Manager perspectives on enhancement strategies and decision support tools and their uptake in fisheries management

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Executive summary

Fisheries enhancement refers to the deliberate application of measures aimed at enhancing productivity and long-term sustainability beyond what is achievable by good harvest management alone. Fisheries enhancement strategies can expand the options available to fisheries managers beyond the use of traditional input-output controls, but their broad uptake across fisheries sectors in Australia has been limited.

A survey of fisheries managers across Australia was undertaken to evaluate their current knowledge levels, experience with, and attitudes towards using fisheries enhancement strategies. The survey also ascertained the perceived knowledge gaps, the types of data managers would like available, and the format which would be most useful to incorporate into the decision making process.

The survey results indicated that enhancement strategies were used almost twice as commonly in recreational fisheries than the commercial sector. Stakeholder and political support are likely significant drivers behind this difference.

A common theme observed in the survey responses was the perceived lack of quantitative data available on fisheries enhancement projects. This is suggested to be one of the main reasons that enhancement projects are not deployed more frequently as a tool by fisheries managers in suitable situations. Such assessment is critical for effective fisheries management because it permits the efficient allocation of management resources and enables comparisons between alternative management options. Improving manager access to quantitative data on the outcomes of enhancement projects will improve their confidence in utilising enhancement strategies and likely lead to greater consideration and uptake.

High implementation costs and resource limitations were perceived as key barriers to uptake of enhancement strategies. Additionally, when sufficient funds were available, the lack of predictable economic return on the investment appeared to more important than the absolute investment required. Results from additional economic analysis may shift the focus away from initial and on-going investment by providing a greater focus on the overall economic outcomes achievable.

There was a strong desire for access to specific decision support tools to better incorporate fisheries enhancement options into current fisheries management decision frameworks. However, there was no consensus on the design and level of complexity of such decision support tools that would be universally appropriate. Disagreement also existed on whether such tools should be stand-alone processes, or able to fully integrate into existing frameworks.

Decision-support frameworks and modelling tools already exist which could be readily adapted to assess the outcomes of fisheries enhancement scenarios. Application of these tools to evaluate the potential for multiplicative gains and the relative costs and benefits of such endeavours, will allow informed decision making prior to any large investments being made. However, until sufficient data is available in Australia to support these existing tools, it is recommended that a suitability matrix for fisheries enhancement options should be developed for all fisheries in Australia to provide managers with a rapid method for identifying appropriate enhancement strategies.

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I would like to express my sincere gratitude to all of the participants from around Australia who took the time to complete the survey. Thanks also goes to those people in each state who helped identify the relevant people to invite to participate in the survey, which enabled the broad coverage of responses to be possible.

Introduction

A broad range of techniques have been used around the world to pro-actively enhance the value and sustainability of recreational and commercial fisheries (Taylor *et al.* 2017). In some scenarios these techniques have proven to be extremely effective and become core components of fisheries management (Taylor *et al.* 2017, Becker *et al.* 2018, Florisson *et al.* 2018, Hunt and Jones 2018). Fisheries enhancement refers to the deliberate application of measures aimed at enhancing productivity and long-term sustainability beyond what is achievable by good harvest management alone. Fisheries enhancement strategies expand the options available to fisheries managers beyond the use of traditional input-output controls. They provide opportunities for significant socio-economic benefits, through actively improving aquatic habitat and management of fish at the population level. Such approaches may simply offer alternative routes to a particular outcome, or they may support or create outcomes that cannot be achieved by other fisheries management measures (e.g. stocked impoundment fisheries). Enhancement strategies also have the potential to help manage the sometimes high social costs associated with harvest regulations.

Within Australia, fishery enhancement strategies have been applied across a variety of fisheries, but broad and consistent uptake has been limited. Some enhancement approaches have been widely applied (e.g. freshwater fish stocking, Hunt and Jones 2018), some have had limited uptake (e.g. offshore artificial reefs, Florisson *et al.* 2018), and others have rarely been used (ranching, Melville-Smith *et al.* 2017).

Constraints to uptake include fishery manager knowledge levels and their ability to incorporate information on relative merits of different enhancement techniques into their fisheries management decision making processes (Ruckelshaus *et al.* 2015, Taylor *et al.* 2017). It is therefore important to understand how mangers currently make decisions regarding the use of fishery enhancement techniques and what they consider to be the critical characteristics of decision support tools needed to improve uptake and application of such strategies. At the national and multi-fisheries scale, such information is rare, and typically limited to very specific scenarios. Access to such knowledge will enable more appropriate and effective promotion of suitable enhancement strategies. It will also allow these factors to be incorporated into decision support tools to help increase manager's consideration and uptake of different enhancement strategies in the fisheries they manage.

