IMPACTS TO ABUNDANCE AND DISTRIBUTION OF

FRASER RIVER WHITE STURGEON

RESULTS OF EXPERT ELICITATION SURVEY AND

TECHNICAL WORKSHOP

prepared for: Fraser River Sturgeon Conservation Society
                Fraser River White Sturgeon Working Group

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Table of Contents

1. INTRODUCTION

Development of a Fraser River White Sturgeon Conservation Plan (referred to henceforth as the "Plan") has recently been initiated, and a Working Group has been assembled to oversee development of a draft Plan. The Plan will be a high-level planning document that provides information on white sturgeon biology and conservation, identifies information gaps, and sets priorities for action by government and non-government organizations. The recent COSEWIC listing of white sturgeon as "endangered" emphasizes the need for a Conservation Plan.

Development of the Plan requires an understanding of the threats to long-term persistence of white sturgeon in the Fraser River. A brief background to white sturgeon biology and a summary of the issues facing conservation of Fraser River white sturgeon stocks was prepared by Hatfield et al. (2004). During preparation of that document and during discussions with the Working Group it became apparent that although a great deal was known about Fraser River white sturgeon there were nevertheless substantial gaps and uncertainties in the information base. For example, much of the information is based on experience rather than formal data collection during empirical studies. Additionally, many of the impacts are specific to certain stocks, locations or times. The relative importance of different impacts is therefore not entirely clear cut, so development of a Conservation Plan is not a simple task of collating information on impacts and recommending management actions to address the impacts. Considerable subjective judgement is required to rank the relative importance of different impacts and data requirements.

We captured subjective judgements of impact and action priorities by using a panel of resource managers with specific expertise in white sturgeon biology or habitat management. The expert elicitation involved a questionnaire, a formal scoring procedure for the questionnaire responses, and structured discussion at a follow up technical workshop. This document describes the methods used and the results obtained from the expert panel.

2. METHODS

We assembled an expert panel with representation from Fisheries and Oceans Canada, Ministry of Water, Land and Air Protection, First Nations, consultants, fishing guides, academics, and the Fraser River Sturgeon Conservation Society (). We made a concerted effort to obtain representation from throughout the watershed.

We devised a questionnaire focusing on the 15 "impact hypotheses" for Fraser River white sturgeon as presented and discussed in Hatfield et al. (2004). A copy of the questionnaire is provided in Appendix A. The questionnaire was written in an Excel spreadsheet and distributed to the expert panel via Email.

Technical Expert	Affiliation
Don Cadden	Ministry of Water Land and Air Protection
Dave Lane	Malaspina University College
Marc Laynes	Cascade Fishing Charters
Steve McAdam	Ministry of Water Land and Air Protection
Ian McGregor	Ministry of Water Land and Air Protection
Troy Nelson	Fraser River Sturgeon Conservation Society
Chris Perrin	Limnotek Research and Development Inc
Mike Ramsay	Ministry of Water Land and Air Protection
Marvin Rosenau	Ministry of Water Land and Air Protection
Dan Sneep	Fisheries and Oceans Canada
Brian Toth	Lheidli T'enneh First Nation

Table 1. List of respondents to the expert questionnaire.

A major intent of the exercise was to focus attention first on the underlying mechanisms influencing white sturgeon (e.g., water temperature) before assessing the causal agents controlling the mechanism (e.g., river regulation). Our aim in doing this was to focus on available data and uncertainties as a first step, rather than foster immediate arguments about which cause is most important. The questionnaire listed the 15 impact hypotheses for each of the four stock groups. For each impact hypothesis experts were asked a series of six questions:

1. Is this impact hypothesis relevant to this stock group?
2. How large is the geographic area over which this impact occurs?
3. What is the magnitude of this impact?
4. How frequently does this impact occur?
5. How sensitive is this impact to species-specific management actions?
6. What is the value of additional data for this impact?

Answers were restricted to either a yes or no (for question 1) or a numerical response between 0 and 5 (for all other questions). Definitions were provided to guide numerical responses, see Appendix B.

Experts were asked to bear in mind the following as they filled in the spreadsheet:

1. to be as objective as possible. The success of this exercise depended in part on experts not being strategic when applying the scores. We expected there to be differences of opinion among respondents regarding the relative importance of different impacts, but respondents were asked to not attempt to make a "favourite" impact stand out by inflating its score, or deflating scores for other impacts.

2. to not assess the relative importance of impacts among the stock groups. It was decided early on that results for each stock group would be kept separate throughout the examination of scores and reporting of results. If prioritization among stock groups is necessary it will be addressed outside the scope of this exercise.

3. to not re-examine recommendations of the Nechako Recovery Team, or to exert influence over recommendations made by that group. The Nechako was examined here primarily for the sake of completeness, since the Conservation Plan is meant to cover the entire watershed.

4. to gauge the present state against the perceived natural state. For example, we know the present turbidity regime in different parts of the river and respondents were being asked to gauge this against what they believe the natural state to be (i.e., are any changes "significant"). In assessing one impact hypothesis, hatchery effects, this could not be done because there are no sturgeon hatcheries operating in the Fraser River watershed. However, there is some likelihood that this may occur, so we asked experts to consider possible effects. In this case, experts were asked to base responses on experience outside the watershed or within the watershed with different species.

When we received the completed questionnaires they were analyzed separately using a scoring system for impact, management action, and an information score. The scores were calculated according to the following formulae:

> impact score = impact area + impact magnitude + impact frequency
> action score = impact score * sensitivity to management
> information score = impact score * value of additional data

Since answers to each question could span a range of 0 to 5, the formulae allow impact scores to range from 0 to 15, whereas action and information scores could range from 0 to 75. Implicit in these formulae are weighting factors of 1 for each of the individual scores. Under this weighting impact area is of equal importance to impact magnitude and impact frequency.

The verbal rationale for these formulae is as follows. An impact is scored relatively highly if it occurs over a broad geographic area, seriously affects a substantial portion of the population, and occurs frequently. An impact should be addressed preferentially by management if the impact is relatively serious and it is amenable to cost-effective mitigation: a high impact score need not translate into a high action score if mitigating the impact is not tractable. An impact should be further investigated (i.e., targeted for research) if it is currently deemed a serious impact but there is little known about how it operates.

Impact, action and information scores were calculated separately for each respondent and then compiled for the group. Group scores were calculated using medians and ranges for each impact hypothesis, and for each stock group. Results were plotted as histograms and dot plots.

A technical workshop was held in Vancouver on January 22, 2004 with the same group of experts. At the workshop we presented the group's questionnaire responses to stimulate and guide discussion. During discussion we reviewed the scores and then categorized impacts, management action, and information needs into bins of high, medium and low priority. No formal procedure was used to develop threshold values for the priority bins, but discussion throughout the categorization process focussed on whether assignment to the different bins was logical and defensible. Rationale for the categorization was developed where necessary. Time limitations in the workshop did not allow detailed exploration of respondents' opinions of the

weights used in the scoring formulae; however, there were no objections to the use of a weight of 1.0 (i.e. equal weights) to each of the elements of the formulae.

At the workshop respondents were encouraged to update their scores if they felt that changes were appropriate given the information discussed during the day. Only three respondents submitted updated scores, so we decided not to update the analysis of respondent scores.

3. RESULTS

Initial results from the survey are shown in Figure 1 to Figure 12. The results are presented separately for impact, action and information scores, and are also presented separately for each stock. Many of the impact, action and information scores indicate considerable concordance among the experts, although some issues elicited considerable variation among respondents. Some topics received high scores throughout the watershed, whereas other topics were viewed quite differently for each stock, indicating the different nature of management actions that may need to be applied in different areas.

Some of the variation in responses can also be attributed to a misreading of the task set – some participants answered the questions with a slightly different framing of the questions than others. Also, the scales presented in Appendix B were designed to be as flexible and consistent as possible across the various hazard types; however, this introduced some ambiguities that were a source of confusion in a small number of cases. One purpose of the workshop was to highlight areas of genuine disagreement and agreement by ensuring that all participants were considering the same issues. This was effectively achieved through the course of the day, but is not documented here in detail.

