EVALUATING TRENDS AND OUTCOMES IN NORTHEAST FISHERIES SCIENCE AND MANAGEMENT DECISIONS

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ABSTRACT

In response to growing contention between the fishing industry and fisheries scientists, cooperative research projects have been developed to provide a structure for industry and scientists to collaborate on fisheries research and generate data to improve fisheries management decisions. These partnerships produce many direct and indirect benefits but, little is known about the current degree of fishermen participation in these projects. This study describes the results from surveys administered to fishermen and scientists in the Northeastern United States to understand (1) individual experiences collaborating in scientific research and (2) current beliefs about ecosystem health, participation in science and management, fisheries decision-making, and ecosystem/economic processes. Binary logistic regression models were used to analyze the 472 responses from this survey. Many aspects of fisheries science and management still remain polarizing issues. The number of years in one's profession and the degree of fisher involvement significantly influenced the responses to survey questions.

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ABBREVIATIONS

PPSR: Public Participation in Scientific Research

NCRP: Northeast Cooperative Research Program

NOAA: National Oceanic and Atmospheric Administration

NEMFS: Northeast Marine Fisheries Service

CHAPTER 1. INTRODUCTION

Fisheries science and management decisions in the Northeastern United States have been a contentious topic for several decades. Resource disputes between fishermen and scientists are often a result of poor communication between the two groups (Hartley et al. 2006, Delaney et al. 2007, Kaplan et al. 2004). The lack of agreement has led to an escalating sense of distrust that is a barrier for effective marine resource management. One inhibitor for knowledge exchange between fishermen and scientists is the difference between the scale and type of knowledge that each group possesses. Fishermen possess place-based knowledge that develops through experience from a life at sea. Their information is passed down through generations and is adapted to reflect long-term ecological change (Ford et al. 2000, Haggan et al. 2007). Scientists possess knowledge about biological and natural processes that examines long-term ecological change based on specific research-based information. Because each group offers a unique perspective, the combining scientific and fisher knowledge will lead to the development of effective resource management decisions.

Local ecological knowledge can be considered expert or inexpert based on the individual's level of experience and their ability to notice, organize and interpret information (Fazey et al. 2006). Individuals seen as local ecological knowledge experts have a deep understanding of the environmental system in which they work and are able to make future predictions (Fazey et al. 2006, Haggan et al. 2007). Due to the variety of ways in which this knowledge has been categorized, significant confusion exists as to its relevance for environmental management (Raymond et al. 2010). Despite categorical discrepancies, local ecological knowledge is an important source of information for environmental management and should be utilized as such.

Additional concerns for employing fisher knowledge arise from the lack of systematic measurement, quantitative data, and biased place based perspectives. Local ecological knowledge is holistic in outlook and adaptive by nature because it is used to predict environmental phenomena upon which the livelihood of individuals depends (Berkes et al. 2000, Huntington et al. 2000). Such information accumulates over time and is passed down through generations either orally or through shared experiences (Ohmagari et al. 1997). Fisher knowledge is largely qualitative and generally describes migratory patterns, spawning grounds, juvenile habitat, and stock structure (Johnson et al. 2007, Haggan et al. 2007). This kind of knowledge is generally in great detail over a fine scale area. This kind of unwritten knowledge can be difficult to articulate and is often distrusted by scientists (Berkes, 2009, Fazey et al. 2006).

In contrast, scientific knowledge is created by more systematic means and utilizes agreed principles and processes of study to generate new information (Turnbull, 1997). Knowledge that is generated scientifically is commonly explicit and aims to increase rigor with respect to validity and reliability (Raymond et al. 2010). Scientific knowledge is quantitative and often revolves around data sets for specific biological processes. During the data collection process research vessels generally focus on multiple species over large areas (Johnson et al. 2007). The differences in local ecological knowledge and scientific knowledge are often the result of scale and the employment of qualitative versus quantitative data.

The differences in knowledge type combined with communication challenges over the years have contributed to the distrust between fishermen and scientists. Tensions between the two groups escalated significantly after the 2000 stock assessment survey commonly referred to as "trawl gate". A misrigged trawl net used by Northeast Marine Fisheries Service (NMFS) was collecting data for two years before the problem was noticed (Malakoff, 2002). This type of stock assessment is responsible for the catch limits and other regulations set on important ground fisheries. As a result, fishermen began to adamantly distrust the science that is used mange commercial fisheries. In response to "trawl gate" in 2000, NOAA developed the Northeast Cooperative Research Program (NCRP) to improve the collection of fisher data and reduce the impacts of fishing activities through gear selectivity studies.

Cooperative research is a form of Public Participation in Scientific Research (PPSR), which has been developed to increase scientific literacy in the general public (Bonney et al. 2009). The importance of PPSR has been widely recognized as a means to increase support for scientific research, thereby increasing economic benefits as well as human well being (Bonney et al., 2009). In the fisheries context, cooperative research is the joint participation of fishermen and scientists in fisheries research projects so that fishermen can be integrated into management decisions.