A survey of fisheries managers across Australia was undertaken to evaluate their current knowledge levels, experience with, and attitudes towards using fisheries enhancement strategies. The survey also ascertained the perceived knowledge gaps, the types of data managers would like, and the format which would be most useful to incorporate into the decision making process.

The aims of this study were to:

1. Understand fishery managers' awareness and use of fishery enhancement strategies
2. Identify key factors currently used in their fishery management decision making processes
3. Identify desirable and undesirable parameters for a fishery enhancement decision support tool.

Methods

A national online survey of people involved in fisheries management decisions was undertaken to understand their awareness and use of fisheries enhancement strategies, identify the key factors currently used when making fisheries management decisions, and to identify desirable and undesirable parameters for fisheries enhancement decision support tools.

The study collected information from project participants through an online survey and some direct, unstructured follow-up interviews. The survey questions were divided into four sections exploring survey participant's:

- Current role in the fishery

- Knowledge and experience regarding the use of enhancement strategies

- Current management decision making processes

- Desired criteria and potential willingness to use fishery enhancement decision support tools.

Initial survey questions covered respondent characteristics, including their location, role in fisheries management, and the specific fisheries they provide input into. Harvey *et al.* (2021) identified significant differences in the perspectives towards man-made marine structures between commercial and recreational fishers. Similar differences may also be evident in how these two fisheries sectors are managed. Respondents were therefore also asked to self-allocate whether their fisheries management role related to either recreational fisheries, commercial fisheries or both, to investigate whether experience with fisheries enhancement and management practices varied between the two sectors.

The online survey used a combination of question types to collect both quantitative and qualitative data. Five-point Likert scale questions (Tugend *et al.*, 1999, Fitzsimmons 2008, Watson and Preedy 2010) were applied to employed to convert qualitative information into quantitative data on respondents' perceptions of fisheries enhancement (ranging from strongly disagree to strongly agree) and the importance of various values when making decisions (ranging from not at all important to extremely important). Open-ended questions were used to capture qualitative data, such as descriptions of benefits and limitations, explanations, comments or identify suitable reference material for the cost benefit analysis. In this way, further information on values and perceptions that could extend the closed response questions were gathered. Several questions required respondents to rank lists of answers to grade their relative importance, while other closed questions required respondents to select the relevant answers from a list or provide Yes or No responses.

The survey was pilot tested by a small focus group of fisheries managers within the Queensland Department of Agriculture and Fisheries (DAF). The pilot enabled the survey to be refined to ensure it addresses all of the topics in a concise yet comprehensive manner, and that it was not too onerous for participants. A copy of the survey can be found in Appendix A.

The survey targeted people involved in the management decisions for various fisheries in Australia, both stock and harvest management, and policy development. Researchers and lead industry representatives who play a key role in management decisions were also be included because of their advisory role. The potential broad scope of enhancement technique application across fisheries means that as wide a profile as possible of fisheries managers were surveyed to ensure all views and

experience levels were captured. The level of experience and current use of fishery enhancement techniques varies greatly between states in Australia. Therefore, fisheries managers from across Australia were asked to participate to capture regional views, issues and experiences.

Potential participants were initially approached by email. All participants in the survey were volunteers and did not receive any payment or incentive to participate. Following acknowledgement of their willingness to participate, they were allocated a Unique Identifier Code (UIC) and emailed a link to the survey. A total of 98 people were sent invitations to participate, of which 43 completed the survey. The survey was open for a period of four weeks to allow participants sufficient time to respond. All participants received the same questionnaire, but their personal information was kept confidential through allocation of the UIC. Only the principal investigator had access to this information and at the end of the project, the UIC code key was deleted to permanently de-identify individual survey responses.

In some instances where respondents provided examples on scenarios where particular fishery enhancement techniques have been used, follow-up telephone conversations were had to gather more details for a literature review and cost-benefit analysis These conversations were unstructured and explore the costs, benefits, success and learnings from that application of enhancement strategies.