During the workshop experts were asked to act as a group in order to categorize impacts, management actions and information needs into high, medium and low priority "bins." Results of the categorization are presented in .
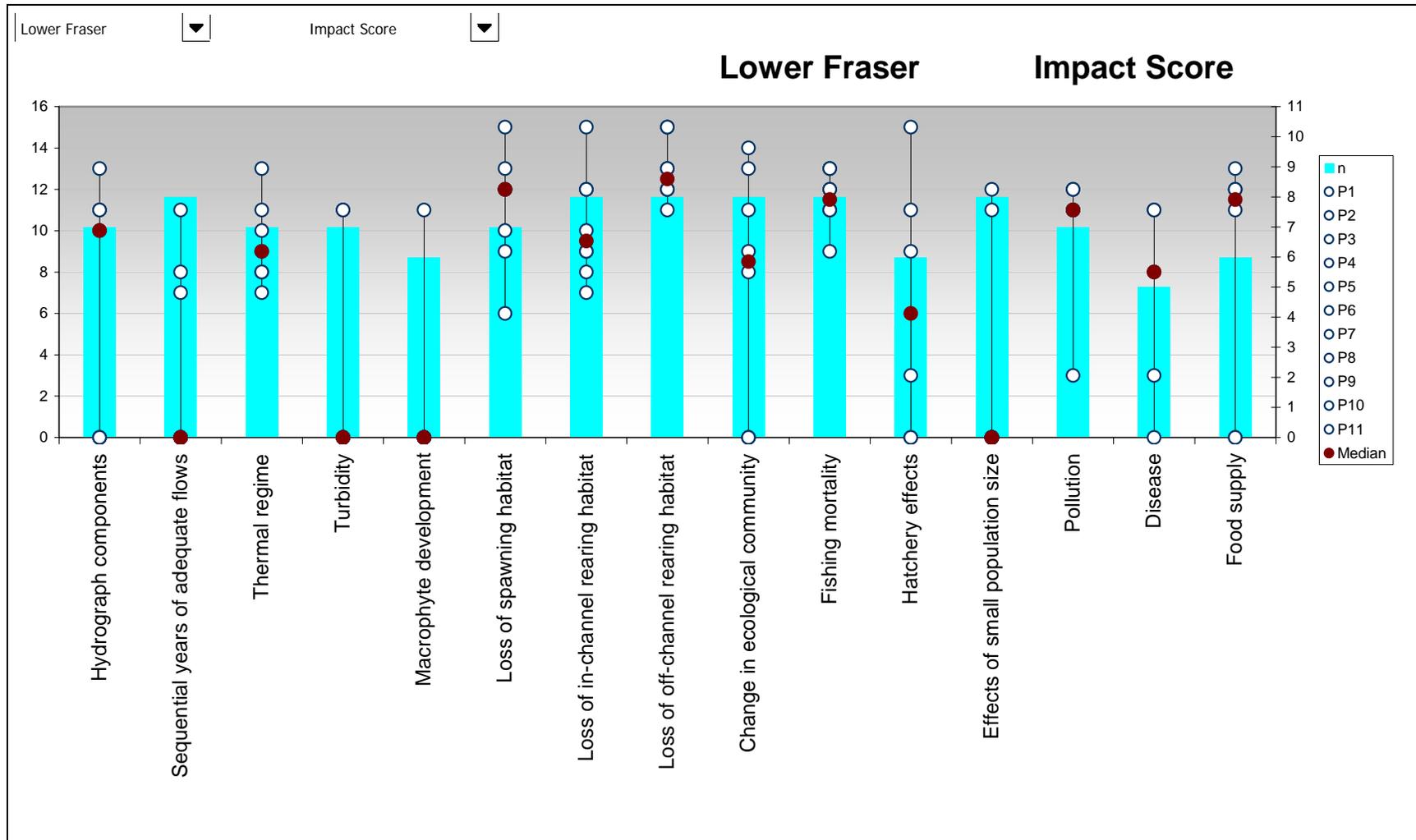
Figure 1. Impact scores for the lower Fraser River, as determined from the expert panel. Sample size (number of experts responding to a question) is indicated by the blue histograms. Individual scores are indicated as points, with minimum and maximum scores joined to show ranges. Median scores are indicated by red points. Individual respondent scores are confidential.
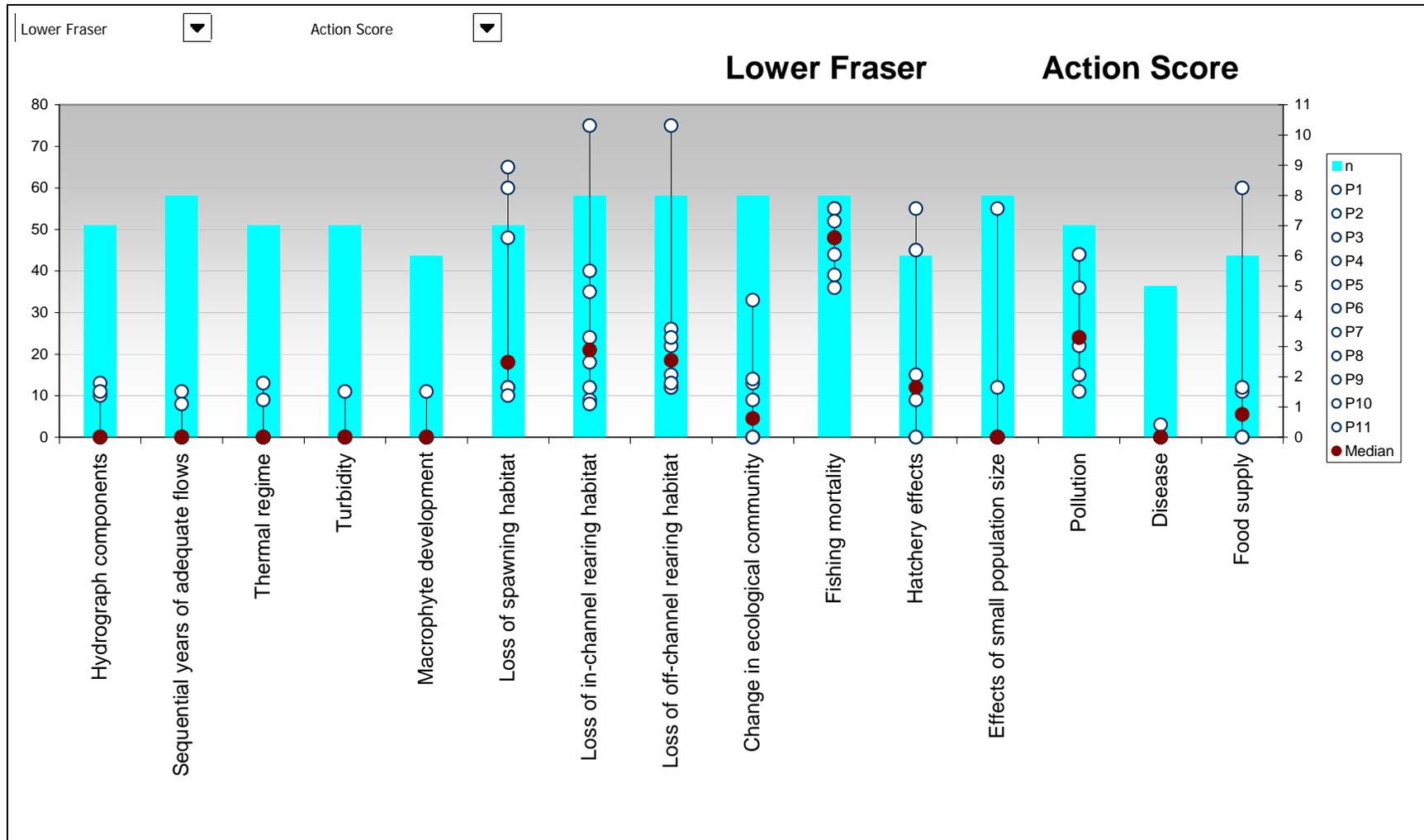
Figure 2. Scores for management actions for the lower Fraser River, as determined from the expert panel.