Cooperative research facilitates communication and transparency between fishermen and scientists (Johnson et al. 2007, Hartley et al. 2006, Pomeroy et al. 2006) while creating a sense of shared ownership (Holmes et al. 2010). As fishermen and scientists come together to work on fisheries projects, they communicate openly and the end result is that researchers gain knowledge and experience from the fishermen while the fishermen learn about the research process and the application of science in management decision making (Johnson et al. 2007, Hartley et al. 2006, Yates, 2014). Open communication will also foster trust as the group works together to reach projects goals (Kaplan et al. 2004). Trust between fishermen and scientists bring science and management together to address industry issues (Johnson et al. 2007, Hartley et al. 2006, Holmes et al. 2010, Yates, 2014) while breaking down former prejudices and hostilities (Armstrong et al. 2013). Once fisher knowledge is incorporated into the research process, all fishermen are more likely to view the data, the analysis and the recommendations that drive management decisions as more legitimate. While the scientific community gains buy-in from fishermen, cooperative research also leads to industry capacity building. Fishermen learn to interpret the data they are collecting as well as developing an understanding and appreciation of the scientific process (Johnson et al. 2007, Hartley et al. 2006, Schumann, 2007). This combination of knowledge supports resource monitoring in a way that lends itself to sustainable use (Folke, 2004). As is the case with co-management, cooperative research also allows people whose livelihoods are affected by management decisions to have a say in the decision-making process (Berkes, 2009, Yates, 2014). However, these partnerships can only succeed when scientists and fishers understand and accept the knowledge set that the other group has to offer (Armstrong et al. 2013).

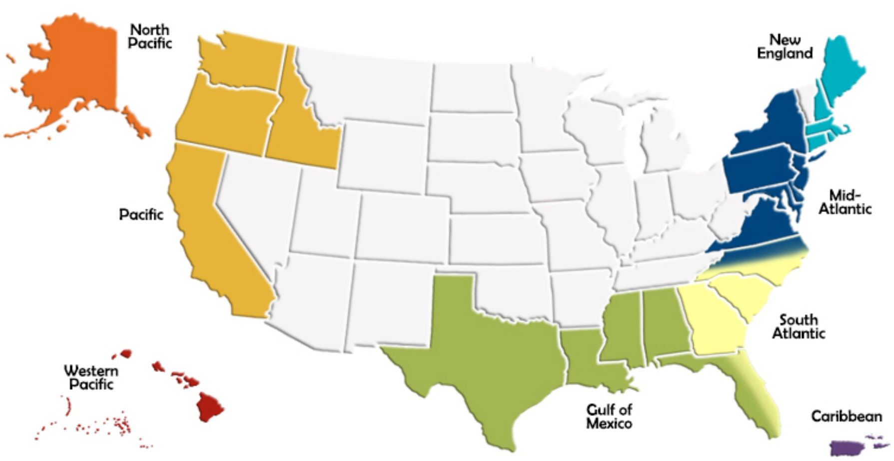
Despite the known benefits of cooperative research, little data that supports the notion that cooperative research leads to consensus between fishermen and scientists exists. In a previous study done by Hartley et al. 2006, the effectiveness of cooperative research was studied using a program designed by the Northeast Consortium in New England. The study showed that cooperative research results in fishermen and scientists being more informed about science and fishing respectively as well as greater mutual understanding and trust (Hartley et al. 2006). It used consensus analysis based on the results of a true/false survey to compare the responses of fishermen and scientists to statements addressing fisheries science and management decisions. The survey questions were based upon the ecological, economic, and social dimensions of fisheries management, all of which are necessary for sustainable development (Folke et al. 2007, Hilborn, 2006). Consensus analysis is a common technique used to compare and contrast responses across individuals or groups (source). Because individuals and groups have their own knowledge and belief systems, responses to questions surrounding fisheries science and management vary. Binary logistic regression models were used for each question to determine which independent variables determine fisher and scientists responses to questions surrounding fisheries management decisions.

In addition to the true false component of the survey, respondents were asked whether or not they had participated in cooperative research and the steps of the scientific process in which fishermen were involved. The steps of the scientific process were determined using Bonney et al. 2009 model for public participation in scientific research. Bonney et al. identified three levels of public participation in science: contributory, collaborative, and co-created projects. In contributory projects, the public is involved in data collection or recording and sometimes data analysis and the dissemination of conclusions. Collaborative projects involve the public in data collection or recording, sample and data analysis, and sometimes data collection design, interpretation of data, and the dissemination of conclusions. Co-created projects involve the public through all steps of the scientific process beginning with defining the research questions and ending in the discussion of results and formation of new questions. Based on the continued contention in fisheries science and management we hypothesize that the majority of cooperative research projects are contributory and collaborative with few co-created projects. By asking fishermen and scientists alike to indicate the degree of fisher participation in cooperative research in which they have participated, the steps of the scientific process that are lacking fisher knowledge and input can be identified in order to improve current cooperative research efforts.

CHAPTER 2. METHODS

The objective of this research is to understand how fisher participation in research may influence cultural changes in fisheries management. As seen in the literature, surveys are a common method to evaluate consensus among groups (Grant, 2004 and Dillman, 2007). This survey was developed over several months following an extensive literature review and involved input from both fisherman and scientists. It was divided into sections based upon the type of information provided and the data analysis methods used.

This survey was designed to target fishermen, scientists, and managers in the Northeastern United States. As such, the states included in this survey were determined based upon the region funded by NOAA's Northeast Cooperative Research Program and the New England and Mid-Atlantic Fisheries Councils (figure 1).



U.S. Regional Fishery Management Councils as Designated by NOAA

In July 2013 the survey was presented to fishermen and scientists via survey monkey. Using snowball-sampling techniques the scientist sample included representatives from academic, governmental, non-governmental and private organizations with the bulk of participants being members of The American Fisheries Society. Fishermen were also targeted using snowball-sampling techniques through existing cooperative research programs and industry contacts. The online survey was administered according to Dillman's Tailored Design Method

(Dillman, 2007). The survey instrument and procedures were evaluated for ethical appropriateness by the University of Hawai'i's Internal Review Board. To encourage responses, e-mail recipients received a cover letter with the researchers' contact information to answer any questions survey participants may have. An initial cover letter and link to the online survey was sent to participants in the first week of July. One week later, a reminder/ thank you postcard was sent out. A final e-mail with a link to the survey was administered two weeks later. After one final week, the online survey was closed.