Data from the 5-point Likert and rank questions were analysed for median and mode to identify the most common response and the overall average response for those questions. Data was also graphically plotted to help visualise trends in the responses between groups. For questions where participants are asked to choose for a list of answers, provide a list of answers, or answer yes or no, the frequency of response was used as the key measure. Where sufficient demographic diversity existed, data was analysed between commercial and recreational sectors and regions to help inform development and extension of any decision support tools.

Results

The following summarizes the key results from the manager survey. Data has been de-identified and grouped where necessary to protect confidentiality.

Demographics

A total of 98 people from across Australia were invited to participate in this project because of their role as a fisheries manager, policy analyst, advisor or policy maker. A 44% response rate for participation was recorded. The majority of participants were fishery managers or researchers who advised managers on management decisions. Respondents included representatives from all states, territories and the Commonwealth Government, with participation highest from NSW and WA. Management responsibilities accounted for wide range of recreational and commercial finfish and commercial fisheries, covering both marine and freshwater habitats. The greatest number of respondents (47%) were involved with management of fisheries containing both commercial and recreational sectors, whilst 40% focussed only on recreational fisheries and 14% solely on commercial fisheries.

Use of enhancement strategies

The vast majority (92%) of participants involved with recreational fisheries had previously used fisheries enhancement strategies to improve fishery outcomes. In contrast, only 50% of respondents involved with commercial fisheries had previous experience with fishery enhancement strategies. For respondents who had previously used an enhancement strategy, stocking (via hatchery-rearing and translocation) of fish and invertebrates was the most commonly approach used in both the recreational and commercial sectors, followed by the use of artificial reefs (Figure 1).
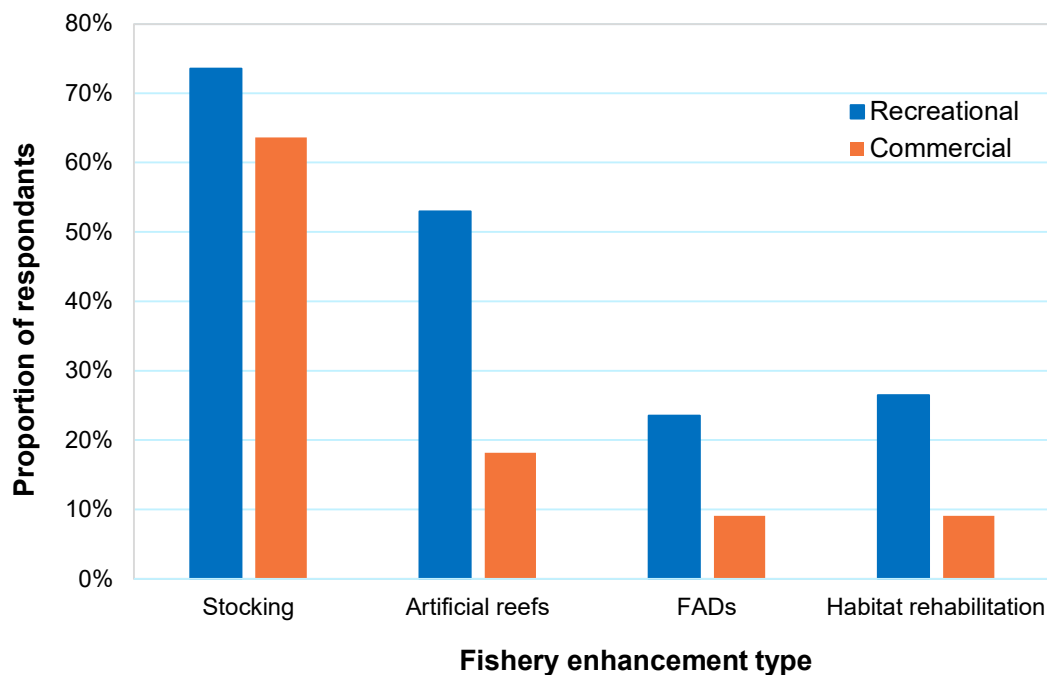

Figure 1 *Type of fishery enhancement strategy previously used by survey respondents to manage recreational and commercial fisheries.*