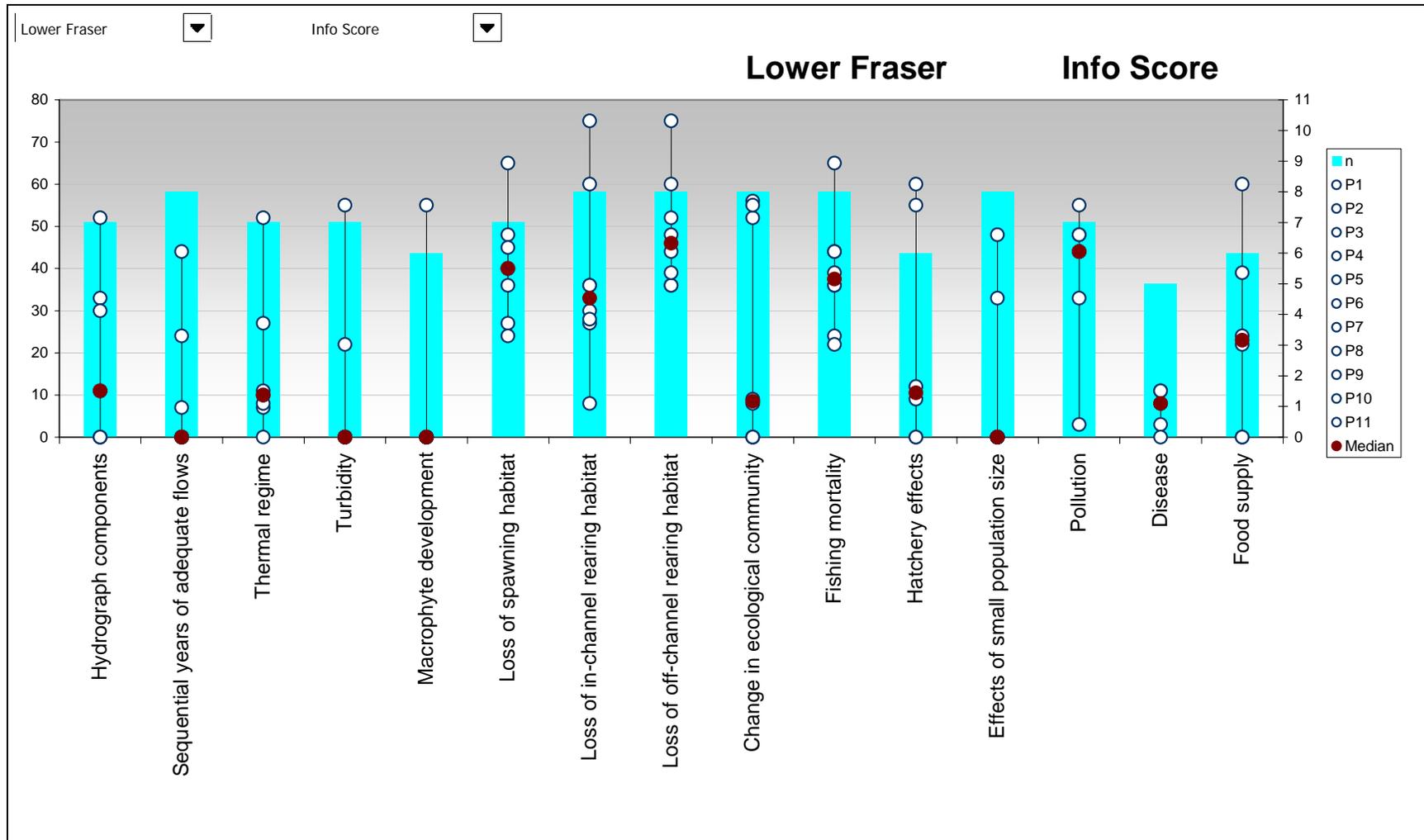Figure 3. Information (data gap) scores for the lower Fraser River, as determined from the expert panel.

Figure 4. Impact scores for the mid Fraser River, as determined from the expert panel.

Figure 5. Scores for management actions for the mid Fraser River, as determined from the expert panel.

Figure 6. Information (data gap) scores for the mid Fraser River, as determined from the expert panel.

Figure 7. Impact scores for the upper Fraser River, as determined from the expert panel.

Figure 8. Scores for management actions for the upper Fraser River, as determined from the expert panel.

Figure 9. Information (data gap) scores for the upper Fraser River, as determined from the expert panel.
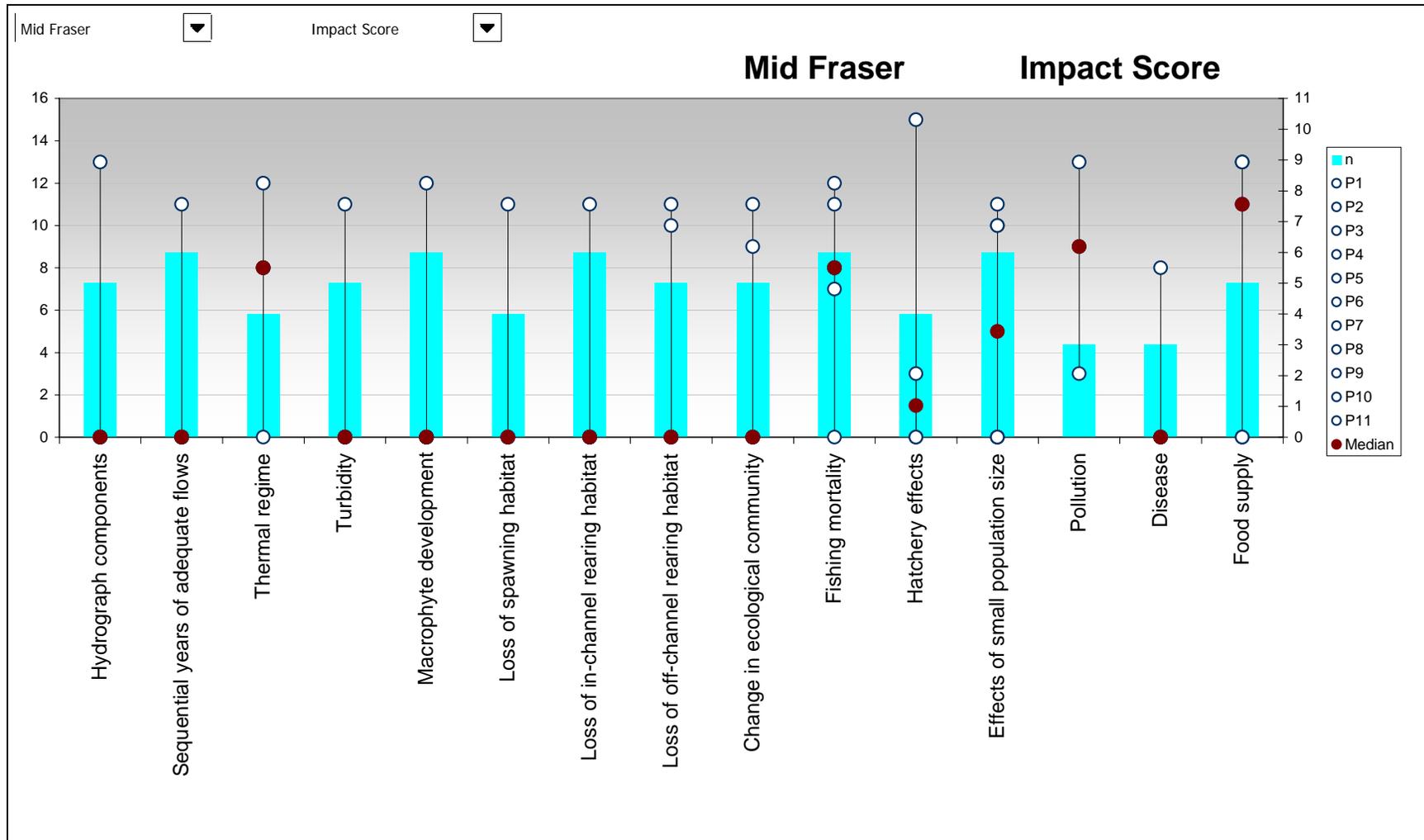
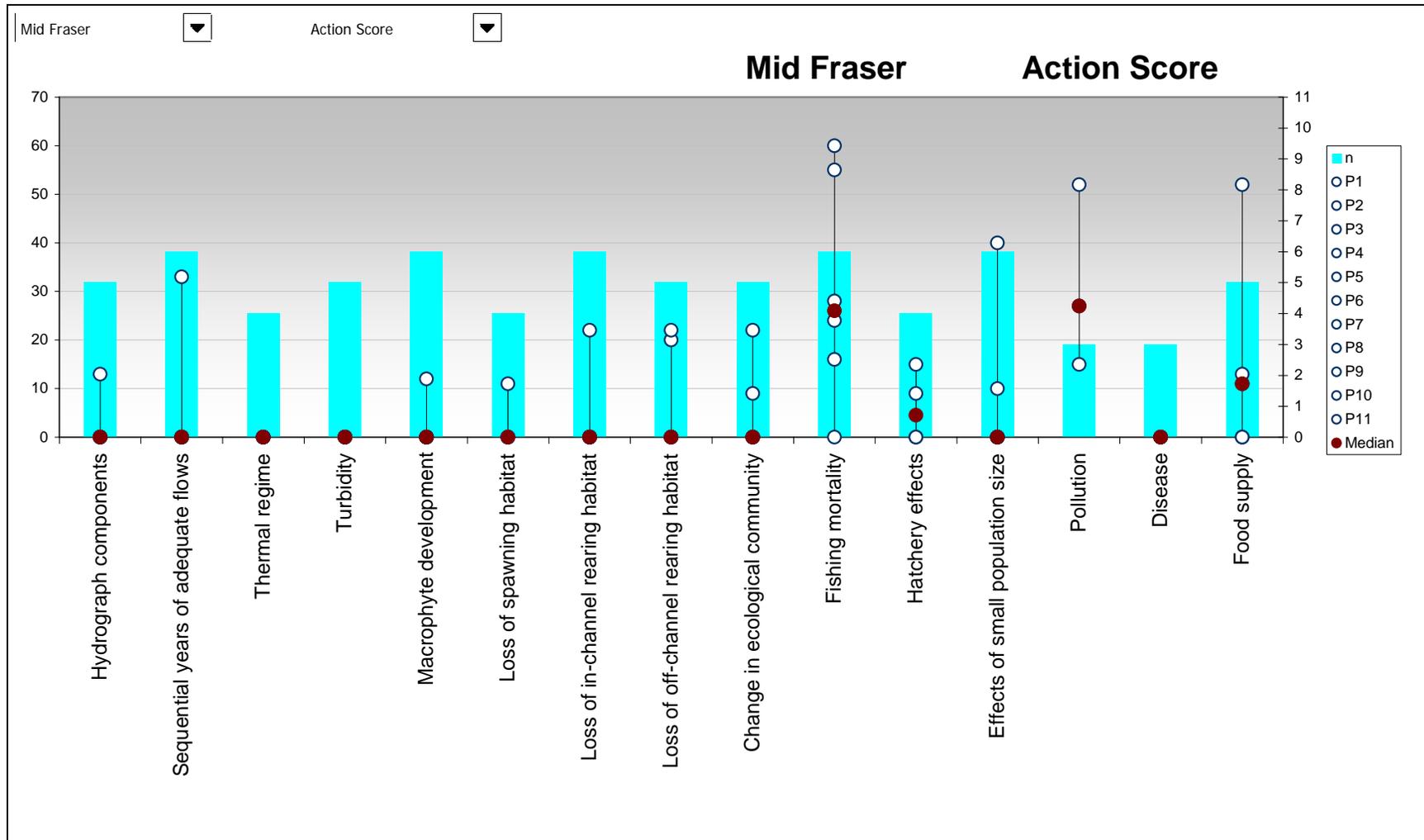Figure 10.   Impact scores for the Nechako River, as determined from the expert panel.