The electronic survey received a total of 48 fishermen responses out of approximately 8,000 fishermen listed on NOAA's commercial operator license list from the designated region. A total of 498 responses were received from scientists and managers. As no such list exists for scientists and managers, the exact sample population for scientists and managers is unknown. Due to the lack of responses from fishermen to the online version of the survey, a mail survey was generated and distributed in February 2014. Fishermen that received the mail survey were selected from the NOAA commercial operators license list. All fishermen with licenses belonging to states designated by the New England and Mid-Atlantic Fisheries Councils were included in the population from which the sample was drawn. Using Mail Manager from BCC Software, 1500 names were randomly selected from the list of approximately eight thousand licenses. The number of names selected per state were in proportion to the number of licenses per state in order to accurately represent the geographical component of the study. New England Professional Systems, a mailing company located in Holliston Massachusetts, handled survey assembly, distribution and collection. Surveys were again distributed in a three-part sequence, using the "Tailored Design Method" protocol adopted from Dillman, 2007. The first mailing was sent the first week of February and included a cover letter and initial survey. One week later a reminder/ thank you post card was sent out. Two weeks after the reminder postcard, a second copy of the survey was distributed. One week after the third mailing, the survey was closed.

A total of 306 fishermen surveys were returned, yielding a 20.4% response rate. The sampling framework targeted only commercial fishermen. Therefore, any returned survey for which the respondent indicated that he/she was not a commercial fisherman was removed from the study. This reduced the number of useable surveys to 271.

Due to the large number of online survey responses received from scientists in the summer of 2013, a mail survey targeting scientists was not conducted in February 2014. The sampling framework targeted only scientists and managers in the Northeast United States. Therefore, respondents were removed from the study if they indicated that they did not conduct research in the Northeast. Scientists also were removed from the study if they responded to only the first few questions. This reduced the sample size for scientists to 201 surveys.

In order to evaluate the current state of cooperative research, survey respondents were asked if they had ever cooperated with fishermen and scientists on fisheries related projects. Next fishermen were asked to select any activities in which they were involved from the list of the 10 steps of the scientific process according to Bonney et al. 2009. Using the same process, scientists were asked to select all activities in which fishermen had been involved in these cooperative projects.

Researchers evaluated the knowledge and beliefs of both fishermen and scientists with respect to fisheries science and management decisions. This was done by providing survey recipients with 24 statements surrounding several important aspects of fisheries science and management to which they were asked to answer true or false. The designated categories include ecosystem/ resource health, participation in science and management, fisheries decision-making, and ecosystem and economic processes. To ascertain scientist and fishermen opinions about ecosystem health researchers provided the following statements: (1) Legally harvestable fish stocks have remained constant over the past 5 years, (2) Fish habitat has remained stable over the last 5 years, (3) The catch rate of fishes has remained stable over the last 5 years, (4) The quality of fish stocks has remained constant over the last 5 years. To ascertain opinions about ecosystem and economic processes researchers said: (1) The quality of the fishing community (economic or social conditions) has remained stable over the last 5 years, (2) There are fewer fishermen now than there were 5 years ago, (3) I feel single species management is the most effective way to manage commercial fisheries, (4) I feel ecosystem based management is the most effective way to manage commercial fisheries, (5) Fishermen's decisions about fishing are based on short term economic returns (within 5 years). To ascertain scientist and fishermen opinions about participation in science and management survey participants were given the following statements: (1) Currently fishermen knowledge is used in the data collection process for fisheries management decisions, (2) Currently fishermen knowledge is used to analyze data used in fisheries management decisions, (3) Currently fishermen knowledge is used to interpret the scientific information used for fisheries management decisions, (4) I am actively engaged in the decision making process for fisheries management, (5) I want to be involved in fishermen/scientist research collaborations and help develop scientific information that can be used in fisheries management. To ascertain scientists and fisher opinions about fisheries decision making the following statements were provided: (1) Fisheries management decisions are based on sound science, (2) I generally trust the scientific research used in fisheries management, (3) I feel that the scientific assessments used in fisheries management are valuable for managing fisheries sustainably, (4) There is enough data collection to make sound fisheries management decisions, (5) Data analysis used to make fisheries management decisions accurately reflects the health of the resource, (6) It is worth the time for scientists and fishermen to work together because it leads to better management decisions, (7) I feel that my goals for fisheries management are aligned with the goals held by scientists, (8) I feel that my goals for fisheries management are aligned with the goals held by fishermen, (9) Scientists base fisheries management decisions on long-term resource assessments, (10) Fishermen base fisheries management decisions on long term resource assessments.

Spurious data points including symbols such as question marks and asterisks were removed. In cases where a question mark was used to respond to a given statement, the question mark was converted to a blank entry. For the consensus portion of the survey, some respondents selected both true and false for the same question. These responses were often accompanied by words such as “sometimes”. Responses such as this were entered as “true” in the coding scheme because the researchers consider “sometimes” a response that indicates some level of truth in the statement and can therefore not be considered a falsity.

Statistical analyses were performed using Stat Plus software. The mean response per each of the 24 true/false statements was calculated. For the consensus portion of the survey, the responses of true and false were coded as 1, 0, respectively. Therefore, the mean response of each question indicates the degree of truth the entire group of respondents feel the statement has. Because the mean responses are proportional data, survey respondents’ answers to the 24 true/false statements were arc sine square root transformed. A T-test was used to compare the mean scientists and fishermen group values for each of the 24 statements.

