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A Comparison of Conservation Perspectives Between Scientists, Managers, and Industry in the West Coast Groundfish Fishery

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human dimensions

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ABSTRACT

There are several assumptions regarding the behavior and motivations of participants in fishery management that may hinder the effectiveness of the management process. In this research, we examine whether the commercial fishing industry is a homogeneous group whose decision-making is dominated by short-term economic considerations to the detriment of long-term resource conservation. Mail surveys were sent to scientists, managers, and industry members in the West Coast groundfish fishery to examine attitudes on conservation, resource abundance, and biological risk. Results demonstrate that although scientists and industry considered themselves conservation-minded, scientists were relatively critical of industry's conservation ethic. Scientists and industry differed strongly in their perception of resource abundance, but found common ground in their assessments of acceptable levels of biological and economic risks. In general, industry demonstrated considerable diversity in their responses, contradicting assumptions that industry is a monolithic group with little regard for resource conservation. Results indicate a disjuncture between industry's stated concerns and their observed participation in discarding, over-harvesting, or habitat destruction. However, this disjuncture may be the result of misaligned institutional incentives, rather than myopic values and beliefs. This evidence suggests a need to redesign institutions and property rights in order to align the interests of industry, scientists, and managers in conducting effective science and sustainably managing the West Coast groundfish fishery.

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Introduction

Some commonly held assumptions about the attitudes, perceptions, and behavior of members of the commercial fishing industry have been challenged in recent years. In particular, some analysts question the assumptions that presume a homogeneous or shortsighted industry (Hanna and Smith 1993; Clay and McGoodwin 1995; Young et al. 1996). The influence of these assumptions cannot be understated: they underlie models of common property resources including Hardin's (1968) "The Tragedy of the Commons" and the Gordon-Schaefer model of fishery exploitation (Hanna and Smith 1993; Young et al. 1996) and contribute to pervasive misconceptions among many scientists and managers that industry is not concerned about long-term resource sustainability (Thomson 1984; Pringle 1985). The latter notion is particularly disconcerting in that it may subconsciously impact scientists' objectivity in their research (Pringle 1985) or may be factored into the consideration or rejection of certain management strategies. It may also adversely inform scientists' and managers' fundamental opinions of industry members and increase the likelihood of confrontation among these groups (Pringle 1985). These misconceptions can intensify tension among already-strained relationships and hinder innovative developments including cooperative management and research.

Some facts could be interpreted to indicate that industry does indeed have little interest in the long-term conservation of the resource. The United Nations' Food and Agriculture Organization (FAO) estimates that almost 70% of the world's commercially harvested fish stocks are fully exploited, overexploited, depleted, or rebuilding (Mace 1996). Global discard of marine species has been estimated at 27 million metric tons, or nearly one-third of total landings (Alverson et al. 1994). In a survey of environmental beliefs in British Columbia, Edgell and Nowell (1989) found that commercial fishermen almost uniformly disagreed with statements suggesting there are limits to nature's ability to support mankind and that humans have negatively impacted the environment, while they almost uniformly agreed with statements suggesting nature's primary function is to serve humans. Hillis and Whelan (1994) determined that discount rates of Irish fishermen were high enough to render the short term harvest reductions necessary for rebuilding overfished stocks unacceptable to fishermen, despite promises of future harvest increases. Brugge and Holden (1991) observed that commercial fishermen are inclined to employ every scientific argument that appears to support larger harvests but ignore evidence that points to declining stocks.

The perception that industry has a socially inappropriate conservation ethic or narrow time horizon appears to be widely, though not universally held among fishery scientists and managers (Pringle 1985). How is this reconciled with the increasing body of literature that suggests industry is very concerned with the long-term sustainability of the resource (e.g., Gallagher 1987; Hanna and Smith 1993; Acheson and Steneck 1997)? Hanna and Smith (1993) argue that there is often a disjuncture between fishermen's stated attitudes and their observed behavior and suggest that this may be the result of institutional systems that reward myopic behavior such as high-grading and exceeding quotas. Given the considerable variability in industry's income from year to year and the risk of insolvency during periods of low income, Lane (1988) suggests that economic survival is the overriding factor in capital investment decisions. If concern for economic survival also influences fishing decisions, one might expect to observe unsustainable and potentially harmful behavior from industry members who profess an interest in long-term stock conservation. Another possible explanation is that industry is simply skeptical of scientists' predictions of stock status. Francis and Shotton (1997) provide a hypothetical example of industry members supporting a management plan that projects one large initial harvest, followed by subsequent smaller harvests, versus a plan that projects sustained, medium-level harvests. Scientists and managers may interpret this behavior as evidence of industry's high discount rates, although it may really indicate industry simply does not trust the scientists' contention that low harvests will necessarily follow the large initial harvest, or that scientists can accurately predict a period of sustained, medium-level harvests. In addition, fishermen that take issue with assessment results, or with what they perceive as unwarranted conservatism by management, may feel justified in violating the precepts of those management plans (Rice and Richards 1996). Another possible explanation for the apparent dichotomy in stated attitudes and observed behavior may be industry's recognition of the need for conservation, but with the belief that some "other" group is more responsible for the stock declines (e.g., other gear groups, tribal groups, sport fishermen, marine mammals) (Walters 1995).