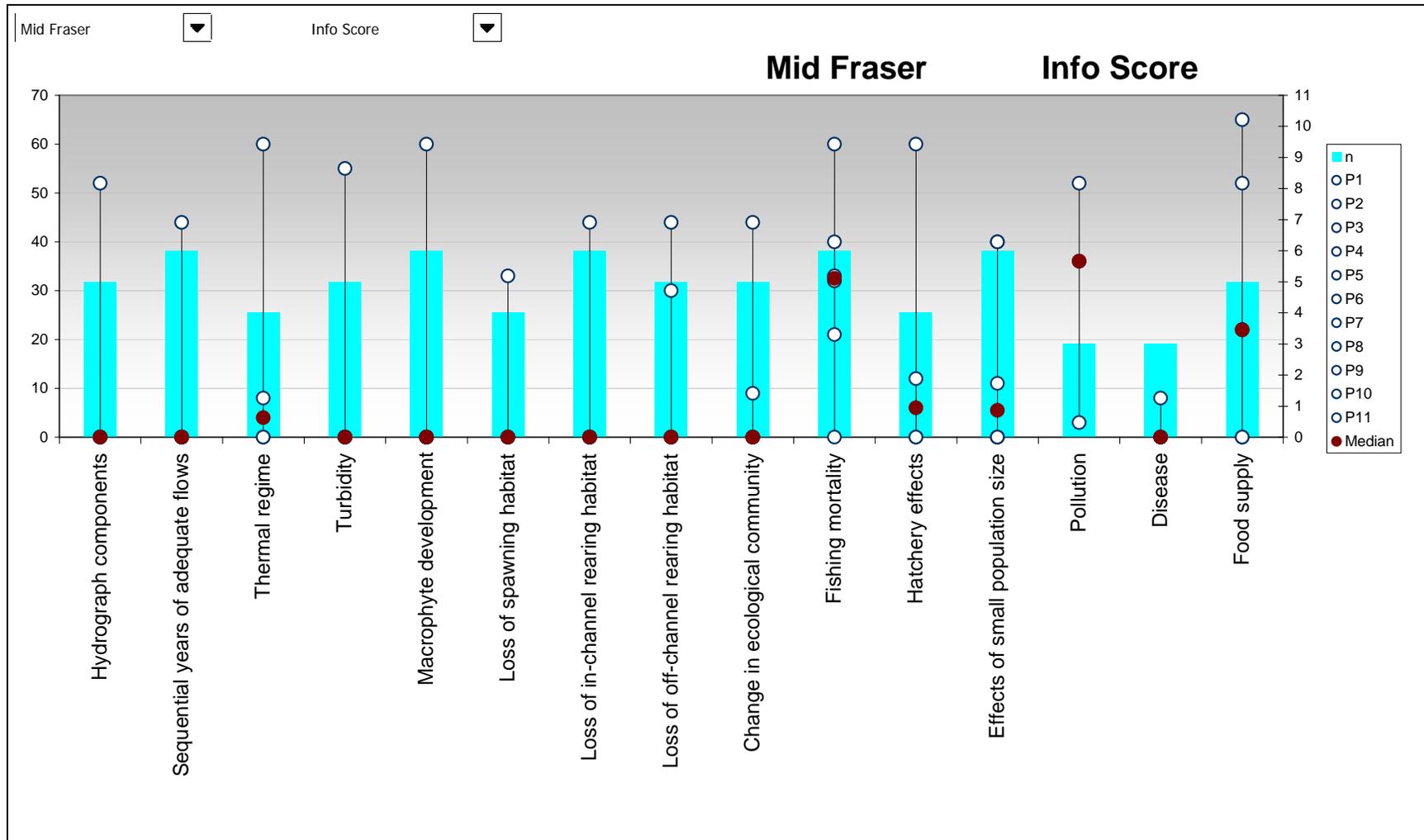Figure 11.   Scores for management actions for the Nechako River, as determined from the expert panel.