Finally binary logistic regression models were run per each of the 24 true/false questions. This model estimates a confidence level for the correlation between each independent variable and the dependent variable of consensus response. The dependent variable for the model is the true or false response to each statement. The independent variables for fishermen are: (1) number of years in the fishery, (2) target species (groundfish, mollusk, or crustacean fishery), and (3) degree of participation in fisheries science and management. The independent variables for scientists are: (1) number of years in research/management, (2) type of research/ management institution (academic, governmental, non-governmental, other), and (3) degree of fisher participation in science and management projects in which they have participated. Unless otherwise noted, data are reported with a P-value of 0.05 considered as significant.

CHAPTER 3. RESULTS

The results of this study show that 145 of the 271 fishermen respondents have cooperated with scientists on fisheries related research projects (53.5 %). Of the 145 fishermen that have participated in cooperative research the following number of participants was found for each step of the scientific process: (1) choosing/defining the research questions: 20 fishermen (13.8%), (2) Gathering information and resources: 109 fishermen (75.2%), (3) Developing theories for the research question: 24 fishermen (16.6%), (4) Designing data collection methods: 30 fishermen (20.7%), (5) Collecting samples/recording data: 108 fishermen (74.5%), (6) Analyzing samples: 24 fishermen (16.6%), (7) Analyzing data: 19 fishermen (13.1%), (8) Interpreting data and drawing conclusions: 16 fishermen (11%), (9) Distributing conclusions of the study: 13 fishermen (9%), (10) Discussing results and asking new questions: 48 fishermen (33.1%). (Table 1.)

Of the 201 scientists and manager respondents, 187 have cooperated with fishermen on fisheries related research projects (93%). The 187 scientists involved in cooperative research indicated in which of steps of the scientific process fishermen had been involved. The following numbers were recorded: (1) choosing/defining the research questions: 71 scientists (38%), (2) Gathering information and resources: 126 scientists (67.4%), (3) Developing theories for the research question: 47 scientists (25.1%), (4) Designing data collection methods: 51 scientists (27.3%), (5) Collecting samples/recording data: 144 scientists (77%), (6) Analyzing samples: 10 scientists (5.3%), (7) Analyzing data: 8 scientists (4.3%), (8) Interpreting data and drawing conclusions: 41 scientists (21.9%), (9) Distributing conclusions of the study: 66 scientists (35.3%), (10) Discussing results and asking new questions: 127 scientists (67.9%). (Table1.)

Table 1. Steps of the Scientific Process in which Fishermen Participate

Steps of the Scientific Process	Fishermen Responses	Scientist Responses
Choosing/defining the research questions	20	71
Gathering information and resources	109	126
Developing theories for the research question	24	47
Designing data collection methods	30	51
Collecting samples/recording data	108	144
Analyzing samples	24	10
Analyzing data	19	8
Interpreting data and drawing conclusions	16	41
Distributing the conclusions of the study	13	66
Discussing results and asking new questions	48	127

*145 of 307 fishermen have participated in cooperative research
*187 0f 201 scientists have participated in cooperative research

The total number of steps of the scientific process in which fishermen indicated their involvement (n=145) averaged 2.83 steps ±5.0. The total number of steps in which scientists felt fishermen were involved (n=187) averaged 3.70 ± 5.5. The mean number of steps of fisher involvement according to fishermen and scientists is significantly different at the 0.001 significance level. (Table2.)

Table 2. T-Test Comparing Mean Fisher Participation in Cooperative Research

VAR	*Sample Size*	*Mean*	*Variance*
Fishermen	145	2.834	5.000
Scientists	187	3.695	5.536
Summary			
Degrees of Freedom	330	*Hypothesized Mean Difference*	0.E+0
Test Statistics	3.378	*Pooled Variance*	5.302
Two-tailed distribution			
p-level	0.001	*T Critical Value (5%)*	1.967

Of the 24 true/false statements provided to survey participants, there were 19 statements whose mean responses differed between the two groups with statistical significance. The corresponding logit models yielded 14 statements with significant independent variables. An additional seven statements had significant model fit values but no significant independent variables. This indicates that the combined independent variables significantly predict the responses for these seven questions.

Questions one through six investigated the health of the ecosystem and fishing community in the past five years. (1) Legally harvestable fish stocks have remained constant over the past 5 years, $t(426) = 5.32$, $p < 0.05$. (2) Fish habitat has remained stable over the last 5 years, $t(426) = 5.80$, $p < 0.05$. (3) The catch rate of fishes has remained stable over the last 5 years, $t(428) = 4.24$, $p < 0.05$. (4) The quality of fish stocks has remained constant over the last 5 years, $t(425) = 5.72$, $p < 0.05$. (5) The quality of the fishing community (economic or social conditions) has remained stable over the last 5 years. For fishermen, the overall logit model fit proved to significantly predict this response with a p-value of 0.004. Significant p-values for the independent variables of years fishing, mollusk fishermen, and crustacean fishermen were also found with values of 0.030 (beta: -0.03), 0.042 (beta: 0.86), and 0.007 (beta: 1.14) respectively. (6) There are fewer fishermen now than there were 5 years ago. The logit model for scientists indicates a significant p-value of 0.033 for the overall model fit and a significant p-value of 0.047 (beta: 0.21) for the degree of fisher participation in the scientific process. The logit model for fishermen indicates a significant p-value of 0.016 for the overall model fit and a p-value of 0.030 (beta: -1.04) for the independent variable of crustacean fishermen. (Table 3., Table 4.)