As interest in cooperative research and co-management programs increases, it is important to identify prevailing attitudes and perceptions of key fishery interest groups and how they may affect the programs' potential for success. A strong working relationship based on mutual trust, open communication, and common goals is essential to develop successful cooperation among scientists, managers, and industry (Bartenuk and Louis 1996). Harboring distrust or cynicism toward other participants in a cooperative management or research program can undermine support for the program and ultimately diminish its chances for success. In the West Coast groundfish fishery, some industry representatives have commented that they believe scientists' perceptions of fishermen's views on conservation have harmed the industry-scientist working relationship (B. Fisher, Midwater Trawlers Cooperative, pers. comm., S. Bodnar, Coos Bay Trawlers Association, pers. comm.). In order to develop a better understanding of the range of perceptions about conservation and resource health held by fishery stakeholders and the potential impact of these perceptions on science and management, we developed three goals for this research: 1) determine the attitudes toward conservation and resource use held by scientists, managers, and industry members in the West Coast groundfish fishery; 2) assess the perceptions these groups have of each other's beliefs and motivations on these issues; and, 3) identify and describe the implications of these attitudes and perceptions for the management of the fishery.

Methods

In March and April 1997, six focused discussions were conducted with industry, managers, and scientists in the West Coast groundfish fishery. Two scientist-manager meetings were held in Newport, OR and Tiburon, CA. Four industry meetings were held in Crescent City, CA, Coos Bay, OR, Newport, OR, and Astoria, OR. Eighteen scientists and managers from universities and federal and state agencies and 28 industry members participated and collectively responded to 10 questions on cooperative research, working relationships between industry and scientists, important trends in the fishery, and general science and management issues. These discussions were held to define key issues within the fishery related to cooperative research and to provide information for designing a written mail questionnaire.

Results from the focused discussions and other background information were used to design a questionnaire which was mailed to: 1) all owners of limited-entry permits in the U.S. West Coast groundfish fishery; 2) selected owners and managers of groundfish processing plants; 3) all known state, federal, and university scientists and researchers involved in U.S. West Coast groundfish issues; 4) members of the Pacific Fishery Mangement Council (PFMC) and its panels; and, 5) Sea Grant extension agents in Washington, Oregon, and California.

A total of 915 surveys were mailed out including 502 to fishermen, 55 to processors, and 348 to scientists, managers, and Sea Grant extension agents. Each of these four major groups received a slightly different version of the questionnaire with changes in question wording appropriate to each group. The initial survey mailing occurred in May 1998. Reminder cards were mailed to non-respondents in June 1998, and a second mailing was administered in July 1998. The overall response rate for the survey was 55.1%: 43.6% for fishermen, 50.0% for processors, and 72.9% for scientists and managers. All individuals received a custom-made groundfish cap for returning a questionnaire.

Survey questions were developed based upon our interpretation of the key themes synthesized from the literature and the six focused discussions. Questions used a four- or five-point ordinal scale to indicate respondents' level of agreement with or support of a particular issue. Space was provided for respondents to provide justification for their responses or other comments regarding the question. We also left considerable room at the end of the questionnaire and encouraged respondents to include any comments relevant to the issues raised in the survey.

One-way analysis of variance (ANOVA) was employed to examine differences in responses among groups (e.g., industry and scientists) as well as differences within these groups (e.g., gear type, agency affiliation, type of scientist, state of residence). Stepwise discriminant analysis was used to conduct multivariate analysis to indicate which variables were associated with differences among clusters of individuals formed as a result of their survey responses.

Results

Because the role of scientists and managers significantly overlapped, the responses of scientists and managers were aggregated in these analyses and are collectively referred to as "scientists." In most cases, the responses from fishermen and processors were aggregated and are collectively referred to as "industry." Table 1 describes some of the variables measured in the mail survey that are discussed in this article.

Table 1. Name, description, and scale of variables used in the cooperative research questionnaire.

Name	Description	Scale
age	Age in years.	Continuous
akfish[a]	Frequency of fishing in AK waters	Ordinal: (1) = "frequently;" (2) = "occasionally;" (3) = "rarely;" and (4) = "never"
crpotent	Cooperative research's potential to improve fisheries science	Ordinal: (1) = "significant potential;" (2) = "moderate potential;" (3) = "little potential;" and (4) = "no potential"
educ	Level of formal education	Ordinal: (1) = "H.S. diploma or less'" (2) = "some college, degree from technical or junior college;" (3) = "Bachelors degree'" and (4) = "some post graduate education or post graduate degree(s)"
family[a]	No. members of immediate family involved in your fishing business	Continuous
income[b]	Gross family income	Ordinal: (1) = "less than 25,000;" (2) = "25,000–49,999; (3) = "50,000–74,999;" (4) = "75,000–99,999;" (5) = "100,000–299,999;" (6) = "300,000–599,999;" (7) = "600,000–1 million;" and (8) = "more than 1 million." Figures in U.S. dollars
industry	Indicates respondent works in the commercial fishing industry	Binary: (0) = "no"; and (1) = "yes"
invlv	Degree of involvement in the management process	Ordinal: (1) = "very involved;" (2) = "somewhat involved;" (3) = "not very involved;" and (4) = "not at all involved"
length[a]	Length in feet of respondent's most important boat	Continuous
longline[a]	Indicates primary gear type is longline.	Binary: (0) = "no"; and (1) = "yes"
pcntfsh[a]	% of family income derived from your fishing business	Ordinal: (1) = "less than 10%;" (2) = "10%–24%;" (3) "25%–49%;" (4) = "50%–74%;" (5) = "75–95%;" and (6) = "95%–100%"
permown[a]	No. fishing permits owned	Continuous
pot/trapa	Indicates primary gear type is pot/trap	Binary: (0) = "no;" and (1) = "yes"
remain	Length of time respondent plans to remain involved in the fishery	Ordinal: (1) = "less than 6 months;" (2) = "6 months to less than 1 year;" (3) = "1 year to less than 2 years;" (4) = "2 years to less than 5 years;" (5) = "5 years to less than 10 years;" (6) = "10 years to less than 20 years;" and (7) = "more than 20 years"
stateCA	Respondent resides in CA	Binary: (0) = "no"; and (1) = "yes"
stateOR	Respondent resides in OR	Binary: (0) = "no"; and (1) = "yes"
stateWA	Respondent resides in WA	Binary: (0) = "no"; and (1) = "yes"
trawl[a]	Indicates primary gear type is trawl	Binary: (0) = "no"; and (1) = "yes"
wcgfyrs	Years involved in West Coast groundfish fishery	Continuous