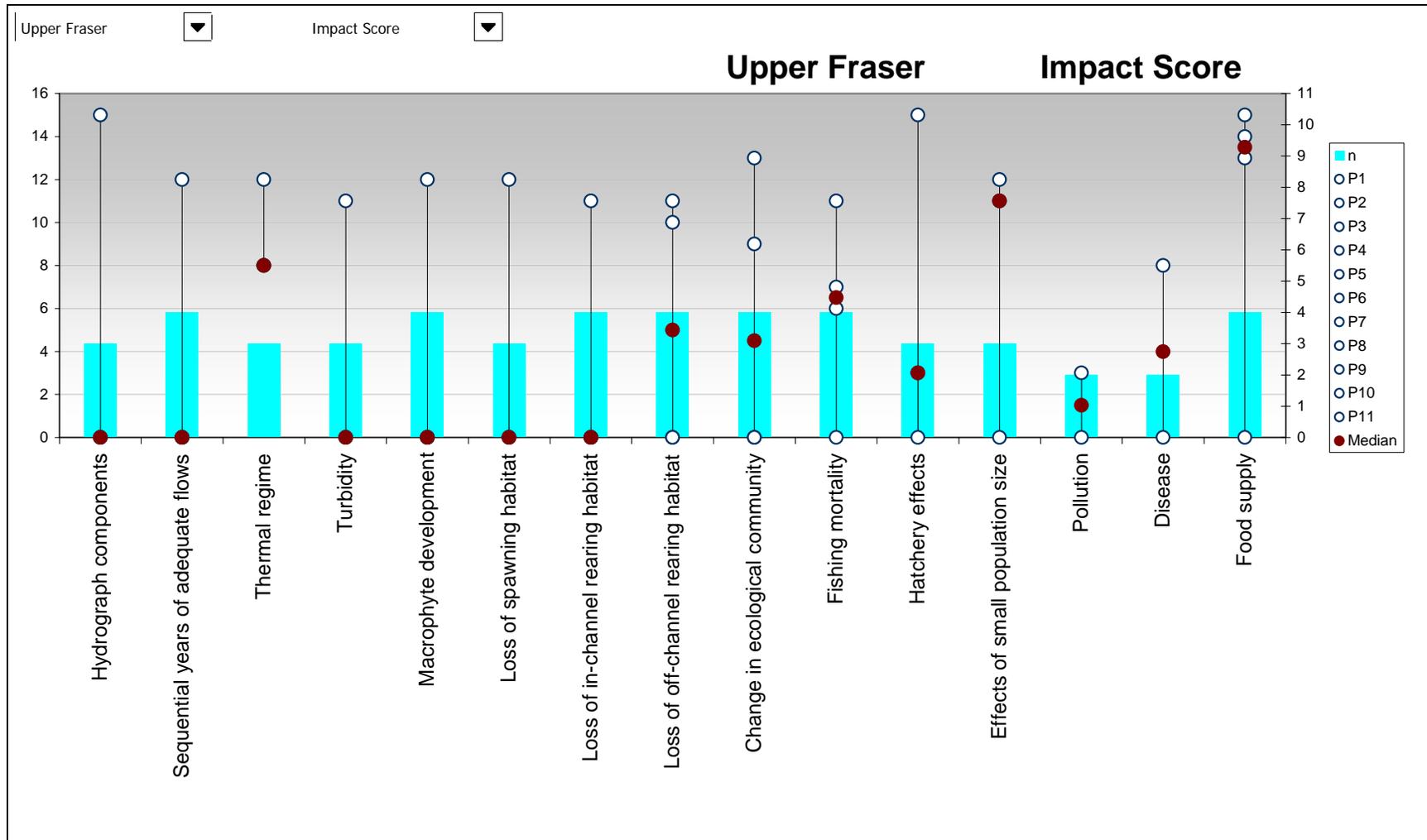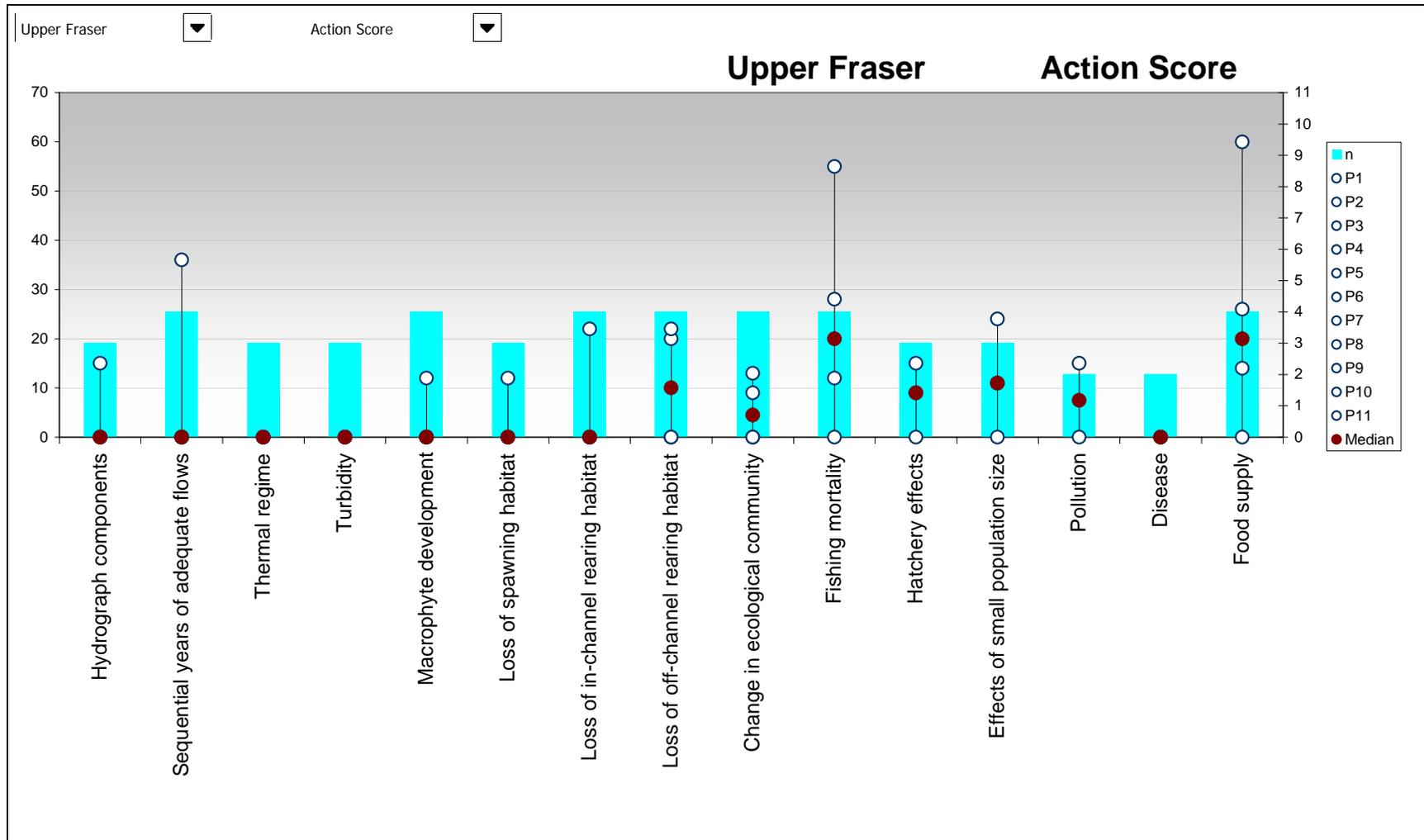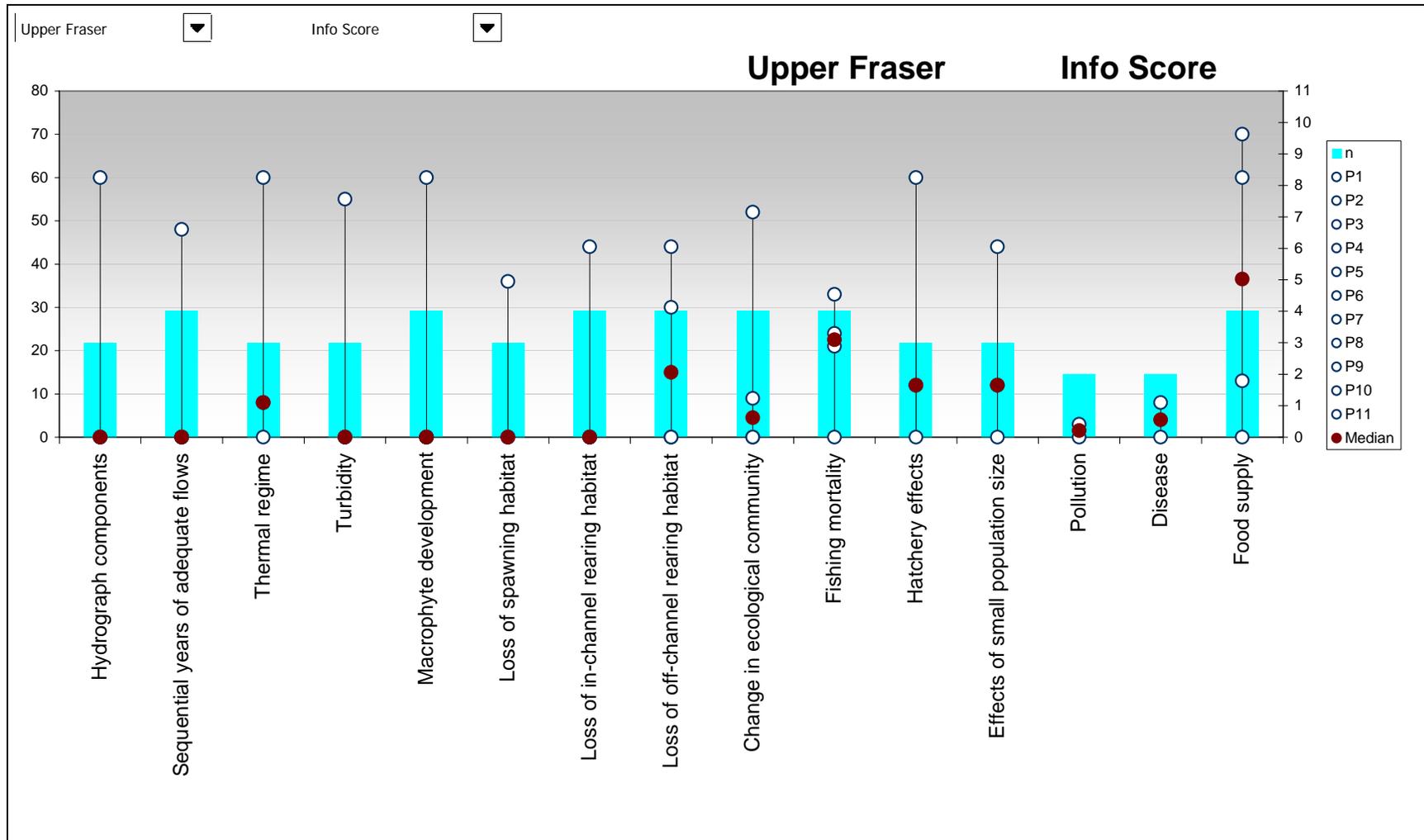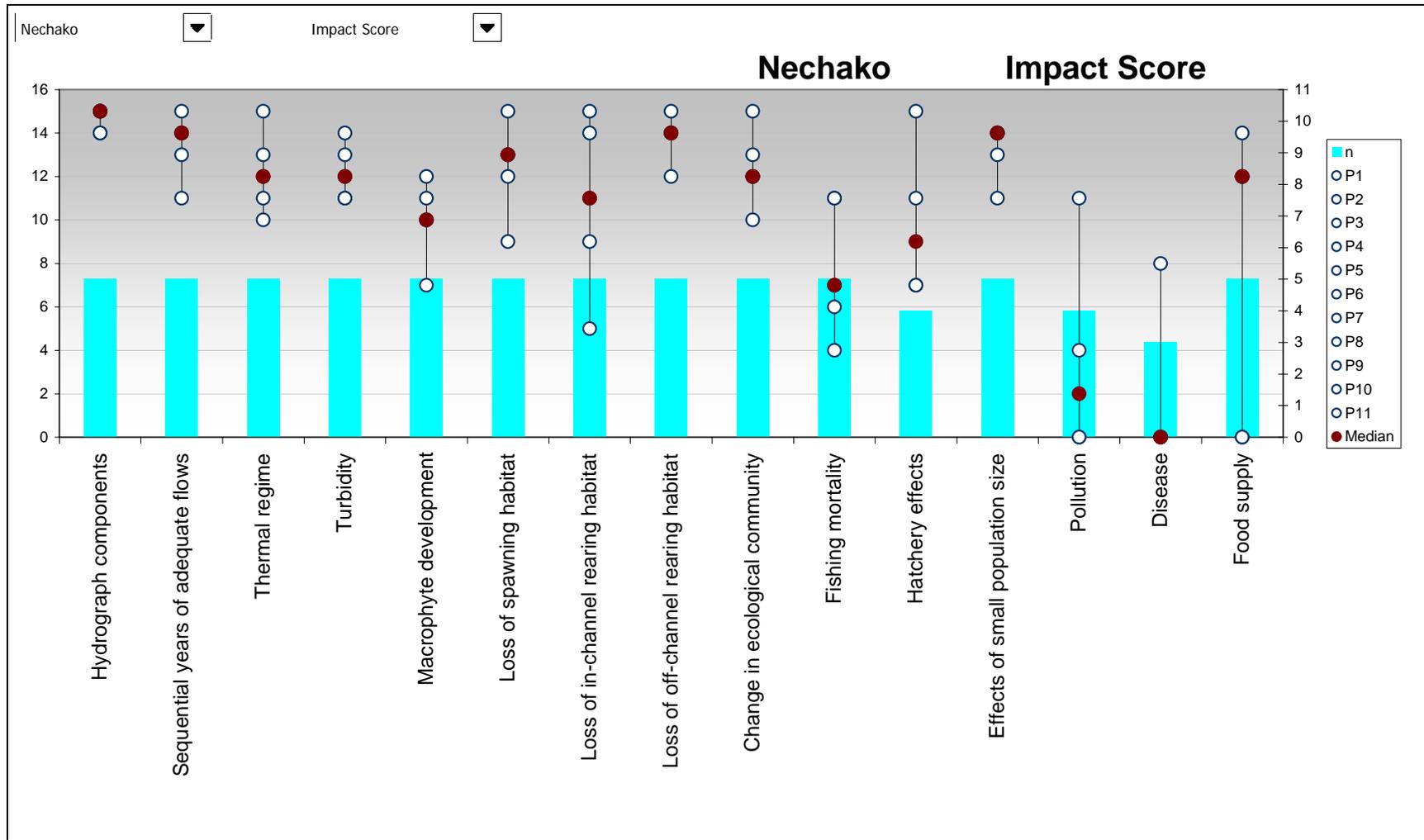