Table 3. Mean Group Response Questions 1-6

Question	Scientists Avg.	Fishermen Avg.
1. Legally harvestable fish stocks have remained constant over the past 5 years	0.236*	0.598*
2. Fish habitat has remained stable over the last 5 years	0.442*	0.872*
3. The catch rate of fishes has remained stable over the last 5 years	0.280*	0.571*
4. The quality of fish stocks has remained constant over the last 5 years	0.307*	0.714*
5. The quality of the fishing community (economic or social conditions) has remained stable over the last 5 years	0.199	0.296
6. There are fewer fishermen now than there were 5 years ago	1.327	1.348

* Indicates statistically different means at the 95% confidence level

Table 4. Significant Logit Results Questions 1-6

Question	Significant Logit Result: Scientists	Significant Logit Result: Fishermen
1. Legally harvestable fish stocks have remained constant over the past 5 years		
2. Fish habitat has remained stable over the last 5 years		Model fit p-level: 0.026
3. The catch rate of fishes has remained stable over the last 5 years		
4. The quality of fish stocks has remained constant over the last 5 years		
5. The quality of the fishing community (economic or social conditions) has remained stable over the last 5 years		Model fit p-level: 0.004 Years in fishery: 0.030, beta: -0.032 Mollusk fishery: 0.042, beta: 0.859 Crustacean fishery: 0.007 beta: 1.137
6. There are fewer fishermen now than there were 5 years ago	Model fit p-level: 0.033 Degree participation: 0.047 beta: 0.213	Model fit p-level: 0.016 Crustacean fishery: 0.030 beta: -1.041

Questions seven through twelve deal with the credibility of fisheries science and management. (7) Fisheries management decisions are based on sound science, $t(425) = 9.85$, $p < 0.05$. (8) I generally trust the scientific research used in fisheries management, $t(436) = 14.33$, $p < 0.05$. (9) I feel that the scientific assessments used in fisheries management are valuable for managing fisheries sustainably, $t(434) = 6.97$, $p < 0.05$. With a p-value of 0.011 (beta: -0.03), the number of years fishing significantly influences the way fishermen respond to this question. (10) There is enough data collection to make sound fisheries management decisions, $t(432) = 3.52$, $p < 0.05$. (11) Data analysis used to make fisheries management decisions accurately reflects the health of the resource, $t(429) = 7.36$, $p < 0.05$. (12) Currently fishermen knowledge is used in the data collection process for fisheries management decisions, $t(430) = 4.25$, $p < 0.05$. The logit model for fishermen indicates a significant p-value of 0.001 for the overall model fit. The independent variables “number of years fishing” and “degree of fisher participation” have significant p-values of 0.006 (beta: -0.04) and 0.006 (beta: 0.19)respectively. (Table 5., Table 6.)

Table 5. Mean Group Response Questions 7-12

Question	Scientists Avg.	Fishermen Avg.
7. Fisheries management decisions are based on sound science	0.903*	0.255*
8. I generally trust the scientific research used in fisheries management	1.300 *	0.393*
9. I feel that the scientific assessments used in fisheries management are valuable for managing fisheries sustainably	1.417*	0.965*
10. There is enough data collection to make sound fisheries management decisions	0.542*	0.308*
11. Data analysis used to make fisheries management decisions accurately reflects the health of the resource	0.876*	0.361*
12. Currently fishermen knowledge is used in the data collection process for fisheries management decisions	0.767*	0.457*

* Indicates statistically different means at the 95% confidence level

Table 6. Significant Logit Results Questions 7-12

Question	Significant Logit Result: Scientists	Significant Logit Result: Fishermen
7. Fisheries management decisions are based on sound science	Model fit p-level: 0.024	
8. I generally trust the scientific research used in fisheries management	Model fit p-level: 0.013	
9. I feel that the scientific assessments used in fisheries management are valuable for managing fisheries sustainably		Years in fishery: 0.011 beta: -0.030
10. There is enough data collection to make sound fisheries management decisions	Model fit p-level: 0.013	
11. Data analysis used to make fisheries management decisions accurately reflects the health of the resource	Model fit p-level: 0.004	
12. Currently fishermen knowledge is used in the data collection process for fisheries management decisions		Model fit p-level: 0.001 Years in fishery: 0.006 beta: -0.035 Degree participation: 0.006 beta: 0.187

Questions thirteen through eighteen of the survey examine fisher involvement in the scientific process and management techniques. (13)Currently fishermen knowledge is used to analyze data used in fisheries management decisions. The logit model for fishermen indicates a significant p-value of 0.0001 for the overall model fit. The independent variables "number of years fishing", "mollusk fishermen", and "degree of fisher participation" have significant p-values of 0.004 (beta:-0.04), 0.017 (beta: 0.94), and 0.008 (beta: -0.96) respectively. (14) Currently fishermen knowledge is used to interpret the scientific information used for fisheries management decisions. The logit model for fishermen displayed a significant p-value of 0.00002 for the overall model fit. The independent variables "number of years fishing" and "mollusk fishermen" have significant p-values of 0.0003 (beta:-0.05) and 0.0086 (beta: 1.07) respectively. (15) I feel single species management is the most effective way to manage commercial fisheries, t(425) =

7.92, $p < 0.05$. (16) I feel ecosystem based management is the most effective way to manage commercial fisheries, $t(415) = 6.95$, $p < 0.05$. For fishermen, the independent variable "groundfishery" had a significant p-value of 0.027 (beta: 0.77). (17) It is worth the time for scientists and fishermen to work together because it leads to better management decisions. For scientists, the degree fisher participation in science had a significant p-value of 0.051 (beta: 0.49). (18) I am actively engaged in the decision making process for fisheries management, $t(432) = 6.98$, $p<0.05$. (Table 7., Table 8.)