Stakeholder demand, research trials and successful use elsewhere in similar scenarios were the most frequently listed reasons for employing particular enhancement strategies in both recreational and commercial fisheries (Figure 2). Additionally, multiple fisheries agencies also had specific policies on recreational fishery enhancement which drive the implementation of different enhancement strategies.
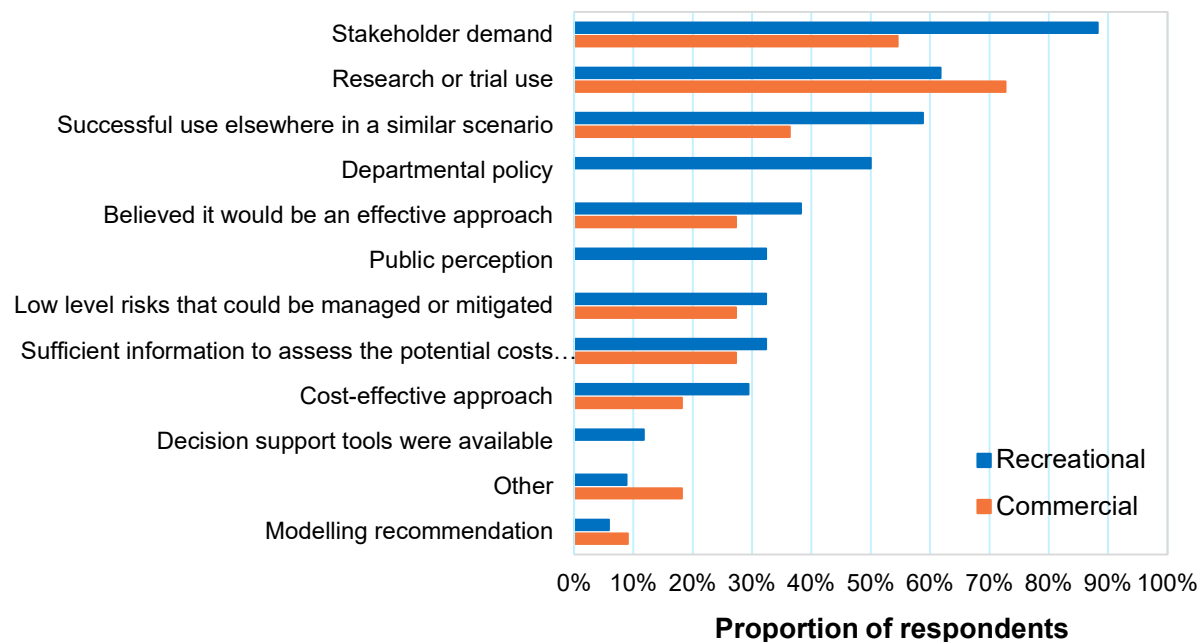

Figure 2 *Reasons for selecting previously used enhancement strategies to manage recreational and commercial fisheries.*

The perceived success of past enhancement projects varied between recreational and commercial fishery sectors (Figure 3). For recreational fisheries, 23% of respondents reported that they were unable to determine if the enhancement activities had had an effect on the fishery or achieved the management objectives. By comparison, no respondents for commercial fisheries reported an inability to determine the impacts of their habitat enhancement projects. Additionally, relatively few (0-29.6% per category) respondents indicated that a particular enhancement strategy was not applicable to their fishery, whilst this was much higher for commercial fisheries (20-60%).

Overall, the perception was that enhancement projects were more successful at achieving their objectives in recreational fisheries, than in commercial fisheries. The trend was most pronounced for habitat rehabilitation, where no responses indicated the technique was effective for commercial fisheries, whilst all responses were neutral of positive for the recreational fishery.
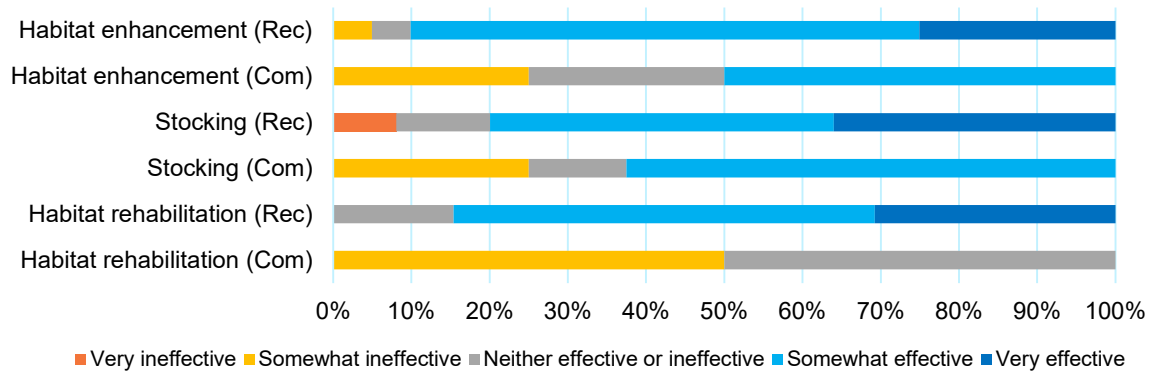
Figure 3 *The perceived success of past fishery enhancement projects in recreational (Rec) and commercial (Com) fisheries. The answers presented are only for respondents did not indicate that they were unable to determine success, or an enhancement was not applicable to their fishery.*