[a] Applicable for fisherman respondents only

[b] Applicable for fisherman and scientist respondents only (excludes processors)

Conservation Ethic

Table 2 summarizes the attitudes of scientists and industry respondents towards their own conservation ethic (i.e., attitude toward the long-sustainability of marine fish stocks), their perceptions of the conservation ethics of their peers, and their perception of the conservation ethics of the "other" group (i.e., industry indicates their perception of scientists' conservation ethic and vice versa).

Both scientist and industry respondents rated their own personal conservation ethics very highly; however, there was a small, but statistically significant difference between the groups. We used a stepwise discriminant analysis of all respondents to identify variables that distinguished individuals with lower self-stated conservation ethics from those who claimed higher conservation ethics. At each step, discriminant analysis evaluates the "predictor" variables and selects the one that best distinguishes one group from the other until none of the remaining predictor variables contribute significantly to the groups' differences. Table 3 indicates that the best discriminator between these groups was degree of involvement in the fishery management and planning process: respondents with higher conservation ethics tended to be more involved in the management process than those with lower conservation ethics. This suggests an intuitive, positive correlation between one's level of involvement in the management process and one's professed concern for long-term stock sustainability among both scientists and industry respondents. Table 4 summarizes a discriminant analysis of fishermen respondents and indicates that fishermen with lower conservation ethics were more likely to reside in California, and fishermen with higher conservation ethics planned to remain involved in the fishery longer than those with lower conservation ethics. Consistent with intuition, fishermen with longer anticipated tenures in the fishery claimed higher conservation ethics than fishermen who planned to leave the fishery sooner, suggesting lower discount rates among the former group. The finding that California fishermen had lower conservation ethics than other fishermen is difficult to interpret and may reflect regional issues of which we are not aware.

Industry respondents rated scientists' conservation ethics highly, but not as highly as their own (Table 2). Scientists, in rating their colleagues, also indicated a fairly high conservation ethic for this group. Industry respondents displayed far more heterogeneity in their responses than did scientists, as evidenced by larger standard deviations. Table 4 indicates fishermen with higher opinions of scientists' conservation ethic tended to fish more frequently in Alaskan waters than those with lower opinions of scientists' conservation ethic. The influence of frequency of fishing in Alaska was somewhat unexpected and may indicate that exposure to different management systems and personnel influences one's perceptions of scientists and their motivations.

Industry respondents rated fellow industry members' conservation ethics a full point lower on the five-point ordinal scale than they rated their own conservation ethic (Table 2). This supports Walters' (1995) argument that while industry members believe conservation of the stocks is necessary, the problem must reside with other sectors of the fishery. Scientists' perception of industry's conservation ethic was even lower still, with a rating between "moderate" and "somewhat weak." This response was expected and reflects comments made by many scientists during the focused discussions. However, during these discussions, a few scientists noted the role that management institutions can play in influencing industry behavior. In particular, they commented upon the incentive to discard created by management plans that employ trip limits in a mixed stock fishery. The larger standard deviation among industry responses reflects relatively greater heterogeneity in this group's opinion of themselves. Gear type was an important variable in discriminating respondents with higher and lower perceptions of other industry members' conservation ethics (Table 4). Those who indicated other industry members had higher conservation ethics were more often trawlers; conversely those who had lower perceptions of other industry members' conservation ethics were more often longliners. These differences among gear groups may be related to other findings from the survey that indicate non-trawlers perceived less trust within the industry than did trawlers. Subjective comments written in survey booklets indicated that some non-trawlers were concerned about trawlers' high discard rate and potential adverse impacts of trawl gear on bottom habitat.

Attribute	Mean score: Industry (sd)	Mean score: Scientists (sd)	F	p
Own conservation ethic	4.263 (0.787)	4.423 (0.636)	5.932	0.015
Scientists'/managers' conservation ethic	4.054 (1.104)	4.180 (0.639)	2.283	0.132
Industry members' conservation ethic	3.229 (1.093)	2.878 (0.860)	14.731	0.000

Table 2. Mean score and tests of statistical significance for scientists' and industry's attitudes on the long term conservation of marine fish stocks. Respondents were asked to indicate their perception of each group's conservation ethic towards all marine fish. Answer categories for each were (1) "very weak," (2) "somewhat weak," (3) "moderate," (4) "somewhat strong," and (5) "very strong."

Table 3. Summary of stepwise discriminant analyses of attitudes toward conservation and resource use for all survey respondents. Significance of F to enter the analysis was 0.050; for removal, 0.100. Prior probabilities of group membership were based on proportion of cases in each group.