Table 7. Mean Group Response Questions 13-18

Question	Scientists Avg.	Fishermen Avg.
13. Currently fishermen knowledge is used to analyze data used in fisheries management decisions	0.316	0.414
14. Currently fishermen knowledge is used to interpret the scientific information used for fisheries management decisions	0.289	0.353
15. I feel single species management is the most effective way to manage commercial fisheries	0.163*	0.689*
16. I feel ecosystem based management is the most effective way to manage commercial fisheries	1.300*	0.808*
17. It is worth the time for scientists and fishermen to work together because it leads to better management decisions	1.499	1.493
18. I am actively engaged in the decision making process for fisheries management	0.686*	0.236*

* Indicates statistically different means at the 95% confidence level

Table 8. Significant Logit Results Questions 13-18

Question	Significant Logit Result: Scientists	Significant Logit Result: Fishermen
13. Currently fishermen knowledge is used to analyze data used in fisheries management decisions		Model fit p-level: 0.000 Years in fishery: 0.004 beta:-0.040 Mollusk fishery: 0.017 beta: 0.944 Degree Participation: 0.008 beta: -0.955
14. Currently fishermen knowledge is used to interpret the scientific information used for fisheries management decisions		Model fit p-level: 0.000 Years in fishery: 0.003 beta: -0.053 Mollusk fishery: 0.009 beta: 1.066
15. I feel single species management is the most effective way to manage commercial fisheries		Model fit p-level: 0.002 Ground fishery: 0.000 beta: -1.426 Mollusk fishery: 0.010 beta: -1.071
16. I feel ecosystem based management is the most effective way to manage commercial fisheries		Ground fishery: 0.027 beta: 0.774
17. It is worth the time for scientists and fishermen to work together because it leads to better management decisions	Degree participation: 0.051 beta: 0.486	
18. I am actively engaged in the decision making process for fisheries management	Years in research: 0.029 beta: -0.028 Degree participation: 0.033 beta: 0.144	Model fit p-level: 0.032 Degree participation: 0.001 beta: 0.257

Questions nineteen through twenty-four continue to examine the issues surrounding fisheries management decisions and collaborations. (19) I want to be involved in fishermen/scientist research collaborations and help to develop scientific information that can be used in fisheries management, $t(431) = 3.15$, $p < 0.05$. For scientists, the independent variables “number of years in profession” and “degree of fisher participation” had significant p-values of 0.012 (beta: -0.04) and 0.000 (beta: 0.52) respectively. For fishermen the independent variables of “number of years in profession” and “degree of fisher participation” also had significant p-values of 0.005 (beta: -0.03) and 0.000 (beta: 0.33) respectively. (20) I feel that my goals for fisheries management are aligned with the goals held by scientists, $t(426) = 9.80$, $p < 0.05$. In the logit model for scientists, the independent variable "degree of fisher participation" had a significant p-value of 0.013 (beta: -0.23). For fishermen, the independent variables "number of years in profession," "mollusk fishermen," and "degree of fisher participation" had significant p-values of 0.002 (beta: -0.04), 0.025 (beta: 0.85), and 0.008 (beta: 0.19) respectively. (21) I feel that my goals for fisheries management are aligned with the goals held by fishermen, $t(425) = 3.64$, $p < 0.05$. The logit model for scientists displayed a significant p-value of 0.010 (beta: 0.19) for the independent variable "degree of fisher participation." (22) Fishermen's decisions about fishing are based on short-term economic returns (within 5 years), $t(423) = 6.32$, $p < 0.05$. (23) Scientists base fisheries management decisions on long-term resource assessments, $t(418) = 5.71$, $p < 0.05$. (24) Fishermen base fisheries management decisions on long-term resource assessments, $t(421) = 7.58$, $p < 0.05$. (Table 9., Table 10.)

Table 9. Mean Group Response Questions 19-24

Question	Scientists Avg.	Fishermen Avg.
19. I want to be involved in fishermen/scientist research collaborations and help develop scientific information that can be used in fisheries management	1.228*	1.007*
20. I feel that my goals for fisheries management are aligned with the goals held by scientists	1.345*	0.674*
21. I feel that my goals for fisheries management are aligned with the goals held by fishermen	0.957*	1.211*
22. Fishermen's decisions about fishing are based on short term economic returns (within 5 years)	1.336*	0.901*
23. Scientists base fisheries management decisions on long term resource assessments	1.336*	0.945*
24. Fishermen base fisheries management decisions on long term resource assessments	0.343*	0.889*

* Indicates statistically different means at the 95% confidence level

Table 10. Significant Logit Results Questions 19-24

Question	Significant Logit Result: Scientists	Significant Logit Result: Fishermen
19. I want to be involved in fishermen/scientist research collaborations and help develop scientific information that can be used in fisheries management	Model fit p-level: 0.000 Years in research: 0.012 beta: -0.040 Degree participation: 0.000 beta: 0.517	Model fit p-level: 0.000 Years in fishery: 0.005 beta: -0.034 Degree participation: 0.000 beta: 0.329
20. I feel that my goals for fisheries management are aligned with the goals held by scientists	Model fit p-level: 0.030 Degree participation: 0.013 beta: -0.226	Model fit p-level: 0.000 Years in fishery: 0.002 beta: -0.037 Mollusk fishery: 0.025 beta: 0.853 Degree participation: 0.008 beta: 0.193
21. I feel that my goals for fisheries management are aligned with the goals held by fishermen	Degree participation: 0.010 beta: 0.187	Degree participation: 0.054 beta: -0.148
22. Fishermen's decisions about fishing are based on short term economic returns (within 5 years)	Model fit p-level: 0.035	
23. Scientists base fisheries management decisions on long term resource assessments	Model fit p-level: 0.003	
24. Fishermen base fisheries management decisions on long term resource assessments	Degree participation: 0.029 beta: 0.165	Crustacean fishery: 0.020 beta: 0.803

