig. 2) indicate that Morro Bay and the Santa Barbara Channel Islands port clusters of the nearshore fishery have many community attributes and external support characteristics that may bolster cooperative research, comanagement, and the integration of scales to improve overall fishery management. We therefore propose the following strategy for planning and implementing cooperative strategies in this fishery.

1. Develop a localized population-assessment model. A number of models can potentially be used to manage at local scales. One promising alternative is the decision-tree approach developed by J. Prince and collaborators (Davies et al., 2007), which can be modified to incorporate MPA data as a proxy for unfished biomass (Wilson et al., in press) for establishing sustainable harvest guidelines.

2. Develop outreach and engagement processes aimed at fishermen. This process will include the cooperative development of protocols for cooperative research, which will ensure that the right kinds of data (those that will drive the stock-assessment model) are collected. It should also include formalized agreements to protect the interests of researchers and fishermen and to define clearly the roles and responsibilities with respect to experimental design; collection, analysis, and synthesis of data; communication; and use of the results.

3. Overcome barriers to incorporating smaller-scale information and assessments into larger-scale management systems by developing a formalized process through which California's resource management agency (Department of Fish and Game) can assess, vet, and accept the results of nonconventional, spatially explicit assessments and cooperative research programs (K. Phipps and R. Fujita, Environmental Defense Fund, and T. Barnes, California Department of Fish and Game, in review).

4. Investigate the potential for the development of a comanagement entity by assessing the local-level fishery needs and matching informal institutions of port-cluster communities with potential benefits and drawbacks of a formal comanagement arrangement.

Conclusion

In striving for future sustainability, fisheries science and management can benefit from systematic assessment of challenges and potential cooperative solutions in which questions are posed and answered at different scales and integrated across scales. We believe our integrative approach will be particularly useful to managers at relatively small scales, primarily from local to regional governance. The approach can, however, be applied at a variety of scales to any fishery or region for evaluation of management outcomes, trends, and opportunities across scales.

Our analysis revealed opportunities for cooperative research and comanagement efforts to complement (but not replace) existing top-down regulation by federal and state fishery managers by (a) collecting data at the appropriate spatial scales; collecting local information, improving the quality of data, and overcoming constraints on data; providing ecosystem insight from a small/local scale for new and different perspectives; reducing conflicts among fishermen, scientists, and regulators; and improving the responsiveness of fisheries management to local needs.The benefits of cooperative strategies extend the capacity of conventional methods to manage fishing mortality and maintain economic viability. Each of these will be shaped by specific research and management goals. For the California nearshore fishery, we suggest that scientists and managers further integrate cooperative strategies (e.g., cooperative research and comanagement) into the management framework. We recommend a strategy for achieving this integration.

Cooperative strategies cannot be developed unless conflicts are overcome. They cannot be expected to solve all problems that plague fisheries, and cooperative strategies are clearly no silver bullet. Moreover, cooperative approaches produce no one-size-fits-all solution. The specific institutional arrangements and organizational attributes of individual fisheries should be carefully considered in tandem with their resource protection needs. The results of our evaluation and those of many others comport with experience: cooperative strategies can help managers and stakeholders of smaller-scale fisheries complement existing regulations and overcome many of the current challenges of fishery management.

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