	Variables in the analysis					
Attribute	**Name[a]**	**Step[b]**	**"1st Group" Mean[c]**	**"2nd Group" Mean[c]**	**Wilk's Lambda**	***p***
Own conservation ethic[d]	invlv	1	2.364 (55)	1.941 (354)	0.972	0.001
	industry	2	0.709	0.466	0.947	0.000
	remain	3	5.618	6.099	0.921	0.000
	crpotent	4	1.800	1.497	0.908	0.000
Scientists' conservation ethic[d]	industry	1	0.676 (74)	0.441 (324)	0.967	0.000
Industry members' conservation ethic[d]	industry	1	0.429 (268)	0.603 (131)	0.973	0.001
	remain	2	5.907	6.244	0.960	0.000
Views on biological risk[e]	industry	1	0.443 (341)	0.735 (68)	0.953	0.000
Are gear improvements masking symptoms of declining stocks?[f]	industry	1	0.339 (242)	0.763 (152)	0.829	0.000
Is scientific uncertainty/inadequacy or declining stocks the reason for reduced harvest guidelines?[g]	industry	1	0.797 (177)	0.242 (219)	0.696	0.000
Would industry participate in a cooperative research project that may limit their quota in the short-term?[h]	industry	1	0.567 (321)	0.177 (51)	0.928	0.000
	crpotent	2	1.467	1.863	0.893	0.000

Table 4. Summary of stepwise discriminant analyses of attitudes toward conservation and resource use for fishermen respondents. Significance of F to enter the analysis was 0.050; for removal, 0.100. Prior probabilities of group membership were based on proportion of cases in each group.

	Variables in the analysis					
Attribute	**Name[a]**	**Step[b]**	**"1st Group" Mean[c]**	**"2nd Group" Mean[c]**	**Wilk's Lambda**	***p***
Own conservation ethic[d]	stateCA	1	0.615 (26)	0.325 (123)	0.948	0.005
	remain	2	5.962	6.390	0.913	0.001
Scientists' conservation ethic[d]	akfish	1	3.605 (43)	3.020 (98)	0.956	0.013
Industry members' conservation ethic[d]	trawl	1	0.378 (90)	0.63 (54)	0.940	0.003
	remain	2	6.189	6.519	0.911	0.001
	longline	3	0.256	0.241	0.886	0.001
Views on biological risk[e]	pot/trap	1	0.226 (115)	0.059 (34)	0.968	0.028
Are gear improvements masking symptoms of declining stocks?[f]	invlv	1	1.867 (60)	2.212 (85)	0.958	0.013
	stateOR	2	0.300	0.459	0.923	0.003
Is scientific uncertainty/inadequacy or declining stocks the reason for reduced harvest guidelines?[g]	trawl	1	0.567 (104)	0.316 (38)	0.950	0.008
Would industry participate in a cooperative research project that may limit their quota in the short-term?[h]	remain	1	6.403 (134)	4.714 (7)	0.853	0.000
	crpotent	2	1.396	2.429	0.777	0.000
	invlv	3	1.963	3.143	0.737	0.000
	stateCA	4	0.381	0.143	0.716	0.000
	akfish	5	3.157	3.571	0.686	0.000

Notes for Tables 3 and 4

a Independent variables eligible to be included in the analyses: age, wcgfyrs, remain, educ, invlv, stateWA, stateOR, stateCA, industry, crpotent. See Table 1 for explanation of variables.

b Step variable was entered into the analysis.

c "1st Group" Mean is the mean of the first group in the discriminant analysis. "2nd Group" Mean is the mean of the second group in the discriminant analysis. Refer to each attribute and accompanying footnotes for grouping information. The parenthetical entries are the number of respondents in the "1st Group" or "2nd Group" in that particular analysis.

d Answer categories were: (1) "very weak," (2) "somewhat weak," (3) "moderate," (4) "somewhat strong," and (5) "very strong." Analysis discriminated respondents who selected (1), (2), or (3) vs. those who selected (4) or (5).

e See Figure 1 for description of answer categories. Analysis discriminated respondents who selected (1) or (2) vs. those who selected (3) or (4).

f Answer categories were: (1) "strongly agree," (2) somewhat agree," (3) "somewhat disagree," and (4) "strongly disagree." Analysis discriminated respondents who selected (1) or (2) vs. those who selected (3) or (4).

g Answer categories were: (1) "strongly agree," (2) somewhat agree," (3) "somewhat disagree," and (4) "strongly disagree." Analysis discriminated respondents who selected (1) or (2) vs. those who selected (3) or (4).

h Answer categories were: (1) "yes," and (2) "no." Analysis discriminated respondents who selected (1) vs. those who selected (2).

Biological Risk

Industry respondents indicated a somewhat more utilitarian attitude toward the economic and biological tradeoffs associated with the harvest of fish stocks (Figure 1). Although the difference in the mean responses for industry and scientists was statistically significant, it does not suggest radically different views regarding the biological and ecological risk to the stocks. In fact, industry respondents more often selected the most conservative response relative to scientist respondents. Gear type best discriminated between fishermen with more conservative and less conservative attitudes toward biological risk, with pot fishermen holding the most conservative views (Table 4). Although we urge caution in interpreting these findings, industry's responses do not suggest that, as a group, they place short-term economic benefit ahead of the long-term health of the stocks and ecosystem.