CHAPTER 4. DISCUSSION

The results of this study reveal the current degree of fisher participation in cooperative research according to fishermen and scientists. Using the 10 steps of the scientific process described by Bonney et al. 2009, fishermen reported less involvement than what was perceived by scientists in eight out of ten steps. With only 145 of 307 fishermen surveyed having participated in cooperative research, those having participated reported a mean involvement of 2.8 steps. Of the 201 scientist respondents, 187 had participated in cooperative research and felt that fishermen were involved in a mean of 3.7 steps. The t-test comparing the two means indicates that fishermen involved in cooperative research believe that they are involved in fewer steps of the scientific process than scientists believe they are. In terms of public participation in scientific research, with a mean of 2.8 steps, fishermen believe they are primarily involved in contributory projects, which involve the public to the smallest degree. This result is further supported by Table 1., which shows the majority of fishermen who participated in cooperative research were involved in gathering information/resources and collecting samples/recording data. Scientists, however, report fisher involvement in an average of about 3.7 steps. This response is possibly due to a differing perception of fisher participation in scientific research. Nonetheless, an average of 3.7 steps qualifies as collaborative research according to the Bonney et al. model for PPSR. While this would be an improvement from the fisher perspective, it does not account for the lack of co-created projects. Co-created projects are found to be the most effective in building trust, improving communication and transparency, and facilitating the knowledge exchange that improves industry/ science relationships as well as management decisions.

The results of this study also highlight several aspects of fisheries science and management that are in need of improvement. With respect to ecosystem and resource health, fishermen and scientists are largely in agreement that the quality and quantity of fish stocks, catch rate, and fish habitat have changed. There is also consensus between fishermen and scientists that the quality of the fishing community has changed over the last five years. The logit model for fishermen indicates that the longer one has fished, the more likely they are to think the health of the fishing community has changed. Scientists and fishermen also agree that there are fewer fishermen now than there were five years ago. Once again the logit model indicates that fishermen with more years of experience are more likely to feel that the fishing industry population has decreased. The logit model for scientists indicates that those researchers involved in cooperative research with fishermen are more likely to feel the industry population has decreased. These findings support the growing awareness in the decline of many Northeast fisheries. Of equal importance is the fact the both groups acknowledge the decline of the fishing community. The decline of economic and social conditions in the fishing community has strong implications for coastal communities where fishing is a significant component of the economy. These implications extend further to significantly impact several coastal states whose economies are in some part dependent on the fishing industry.

In regard to the credibility of fisheries science and management decisions, there is still a distinct lack of consensus between fishermen and scientists. The majority of fishermen do not trust scientific research used in fisheries management. Fishermen at large also do not feel that fisheries management decisions are based on sound science or that scientific assessments are valuable for managing the fishery sustainably. The logit model for fishermen indicates that more years of fishing experience leads fishermen to find scientific assessments less valuable. This could be in part due to the many issues that have arisen in fisheries management over the last several decades. The logit model indicates that the mean number of years of experience in the industry for this particular questions is 31.4 ±12.5 years. It is, therefore, likely that years of contention in fisheries management combined with mishaps such as “trawl gate” have led older fishermen to find scientific assessments less valuable. Interestingly, neither fishermen nor scientists feel that there is enough data collection to make sounds fisheries management decisions. This result would indicate a distinct area in fisheries management in which there exists a consensus over the need for improvement.

Several of the statements provided in the survey were designed to evaluate the current degree of fisher participation in the scientific process. In addition to asking scientists and fishermen about their personal involvement in cooperative research, survey respondents answered several questions on the incorporation of fisher knowledge at large into the scientific process. Specifically, respondents were asking if fisher knowledge was incorporated into data collection, data analysis, and the interpretation of scientific information used for fisheries management decisions. The responses from both fishermen and scientists alike, indicates that the majority of respondents feel that fisher knowledge is not incorporated into the scientific process. The fisher logit model for each of these statements indicates that more years of fishing experience lead fishermen to believe their knowledge is not being incorporated into the scientific process. However, mollusk fishermen are more likely to feel that their knowledge is, in fact, being incorporated into the scientific process. This output from the logit model indicates that the management regime for mollusk fisheries may be more inclusive of fisher knowledge. Additionally, fisher participation in science leads respondents to feel fisher knowledge is being incorporated into the data collection process. Unfortunately, fisher participation in science also leads respondents to feel that fisher knowledge is not being incorporated into the data analysis process.

The results to statements surrounding the decision-making process and research collaborations demonstrate an overall positive influence of cooperative research. The vast majority of fishermen and scientists feel that it is worth the time for the two groups to work together because it leads to better management decisions. Those scientists and fishermen participating in cooperative research are also more likely to want to be involved in fisher/scientist research collaborations. However, scientists and fishermen with more years of experience are less likely to want to be involved in research collaborations possibly indicating a negative side effect of several years of contention and mistrust between the groups. Encouragingly, scientists participating in cooperative research are more likely to feel that their goals for fisheries management align with those held by fishermen and not those held by other scientists. Fishermen participating in cooperative research, likewise, are more likely to feel that their goals for fisheries management align with those held by scientists and not those held by other fishermen. These results from the logit models emphasize the ability of cooperative research to resolve differing opinions about fisheries science and management decisions. This is once again, likely due to known benefits such as increased communication and transparency of information.