For recreational fisheries, 59% of respondents indicated that they were aware of other enhancement strategies that they had not applied yet. Most reported that habitat enhancement and habitat rehabilitation could also likely be beneficial to the fisheries they work with. Only 36% of commercial fishery respondents indicated that there were aware of other potential enhancement options they could consider implementing, with the stock enhancement being the most common suggestion.

Perceptions on using fisheries enhancement strategies

Stakeholder support for using fisheries enhancement strategies differed between the recreational and commercial sectors. All survey participants working with recreational fisheries indicated that there was stakeholder support to use enhancements, whilst only 64% of people involved with managing commercial fisheries indicated there was stakeholder support for employing enhancement strategies.

Overall, survey respondent's confidence to employ fishery enhancement strategies when making management recommendations was higher for the recreational sector than the commercial sector (Figure 4). High confidence was observed for incorporating enhancement strategies when establishing harvest control rules and making policy decisions in recreational fisheries. In contrast, there was very low confidence in recommending fishery enhancement strategies for stock management and investment strategies for commercial fisheries.
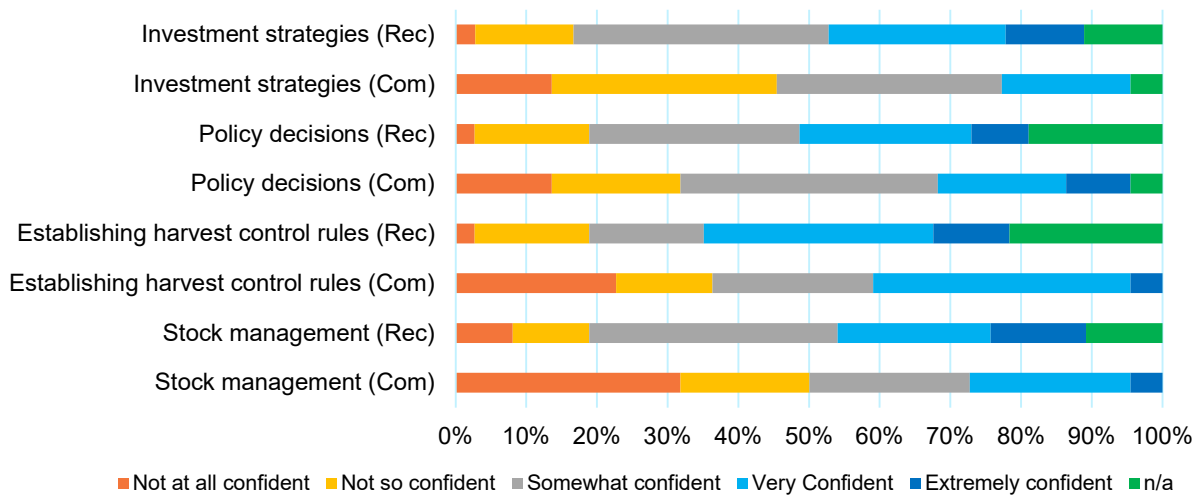
Figure 4 *Respondents confidence to employ fishery enhancement strategies when making management recommendations in various scenarios in recreational (Rec) and commercial (Com) fisheries. n/a (■) indicates where respondents thought enhancement strategies were not appropriate for that scenario.*

The main barriers to broader uptake and adoption of using fishery enhancement strategies in Australia were similar between commercial and recreational sectors, but differed in their order of priority. Both sectors listed costs and resourcing as the number one impediment for greater uptake of fishery enhancement strategies. In the recreational sector, lack of quantified benefits and appropriate evaluation of past enhancement projects was the second highest response, followed by stakeholder knowledge and perceptions, potential resource user conflict, a lack of economic analysis (cost benefit and cost effectiveness) and a lack of essential knowledge on the impacts of enhancement systems. For the commercial sector, stakeholder knowledge and perceptions was the second most prevalent response, followed by the need for economic analysis, quantification and evaluation of the benefit derived from enhancement activities, and resource user conflict.