Views of Resource Abundance

Two survey questions were included to determine whether industry and scientists had fundamentally different views of resource abundance and whether they believed fishing pressure had negatively affected stock sizes. Figure 2 shows very significant differences between these groups' opinions of whether improvements in fishing gear and electronic equipment are keeping catch rates high and masking the symptoms of stock depletion. Discriminant analysis indicates fishermen that agreed with the idea that improvements in gear and electronics may affect one's perception of declining stocks tended to be more involved in the management process and less likely to reside in Oregon (Table 4). This finding may indicate greater familiarity among more-involved fishermen with logbook and fishery-independent data pointing to declining stocks and decreasing catch per unit effort (CPUE). The significance the state of residence plays in influencing perception of the resource status is not clear, but may suggest a greater awareness among Oregon residents of the assessment process and issues such as scientific uncertainty.

Scientists and industry held even more divergent views on whether actual declines in stock abundance are primarily responsible for recent reductions in harvest quotas or whether the reductions are simply a function of inadequate data and increasing emphasis on scientific uncertainty (Figure 3). Among fishermen, gear type best distinguished respondents who agreed or disagreed with the statement in Figure 3, and trawlers were more likely than the other gear groups to agree with the statement (Table 4). That trawlers were less likely to perceive reductions in harvest guidelines were due to real changes in stock size may indicate that they are not seeing evidence of declining stocks relative to fishermen using other gear types. This may be the result of trawlers' involvement in more abundant fisheries including the Pacific whiting (*Merluccius productus*) midwater trawl fishery. It may also indicate certain interactions between gear and stocks that affect actual or relative CPUE. The gear group differences may also indicate "strategic responses" among trawlers.

For both questions, scientists overwhelmingly perceived real declines in stock levels attributable to fishing effort, while industry tended to believe that the stocks are not declining or that scientific methodology may be partially responsible for indicating stock depletion, when no actual reduction is occurring. Industry discussants made statements that support these findings during our focused discussions. One possible explanation for this perspective is that industry members have a vested interest in finding weaknesses in scientists' assessments and "convincing" managers that stocks are large (even when they are not) in an attempt to influence management decisions in their favor. This is similar to Brugge and Holden's (1991) argument that industry understands that the best method to prevent adoption of disadvantageous harvest guidelines is to question the credibility of the science that underlies them. Neis et al. (1996) provided the possible explanation that industry members tend to develop a detailed knowledge of fish populations on a smaller spatial scale, while scientists are more concerned with larger-scale estimates of the entire stock. They suggest industry members will not support scientific findings which conflict with their own perceptions of fish abundance. The differences in scientists' and industry's responses may also be explained by the notion that firsthand industry observations of stock abundance are superior to the potentially biased and uncertain data and models employed by scientists and that the stocks genuinely are not declining. We also acknowledge the possibility that question wording may have had some role in influencing the responses to these questions, particularly the question which addressed improvements in fishing gear.

Short-Term vs. Long-Term Tradeoffs

We also tested the hypothesis that it is in industry's best economic interest to manipulate the perceptions of others in such a way that projects the appearance of high stock levels. Figure 4 indicates that a large majority of industry members would participate in a cooperative research project even if it resulted in a short-term reduction in the available harvest. Almost two-thirds of scientists also believed that industry would participate in such a project. While the group difference is statistically significant, this result suggests a more favorable opinion of industry by scientists than was evident in other questions. It also suggests that many scientists do not assume industry members are unconcerned with resource sustainability, but that management institutions and concern for economic survival may drive fishermen to participate in destructive practices. Discriminant analysis of all respondents indicates occupation (industry or scientist/manager) best differentiated those who believed industry would or would not participate in the hypothetical cooperative research project (Table 3). Respondents who believed industry would participate in the cooperative research project tended to have a higher opinion of cooperative research's potential for improving fisheries science. We found that respondents' attitude toward cooperative research's potential for improving fisheries science was an important predictor of survey response to several questions (some of which are not addressed in this article). We suggest that this may reflect a positive, "can-do" attitude that is manifested in a more optimistic perception of industry members and their ability to engage in scientific research.

Discussion

The findings in this research generally support other studies that have challenged the notion of homogeneous and shortsighted behavior in the commercial fishing industry (e.g., Pringle 1985; Hanna and Smith 1993; Acheson and Steneck 1997). We found significant diversity among fishermen on issues of conservation and resource use, with differences characterized by gear groups, state of residence, length of time one planned to remain involved in the fishery, and frequency of fishing in Alaskan waters. Other studies have documented heterogeneity within the Oregon trawl fleet based upon regional affiliation (Hanna and Smith 1993) and the distinct nature of the trawl fishery and its participants (Smith and Hanna 1993).

Although our results indicate industry members are concerned about long-term stock conservation and recognize the potential ecological risks of overfishing, scientists tended to have less optimistic