CHAPTER 5. CONCLUSION

This study was designed to examine the current degree of fisher participation in scientific research as well as evaluate the current degree of consensus between fishers and scientists regarding science and management decisions. Despite efforts to increase fisher participation in fisheries management decisions through co-management and cooperative research efforts, there continues to be a lack of fisher involvement and persisting tensions in industry/science relations. Based on the PPSR model established by Bonney et al. 2009, fisher participation in cooperative research remains at the contributory/collaborative level. This would lead one to believe that although there have been great strides in establishing cooperative research projects and providing a platform for fishermen and scientists to work together, much work needs to be done in order to improve the cooperative research process. In addition, the series of 24 true/false questions, were designed to elicit the respondents agreement with a series of statements relative to components of fisheries management including ecosystem/ resource health, participation in science and management, fisheries decision-making, and ecosystem and economic processes. The results of the survey indicate that there continue to be many differences in opinions regarding resource health and management decisions. However, there is consensus between the two groups regarding the health of the fishing community, lack of scientific data collection, and the value of fisher/scientists research collaborations. There is also an overwhelming consensus that cooperation between fishers and scientists is incredibly valuable for sound resource management and a clear willingness exists between both parties to participate in cooperative research. The continued disparities revealed in this study emphasize areas of fisheries management and cooperative research that need to be resolved. However, the areas of consensus reveal improvements to fisheries management of which both parties are in favor. Our study demonstrates the need for more in depth fisher participation in scientific research in order to truly reap the benefits of cooperative research. Cooperative research is currently helping to align scientist and fisher goals for fisheries science and management as shown in this study. By establishing more co-created projects, we believe that the known benefits of cooperative research will increase and potentially resolve the continued disparities that this study has highlighted.

APPENDIX

Dear Captain,

This survey has been created in order to evaluate the effectiveness of cooperative research projects in Northeast fisheries in terms of fishermen participation. The survey has been given to fishermen and scientists to understand similarities and differences in attitudes towards fisheries science and management decisions. Although many of the questions are True/False, you are encouraged to provide any additional information that could help us to understand the attitudes towards management decisions in the "comments" section at the end of the survey. From these results our research team plans to evaluate the strengths and weaknesses of cooperative research in order to increase fishermen participation and improve the effectiveness of management decisions. The time and effort that you put into completing this survey is greatly appreciated and will help support the completion of my Masters thesis research.

Sincerely,
Molly Miller
Masters of Science candidate

For the purposes of this survey, a commercial fisherman is one who fishes for profit, not including professionals who take on tourists and recreational fishers for pay.

1. Are you a commercial fisherman? (Please check one) ☐ Yes ☐ No
2. How many years have you commercially fished? ________________ Years
3. What generation fisherman are you? (Please check one) ☐ 1st ☐ 2nd ☐ 3rd ☐ 4th
4. Do you fish inshore (state waters) or offshore (federal waters) most often? (Please check one)

☐ Inshore ☐ Offshore ☐ I fish inshore and offshore about equally

5. Which fish species do you target most often? (feel free to list several)

____

____

6. Where is your main port? (city) ___________________________

7. Have you ever cooperated with scientists on fisheries related research projects? (Please check one).

☐ Yes If you answered yes, please proceed to question 8. ☐ No If you answered 'no' please skip to section B.

8. If you answered 'yes' to question 7, please indicate which of the following research activities that you were personally involved with.

Component	Please check all activities that you were involved with
Choosing/defining the research questions	
Gathering information and resources	
Developing theories for the research question	
Designing data collection methods	
Collecting samples/recording data	
Analyzing samples	
Analyzing data	
Interpreting data and drawing conclusions	
Distributing the conclusions of the study	
Discussing results and asking new questions	
I have never been involved in the research process	

B. For each question, please check ***one*** of the two options that best support your beliefs.

	TRUE	FALSE
1. Legally harvestable fish stocks have remained constant over the past 5 years.	☐ T	☐ F
2. Fish habitat has remained stable over the last 5 years.	☐ T	☐ F
3. The catch rate of fishes has remained stable over the last 5 years.	☐ T	☐ F
4. The quality of fish stocks has remained constant over the last 5 years.	☐ T	☐ F
5. The quality of the fishing community (economic or social conditions) has remained stable over the last 5 years.	☐ T	☐ F
6. The number of fishermen is lower now than it was 5 years ago.	☐ T	☐ F
7. Fisheries management decisions are based on sound science.	☐ T	☐ F
8. I generally trust the scientific research used in fisheries management.	☐ T	☐ F
9. I feel that the scientific assessments used in fisheries management are valuable for managing fisheries sustainably.	☐ T	☐ F
10. Enough data are collected to make sound fisheries management decisions.	☐ T	☐ F
11. Data analysis used to make fisheries management decisions accurately reflects the health of the resource.	☐ T	☐ F
12. Currently fishermen knowledge is used in the data collection process for fisheries management decisions.	☐ T	☐ F
13. Currently fishermen knowledge is used to analyze data used in fisheries management decisions.	☐ T	☐ F
14. Currently fishermen knowledge is used to interpret the scientific information used for fisheries management decisions.	☐ T	☐ F
15. I feel single species management is the most effective way to manage commercial fisheries.	☐ T	☐ F
16. I feel ecosystem based management is the most effective way to manage commercial fisheries.	☐ T	☐ F
17. It is worth the time for scientists and fishermen to work together because it leads to better management decisions.	☐ T	☐ F
18. I am actively engaged in the decision making process for fisheries management.	☐ T	☐ F
19. I want to be involved in fishermen-scientist research collaborations and help develop scientific information that can be used in fisheries management.	☐ T	☐ F

20. I feel that my goals for fisheries management are aligned with the goals held by scientists. ☐ T ☐ F

21. I feel that my goals for fisheries management are aligned with the goals held by fishermen. ☐ T ☐ F

22. Fishermen's decisions about fishing are based on short term economic returns (within 5 years). ☐ T ☐ F

23. Scientists base fisheries management decisions on long term resource assessments. ☐ T ☐ F

24. Fishermen base fisheries management decisions on long term resource assessments. ☐ T ☐ F

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