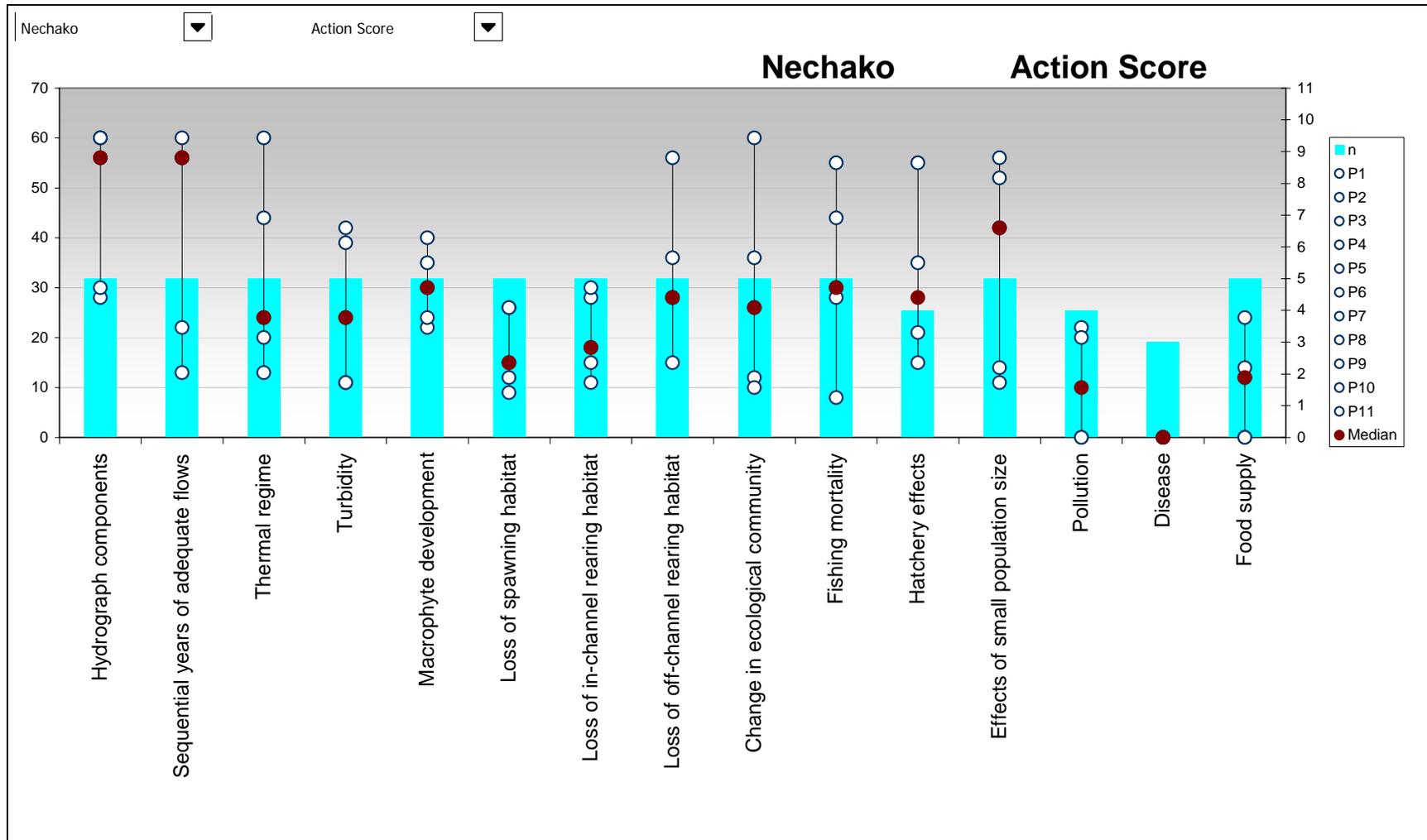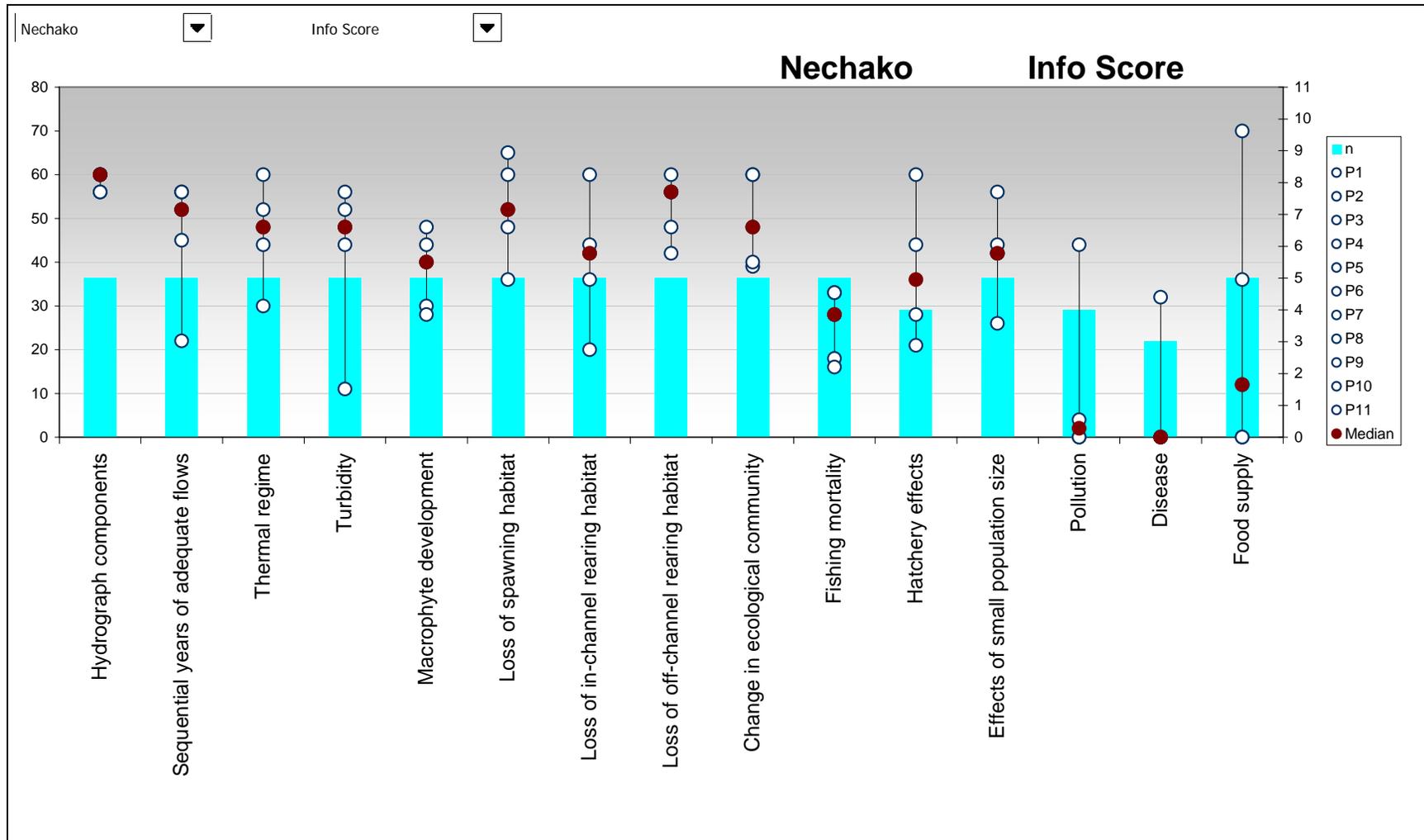Figure 12.   Information (data gap) scores for the Nechako River, as determined from the expert panel.