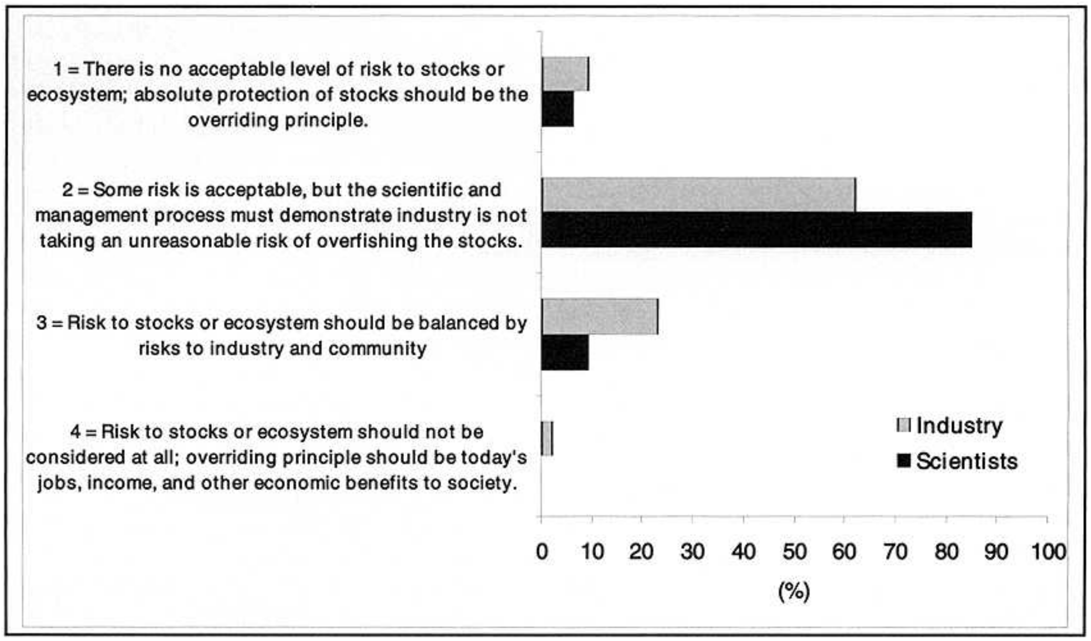

Figure 1. Scientist and industry respondents' views on the long-run conservation and use of marine stocks. Respondents were asked to indicate the statement that most closely reflected their own views. Industry mean = 2.185, sd = .607; scientist mean = 2.029, sd = .382. F2.472 = 11.296; p = .001.

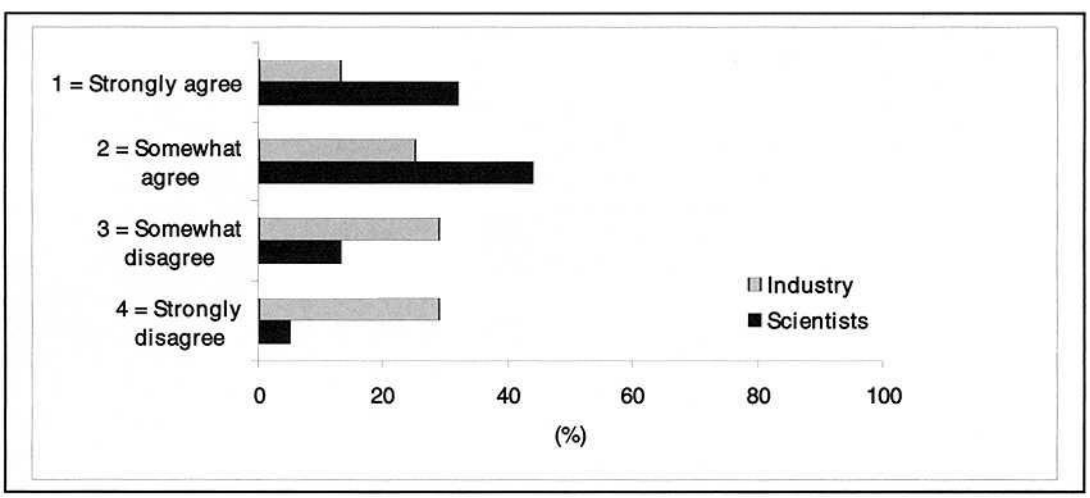

Figure 2. Scientist and industry respondents' views on the role of fishing gear improvements in the perception of stock declines. Data reflect response to the question: "Improvements in commercial fishing gear and associated electronic devices have improved the fleet's efficiency to the point that it is difficult for fishermen to see a decline in fish abundance because they are still catching lots of fish." Industry mean = 2.768, sd = 1.025; scientist mean = 1.903, sd = .825. F2,460 = 99.198, p = .000.

views of industry's conservation ethic. Interestingly, scientist and industry respondents' self-stated conservation ethics were higher than the ratings they attributed to each other and to their peers. This may indicate that both groups tend to believe the attitude and behavior of others, even among their colleagues, is more problematic than their own behavior (Walters 1995).

The vastly different responses of industry and scientists regarding their perceptions of the present state of the stocks may stem from fundamental differences in the groups' perspectives on the resource and their basic views of nature. Industry members' perspective of the resource is generally formed by their firsthand observations of stock abundance and behavior and may or may not be representative of the resource's health throughout its geographical extent. Scientists, on the other hand, typically base their perception of the resource on the analysis of information that should ideally represent the stocks' "true" condition; however, the accuracy and sufficiency of this information is often questioned (NRC 1998; Mace 1996). Acheson and Steneck (1997) and Weeks (1995) suggest industry members tend to be skeptical of the role that humans play in the population dynamics of marine systems, attributing fluctuations to "natural cycles," whereas biologists generally believe human activity can have considerable impact on stock size. Similarly, Smith (1995) believes scientists and industry fall into competing paradigms of world view: scientists tend to think linearly and perceive nature as a system with periodic order whose relationships can be understood (provided the appropriate information can be obtained); industry members tend to view nature as a system characterized by non-random, but unpredictable processes.