When asked what enhancement strategies they would not consider using to help manage their fishery, most respondents were open minded and would consider most options. In the recreational sector, multiple people stated they would not consider stock enhancement for mobile marine species in open marine waters, due to the risk of genetic impacts and likely ineffectiveness of that approach. For commercial fisheries the answers were more varied, and included marine ranching, habitat rehabilitation (due to scale required) and broad-scale marine stocking.

The main reasons survey participants listed against the use of fishery enhancement strategies were lack of evidence demonstrating effectiveness, insufficient resources, insufficient information on strategies and regulatory or legislative restrictions (Table 1). In recreational fisheries. the relative ranking (number of participants listing as a reason) differed between enhancement strategies. For stock supplementation, lack of evidence demonstrating effectiveness and resourcing were the most listed response, whilst the risk of adverse impacts was also high. For both habitat enhancement and rehabilitation, insufficient resources was the most common reason against their use, and the scale of benefits achieved was also a common reason for not using these strategies. Regulatory restrictions and insufficient information on the likely outcomes were also commonly listed reasons. For habitat enhancement, some respondents felt the scale of the impact would be too small, therefore the return on investment would also be too low.

Several different reasons were received against using fishery enhancement in commercial fisheries (Table 1). More of the reasons given related to uncertainty of outcomes, better alternative management strategies and low return on investment. Insufficient resources featured prominently for all three enhancement strategies. For stock supplementation, multiple respondents identified difficulties in integration stocking into the decision making process and limited stakeholder support.

Table 1 *Most common reasons against using a particular fishery enhancement strategy.*

	Recreational	Commercial
Habitat enhancement	• Insufficient resources • ROI too low • Better options available • Legislative restrictions • Scale of benefits too small	• Insufficient resources • Lack of evidence • Insufficient information • Better options available • ROI too low
Stock supplementation	• Lack of evidence • Insufficient resources • Risk of adverse impacts to env. • Risk of overharvest • Not appropriate	• Better options available • Lack of evidence • Difficult to incorporate into decisions • Insufficient resources • Stakeholder support
Habitat rehabilitation	• Insufficient resources • Scale of benefits too small • Legislative restrictions • Lack of evidence • Insufficient information	• Insufficient resources • Lack of evidence • Not needed • Not appropriate • ROI too low