UPPER / MID FRASER			
	ISSUE	**Priority for action**	**Priority for research**
HIGH	Spawning habitat Food supply Hatchery effects (potential)	Fishing effects Food supply	Spawning habitat Fishing effects Mainstem rearing habitat (Mid Fraser) Off-channel rearing habitat (Upper Fraser) Hatchery effects Food Supply
MEDIUM	Mainstem rearing habitat (Mid Fraser) Off-channel rearing habitat (Upper Fraser) Fishing effects Effects of small population size	Effects of small population size	Effects of small population size Pollution
LOW	Hydrograph components Sequential years of adequate flows Thermal regime Turbidity Macrophyte Development Pollution Change in ecological community Disease	Thermal regime Turbidity Macrophyte Development Spawning habitat In-channel rearing habitat Off-channel rearing habitat Change in ecological community Hatchery effects Pollution Disease	Hydrograph components Sequential years of adequate flows Thermal regime Turbidity Macrophyte Development Change in ecological community Disease

LOWER FRASER			
	ISSUE	**Priority for action**	**Priority for research**
HIGH	Spawning habitat Mainstem rearing habitat Off-channel rearing habitat Fishing effects Pollution Hatchery effects (potential)	Spawning habitat Mainstem rearing habitat Off-channel rearing habitat Fishing effects Food supply	Spawning habitat Mainstem rearing habitat Off-channel rearing habitat Fishing effects
MEDIUM	Food Supply		Food Supply
LOW	Hydrograph components Sequential years of adequate flows Thermal regime Turbidity Macrophyte Development Change in ecological community Effects of small population size Disease	Hydrograph components Sequential years of adequate flows Thermal regime Turbidity Macrophyte Development Change in ecological community Hatchery effects Effects of small population size Pollution Disease	Hydrograph components Sequential years of adequate flows Thermal regime Turbidity Macrophyte Development Change in ecological community Hatchery effects Effects of small population size Pollution Disease

Table 2.   Categorization and prioritization of impacts for Fraser River white sturgeon, as determined by the expert panel. Priorities were developed separately for the upper, mid and lower Fraser. Since results for the upper and mid Fraser are very similar they are combined here into a single table. Priorities were not developed for the Nechako River, as this has already been completed by the Nechako River White Sturgeon Recovery Team.

4.   DISCUSSION

Following presentation and detailed discussion of the impact, action, and information scores, the expert panel worked as a group to categorize and prioritize impacts and actions for Fraser River white sturgeon. Priorities were developed separately for the upper, mid and lower Fraser. Since results for the upper and mid Fraser are very similar they are discussed here

together. Priorities were not developed for the Nechako River, as this has already been completed by the Nechako River White Sturgeon Recovery Team.

4.1   Lower Fraser River

Results for the lower Fraser River were somewhat similar to results for the mid and upper Fraser, particularly in that most of the issues flagged as issues of low concern were the same for both areas.

Impacts.— At the technical workshop the expert group categorized sturgeon spawning and rearing habitat, fishing effects (from a variety of fisheries), pollution, and (potential) hatchery effects to be of greatest influence on white sturgeon populations in the lower Fraser River. Scores were consistently high for population effects due to habitat impacts, fishing effects and pollution. The response to hatchery effects was considerably more variable, but the median score and subsequent discussion support ranking this as a potentially serious impact. The effects of habitat degradation or destruction were discussed at length and it was repeatedly emphasized that loss of the floodplain in the lower Fraser (e.g., due to dyking), and continuing disturbance and alteration of existing in-channel and off-channel habitats is a major impact.

There was concern expressed (both in terms of responses to the questionnaire and in discussion during the workshop) about the possible negative effects of high commercial salmon and eulachon harvest, since adult sturgeon in this stock group are highly dependent on this seasonal food source. This issue was categorized as a medium impact. All other issues were deemed to be of relatively low impact at present.

Actions. — The group considered management priorities for white sturgeon in the lower Fraser, based on likely impacts and opportunities for cost-effective mitigation (see Appendix B for guiding definitions of "cost effective"). Although it was acknowledged that comparatively little could be done to offset the effects of habitat loss (e.g., the enormous loss of floodplain habitat due to dyking completed in the early 1900s) the group did not believe that the issue of habitat management should be demoted to a low priority for management action. The rationale given was that the remaining habitats were disproportionately important and protection of these should be a high priority. Protection of the remaining habitats was deemed to be very cost effective mitigation against population decline.

Fishing effects from the several fisheries that occur in the lower Fraser (non-retention angling, aboriginal fisheries, commercial fisheries, and illegal harvest/poaching) were identified as impacts that could be addressed through programs specific to each fishery, so this issue was deemed to be a high priority for management action. Food supply, although identified as a medium impact, was identified as an issue of high priority for action. Discussion during the workshop appeared to acknowledge that the sturgeon population does not at present appear to be food limited, but that high harvest rates in the past were a considerable concern. The suggested action was primarily ensuring that escapement of salmon and eulachon are sufficient to support white sturgeon needs.

Pollution was categorized as a high impact to the white sturgeon in the lower Fraser. Despite this, the group deemed that the topic was of low priority for action simply because there is a high degree of effort already being expended on this issue. The group indicated that it

appeared that additionally direct action on this topic is not warranted at this time. Hatchery effects were similarly treated, in that the group appeared to accept that there should be no immediate action taken on this topic unless proposals for aquaculture become more tangible. All other issues were deemed to be of relatively low priority for management action.

Data gaps. — Virtually all of the issues discussed have substantial data gaps. By necessity, scores were assigned based mostly on professional judgement rather than data from well-executed empirical studies. Only four issues were identified as high priority for research: fishing effects and the three habitat categories. Fishing effects was flagged by the group as both a high impact and an issue in need of empirical study. "Fishing effects" includes several distinct gear types and capture activities, some of which directly target sturgeon and others that intercept sturgeon while targeting other species (in most cases, salmonids). Research would help distinguish the magnitude of effect from the different fisheries, and have large implications for how each fishery is managed. In other words, the return on investment would be high for research conducted on this topic.

The group expressed confidence that their rating of habitat impacts was defensible, but there was also considerable uncertainty expressed with respect to details of how the existing habitats are used. The group stated that additional research on these topics would help define which of the remaining habitats are most important to different life stages of sturgeon and the seasonality of habitat use. This research would help define which human activities should be regulated in these habitats.

Food supply was deemed to be of medium priority for additional research. The group stated that additional work is required to understand how salmon and eulachon escapement rates affect sturgeon abundance and distribution.

4.2   Upper and mid-Fraser River

Impacts.— The expert group deemed sturgeon spawning habitat and food supply to be of greatest concern to these white sturgeon populations in the upper and mid-Fraser River. There was particular concern expressed about the possible negative effects of high commercial salmon harvest, since adult sturgeon in this stock group are highly dependent on this seasonal food source. Hatchery effects were also flagged as a potentially serious issue, although the group acknowledged considerable uncertainty with respect to this issue and indicated a need to further assess the potential risk of conservation hatchery releases in the Nechako River to downstream sturgeon populations.

Rearing habitat, fishing effects, and effects of small population size were identified as issues of medium concern. Mainstem rearing habitat was identified as an issue in the mid-Fraser, whereas off-channel habitat was identified as a concern in the upper Fraser. There was also a moderate concern that the small population number of sturgeon in the upper and mid-Fraser may make them especially vulnerable. All other issues were deemed of much lower consequence for sturgeon in this region.

Actions. — The group considered management priorities for white sturgeon in the upper and mid Fraser, based on likely impacts and opportunities for cost-effective mitigation. Although

spawning habitat was identified as a substantial concern, the group determined that little could be done to mitigate impacts to spawning, so the issue was demoted to a low priority for management action. Conversely, fishing effects were identified as only a medium impact, but due to the relative ease with which mitigation could be deployed this issue was deemed to be a high priority for management action. Food supply was also identified as an issue of high priority for action, with the intended action being primarily ensuring escapement to these stream sections sufficient to support white sturgeon. Effects of small population size was identified as a medium priority for action, although it may be difficult to address this issue directly. If research confirms that this is a significant concern for populations in the upper and mid-Fraser then there may be justification to treat these as especially sensitive stocks.