These contrasting perspectives and world views may influence not only their perceptions of the state of the resource, but also how it should be managed. Acheson and Steneck (1997) observed that biologists in New England favored controlling the amount of fishing effort as the primary means of managing the lobster fishery, but those authors concluded oceanographic conditions were the main cause of stock variability and that regulations which protect certain life history stages would be more effective. This case study may also indicate that both scientists and industry members tend to remain loyal to explanations and management strategies that favor their perspective at the expense of the perspectives of the other group. When asked to speculate about the causes of high variability in the fishery, some lobstermen offered an unusual explanation, attributing increases in population in part to the growing numbers of traps providing food (in the form of bait) for the lobster population. Conversely, some biologists tended to place the blame for periods of low harvests on excessive fishing effort, even in situations that had occurred 70 years ago where they had no firsthand knowledge of the declines. Many agency biologists have also been reluctant to aban-

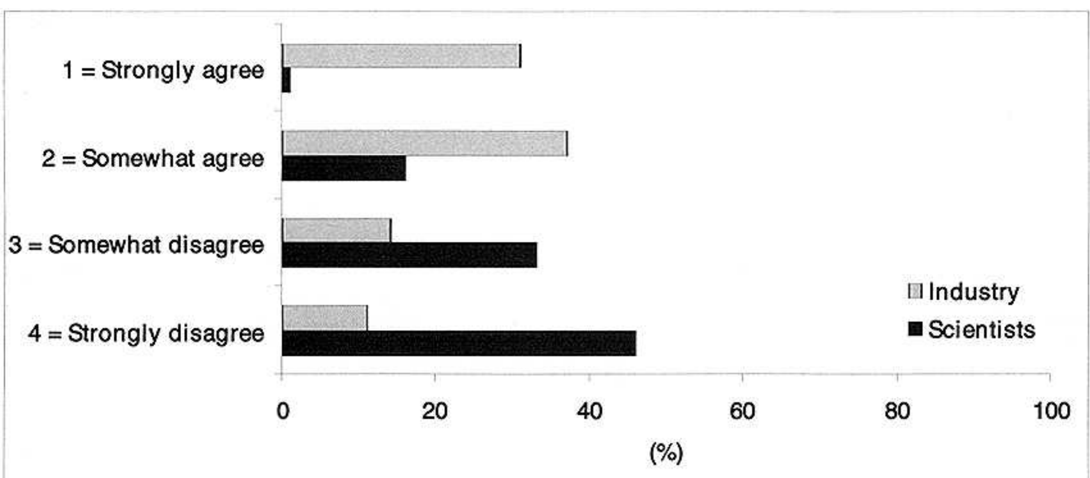

Figure 3. Scientist and industry respondents' views on the role of scientific inadequacy and uncertainty in reducing harvest quotas. Data reflect response to the question: "The inadequacy of science and the increasing emphasis on 'uncertainty' in fisheries science are reducing harvest quotas, rather than any actual decline in the stocks themselves." Industry mean = 2.044, sd = 0.9811; scientist mean = 3.286, sd = 0.7834. F2,458 = 224.393; p = 0.000.

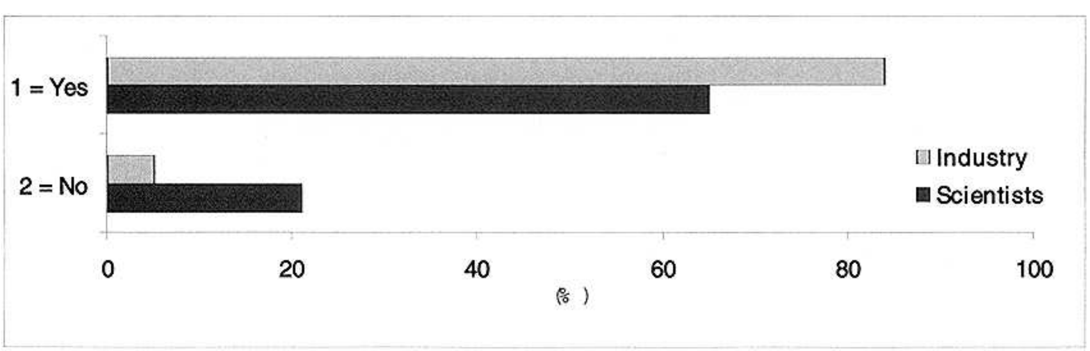

Figure 4. Perceptions of industry's views on short-term and long-term tradeoffs in harvest quotas. Data reflect response to the question: "Would industry participate in a cooperative research program knowing beforehand that the information they provide could potentially confirm small stock size and reduce harvest quotas in the short term? Keep in mind that a short term reduction in quota might result in a larger quota in the long term if the stock is able to rebuild." Industry mean = 1.051, sd = 0.220; scientist mean = 1.245, sd = 0.431. F2,424 = 34.486; p = 0.000.

don certain statistical models despite their failure to predict the historic highs in lobster populations in the 1990s (Acheson and Steneck 1997).

We suggest the differing world views of industry and scientists drive a counterproductive cycle of perceptions and behavior that is exacerbated by the fishery's research and management institutions. The current management system in the West Coast groundfish fishery employs limited-entry permits and intra-annual trip limits that provide financial incentives for industry to engage in harmful fishing practices such as discarding and highgrading. As these limits continue to shrink, the struggle for economic survival may induce otherwise conservation-minded fishermen to discard fish that, under different regimes, could be landed and brought to market. Our survey results indicate scientists and managers perceive industry as having a much lower conservation ethic than the levels that industry members rated themselves. One possible explanation for this disparity is that, rather than rating their perception of industry members' attitudes toward conservation, scientists instead indicated their perception of industry's actual behavior on the fishing grounds. Consequently, scientists' perception of industry behavior may have been colored by their beliefs about discarding or other forms of industry noncompliance with management, even though the scientists might be aware of or even sympathetic to the complex economic and institutional factors that drive this behavior.

Another possible explanation for this disparity might be drawn from Walters' (1995) observation that while most industry members are interested in conservation, there are some individuals who do not share a long-term vision for the fishery and seek to maximize short term profits at the expense of resource sustainability. Perhaps this relatively small group of short-sighted fishermen has a disproportionate influence on scientists' views of the industry. In either case, if this perception of industry's conservation ethic fosters or promotes a sense among scientists that they need to protect fish stocks or aquatic ecosystems, it might be appropriate to question whether their scientific objectivity has been compromised. For example, in some of our focused discussions, some scientists considered themselves "advocates" for the fish. Similarly, Weeks (1995) suggested that implicit responsibilities of husbandry and stewardship required of agency scientists might prevent them from approaching science from a purely disinterested perspective. These attitudes could potentially impact the manner in which scientists analyze and interpret scientific data, allowing for personal biases to enter the process. Hutchings et al. (1997) described the sobering implications of allowing non-science influences to invade fisheries research and management.

The assumption that industry is not concerned with conservation may also negatively impact scientists' working relationship with industry by calling into question the motives behind industry members' behavior (Pringle 1985). Industry members sense this cynicism which increases their distrust of scientists. The limited interaction between the groups allows the mutual misconceptions and distrust to grow. Poor working relationships lead to reduced interest in interaction among both groups and reduced opportunities for industry input into the fishery's research and management processes. Management plans may be developed without significant industry consultation and may incorporate misconceptions of industry motivations. Plans that fail to address industry concerns or those which industry perceives as unnecessary or ineffective will lack legitimacy in the eyes of industry and may result in compliance problems (Rice and Richards 1996; Thomson 1984). Further, the present groundfish allocation process pits industry groups against each other and adds unnecessary complexity to a management system that a majority of both scientists and industry already perceive as having serious flaws (Harms and Sylvia, unpublished data). Allocation "battles" often become so contentious and disruptive that they halt progress toward identifying and developing potential research and management solutions.

We conclude that maintaining the institutional status quo will continue to breed acrimony between and among scientists and industry, sustain wasteful practices such as discarding, and encourage other forms of non-compliance toward management plan objectives. Uncertainty surrounding industry's reaction to management plans and harvest recommendations results in the incorporation of questionable scientific assumptions into subsequent assessment models. Developing research and management institutions that align the objectives of scientists and industry may be the key to the successful sharing of knowledge, ideas, and observations that improve fisheries science and ultimately generate the greatest benefit from the use of our fisheries resources. We suggest that these institutions must encourage resource stewardship and diminish some of the economic incentives to discard fish. They must also promote long-range planning horizons for industry by eliminating trip limits and intra-annual quotas and

Table 5. Summary of industry and scientist respondents' opinions on the best actions for improving the working relationship between industry and scientists. The first values are percentages of respondents who selected this option as one of their top two choices, and the parenthetical values are percentages of those who selected this option as their first choice. Respondents were asked to select their top two choices for improving the working relationship between industry and scientists.

Action	Industry	Scientists
Scientists visiting the docks more often	28 (11)	40 (17)
Industry visiting scientific facilities more often	5 (1)	11 (3)
Scientists accompanying fishermen on fishing vessels	56 (36)	52 (32)
Informal coffees at local coffee houses	11 (5)	15 (6)
Regularly-scheduled industry-scientist meetings	30 (14)	44 (21)
Newsletter of current events with fishermen and scientists	12 (1)	14 (4)
Organizing formal, independent cooperative research organization	44 (25)	24 (13)
Other	7 (4)	6 (4)

allowing industry maximum flexibility in planning their fishing activities. Reducing the economic uncertainty that results from yearly allocation politics is also important in developing a longer industry planning horizon. Although additional research is needed to identify the precise characteristics of management institutions that would best facilitate win-win scenarios for the West Coast groundfish fishery, some form of transferable property rights in concert with a buyout program may be the most appropriate system to achieve these objectives.

Further, these win-win scenarios must include meaningful consultation with industry in research prioritization and conduct as well as in the development of management plans. The council process does provide some opportunities for industry to be engaged in management, generally through industry advisory panels or public testimony; however, industry involvement in scientific research is more limited. The present system largely alienates industry from making substantive contributions to the "inputs" of fisheries science and relegates them to the role of reacting to system "outputs."

We advocate some form of genuine interaction among scientists, managers, and industry that focuses on improving the working relationship, providing industry with input into the research and management processes, and offers opportunities for the mutual education of both groups. Potential strategies to achieve this interaction are described in Table 5 and may include formal and informal approaches. Ultimately, these changes will result in: 1) more informed science and management decisions stemming from exposure to new ideas and observations provided by the fishing industry; 2) a more informed industry with a better understanding and appreciation of the complexities and uncertainty associated with fisheries science; 3) legitimate and credible management plans that industry supports and that take advantage of industry's conservation ethic; 4) more certainty in achieving management objectives and in the assumptions and parameters employed in future stock assessments; and, 5) an improved mutual understanding of the perspectives and motivations of scientists and industry which can support innovative approaches including cooperative research and co-management.

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