Data gaps. — A total of six issues were identified as issues of high priority for research. The best way to understand why these issues were flagged as high priority for research is that there is some uncertainty in the rating, such that additional research has a reasonable probability of altering the impact rating the group assigned. For example, fishing effects was flagged as a medium impact by the group; however, there has not been much empirical study of this issue. Therefore additional research may indicate that the issue can be safely downgraded to an issue of low concern, upgraded to higher concern, or confirm that it is of medium impact to Fraser River white sturgeon abundance and distribution. Such findings would have large implication on how a fishery would be managed. In other words, the return on investment would be high for research conducted on this topic. Other issues in this category included, spawning and rearing habitat, hatchery effects and food supply. Two topics were deemed to be of medium priority for additional research: the effects of small population size and pollution.

4.3   Nechako River

As noted earlier, a Recovery Plan has been completed for the Nechako River population of white sturgeon. The purpose of completing the survey for this part of the Fraser River basin was to provide a point of comparison for populations elsewhere in the Fraser basin. Very little workshop time was devoted to the Nechako River, and the group did not attempt to categorize impacts, actions or information needs. There were a maximum of four respondents for this portion of the Fraser basin.

Impacts. — Issues receiving high scores were quite different than elsewhere in the Fraser River watershed. Issues of greatest importance are those associated in some way with the hydrograph; this result is not surprising given that it is a regulated system. A considerable number of the impact hypotheses received high scores, and in some cases it appears that these impacts may be considered competing hypotheses. Only three impacts received relatively low scores: fishing effects, pollution and disease.

Actions. — We did not attempt to categorize action scores into bins of high, medium and low priority, however the scores do appear to indicate that this is possible. For example, pollution, disease and food supply appear to deserve a relatively low ranking. At the other end of the continuum hydrograph components and effects of small population size are ranked relatively high. How other scores should be categorized should be decided upon by the group of experts in a manner consistent with the other categorizations. At that time, the group may also wish to consider whether some of the scores require updating based on discussion within the group.

Data gaps. — A large number of issues consistently rank high with respect to needs for additional information. Pollution, disease and perhaps food supply received relatively low scores. Fishing effects received a moderate score. The remaining impact hypotheses received consistently high scores for additional research needs. There clearly are some substantial data gaps for white sturgeon in the Nechako River.

5. CONCLUSIONS

We used a detailed questionnaire with a group of sturgeon experts to obtain scores that allowed ranking of impacts, management actions and research needs for four stocks of Fraser River white sturgeon. A technical workshop was conducted with the group to make adjustments to the scores and to categorize the impacts, actions and data needs into categories of low, medium and high priority. There is clearly some variation among individuals within the expert group, but as a whole the group was fully supportive of the categorization results and the methods used to achieve the categorization. These results should be used to guide priorities for the Fraser River White Sturgeon Conservation Plan.

6. REFERENCES

Hatfield, T., S. McAdam, and T. Nelson. 2004. Impacts to abundance and distribution of Fraser River white sturgeon. A summary of existing information and presentation of impact hypotheses: Report prepared for the Fraser River Sturgeon Conservation Society and the Fraser River White Sturgeon Working Group.

Appendix A

Questionnaire distributed to experts

Prioritization Matrix for Fraser River White Sturgeon Conservation Plan

to be filled in by appropriate experts

version: 12/18/2003

filled in by: put your name here

Topics & Questions	Answer options	SG1 Impact (lower Fraser)	SG2 Impact (mid Fraser)	SG3 Impact (upper Fraser)	SG4 Impact (Nechako)
Hydrograph components					
Is this impact hypothesis relevant to this stock group?	y / n				
How large is the geographic area over which this impact occurs?	0 to 5				
What is the magnitude of this impact?	0 to 5				
How frequently does this impact occur?	0 to 5				
How sensitive is this impact to species-specific management actions?	0 to 5				
What is the value of additional data for this impact?	0 to 5				
impact score					
score for management actions					
score for additional data collection					
Sequential years of adequate flows					
Is this impact hypothesis relevant to this stock group?	y / n				
How large is the geographic area over which this impact occurs?	0 to 5				
What is the magnitude of this impact?	0 to 5				
How frequently does this impact occur?	0 to 5				
How sensitive is this impact to species-specific management actions?	0 to 5				
What is the value of additional data for this impact?	0 to 5				
impact score					
score for management actions					
score for additional data collection					
Thermal regime					
Is this impact hypothesis relevant to this stock group?	y / n				
How large is the geographic area over which this impact occurs?	0 to 5				
What is the magnitude of this impact?	0 to 5				
How frequently does this impact occur?	0 to 5				
How sensitive is this impact to species-specific management actions?	0 to 5				
What is the value of additional data for this impact?	0 to 5				
impact score					
score for management actions					
score for additional data collection					
Turbidity					
Is this impact hypothesis relevant to this stock group?	y / n				
How large is the geographic area over which this impact occurs?	0 to 5				
What is the magnitude of this impact?	0 to 5				
How frequently does this impact occur?	0 to 5				
How sensitive is this impact to species-specific management actions?	0 to 5				
What is the value of additional data for this impact?	0 to 5				
impact score					
score for management actions					
score for additional data collection					
Macrophyte development					
Is this impact hypothesis relevant to this stock group?	y / n				
How large is the geographic area over which this impact occurs?	0 to 5				
What is the magnitude of this impact?	0 to 5				
How frequently does this impact occur?	0 to 5				
How sensitive is this impact to species-specific management actions?	0 to 5				
What is the value of additional data for this impact?	0 to 5				
impact score					
score for management actions					
score for additional data collection					

Spawning habitat						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
In-channel rearing habitat						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
Off-channel rearing habitat						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
Change in ecological community						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
Fishing mortality						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						

Hatchery effects						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
Effects of small population size						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
Pollution						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
Disease						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						
Food supply						
Is this impact hypothesis relevant to this stock group?	y / n					
How large is the geographic area over which this impact occurs?	0 to 5					
What is the magnitude of this impact?	0 to 5					
How frequently does this impact occur?	0 to 5					
How sensitive is this impact to species-specific management actions?	0 to 5					
What is the value of additional data for this impact?	0 to 5					
impact score						
score for management actions						
score for additional data collection						

Appendix B

Definitions provided to guide responses to questionnaire

Area of Impact

Rating	Description
0	No impact on this stock
1	The affected area exposes less than 5% of the stock group to this impact.
2	The affected area exposes 5 to 10% of the stock group to this impact.
3	The affected area exposes 10 to 25% of the stock group to this impact.
4	The affected area exposes 25 to 50% of the stock group to this impact.
5	The affected area exposes more than 50% of the stock group to this impact.

Magnitude of Impact

Rating	Description
0	No impact on this stock
1	Within the affected area less than 5% of fish will experience significant changes in mortality or fecundity due to this impact.
2	Within the affected area 5 to 10% of fish will experience significant changes in mortality or fecundity due to this impact.
3	Within the affected area 10 to 25% of fish will experience significant changes in mortality or fecundity due to this impact.
4	Within the affected area 25 to 50% of fish will experience significant changes in mortality or fecundity due to this impact.
5	Within the affected area more than 50% of fish will experience significant changes in mortality or fecundity due to this impact.

Frequency of Impact

Rating	Description
0	No impact on this stock
1	Within the affected area this impact occurs, on average, less than one year in 10
2	Within the affected area this impact occurs, on average, at least once every 7 years
3	Within the affected area this impact occurs, on average, at least once every 5 years
4	Within the affected area this impact occurs, on average, at least once every 2 years
5	Within the affected area this impact at least once a year

Sensitivity to Management Actions

Rating	Description
0	There are no management actions that could cost-effectively address this issue
1	The impact could be mitigated to a small degree, but at high cost
2	The impact could be mitigated to a moderate degree at a high cost, or mitigated to a small degree at a moderate cost
3	The impact could be mitigated to a moderate degree at a moderate cost
4	The impact could be mitigated to a large degree but at high cost, or mitigated to a moderate degree at a low cost
5	This impact could be well mitigated in a highly cost-effective manner

Data Gaps - Value of Additional Information

Rating	Description
0	We do not need any more information on this impact
1	Additional info would be useful for understanding basic sturgeon biology or impacts, but influence on management priorities is unlikely
2	We are able to make an informed estimate on this issue
3	Making an informed estimate on this issue is possible, but more information would help define management priorities
4	There is sufficient uncertainty on this issue that additional information may influence management priorities
5	We have essentially no information on this impact; any information at all would be valuable

where:

High Cost: > $10M per year
Moderate Cost: $1M - 10M per year
Low Cost: < $1M per year

mitigated to a small degree: impact score reduced by < 20%
mitigated to a moderate degree: impact score reduced by 20 to 50%
mitigated to a large degree: impact score reduced by > 50%