Participant's responses regarding the importance of various factors when recommending management actions for different aspects of particular fisheries are outlined in Figures 5-8. Overall, environmental impacts was consistently one of the factors of highest importance for both fishery sectors. The importance of having a decision support tool (DST) was lower for the recreational sector than the commercial sector, potentially reflecting the greater influence of politics in recreational fisheries management decisions. Policy, regulations and legislation were slightly more important factors in decisions on recreational fisheries, as was consideration of stakeholder perception regarding policy and investment decisions. The relative importance of economic factors (e.g. cost-benefit ratio, investment, ROI etc.) varied between the aspect of the fishery being addressed. For decisions focussing on stock structures and harvest mortality, economic factors were listed as less important in the commercial sector. Conversely, for decisions relating to policy and investment, higher importance was indicated for economic factors in the commercial sector.
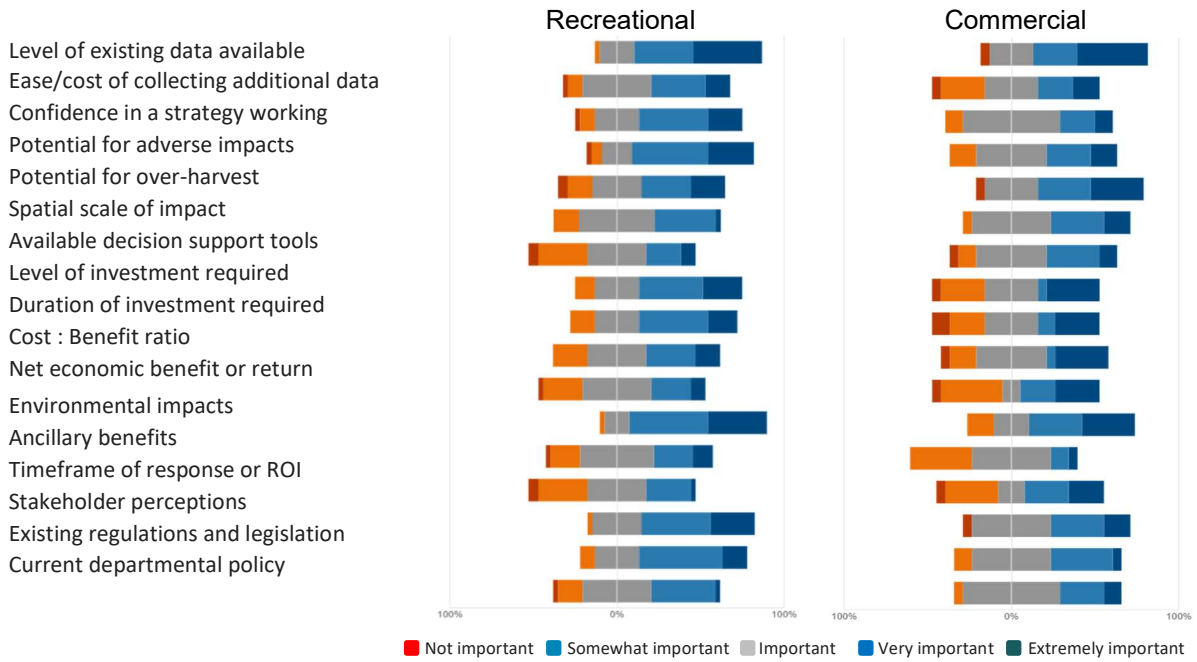
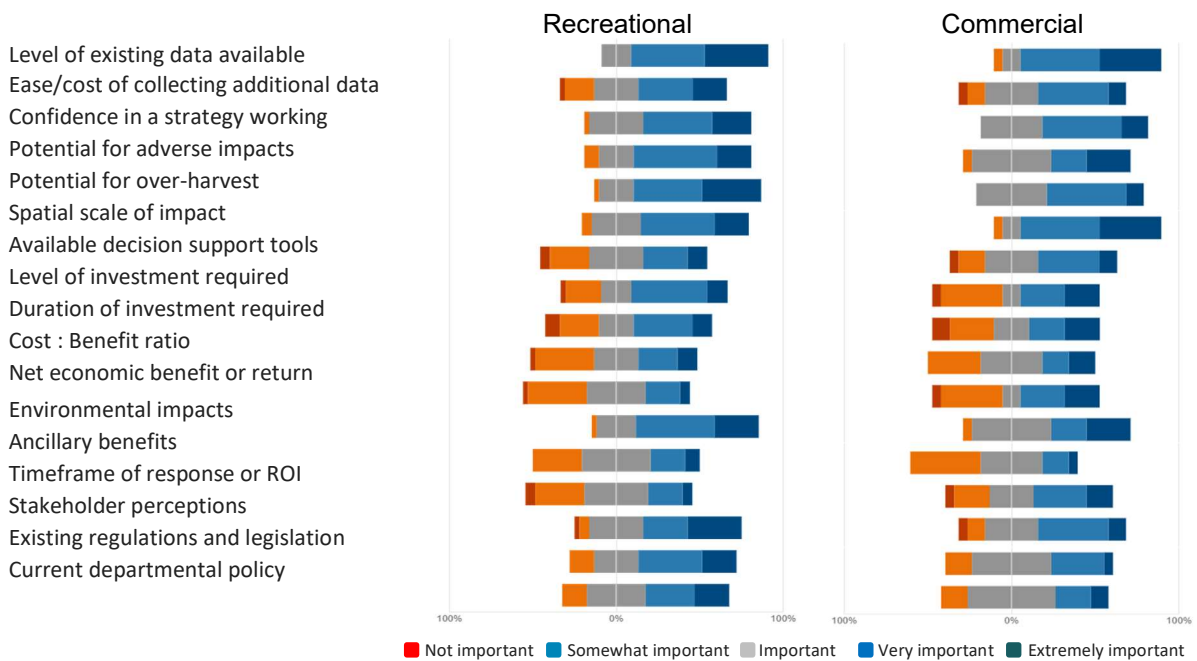**Figure 5** *Importance when recommending actions to manage stock structures.*

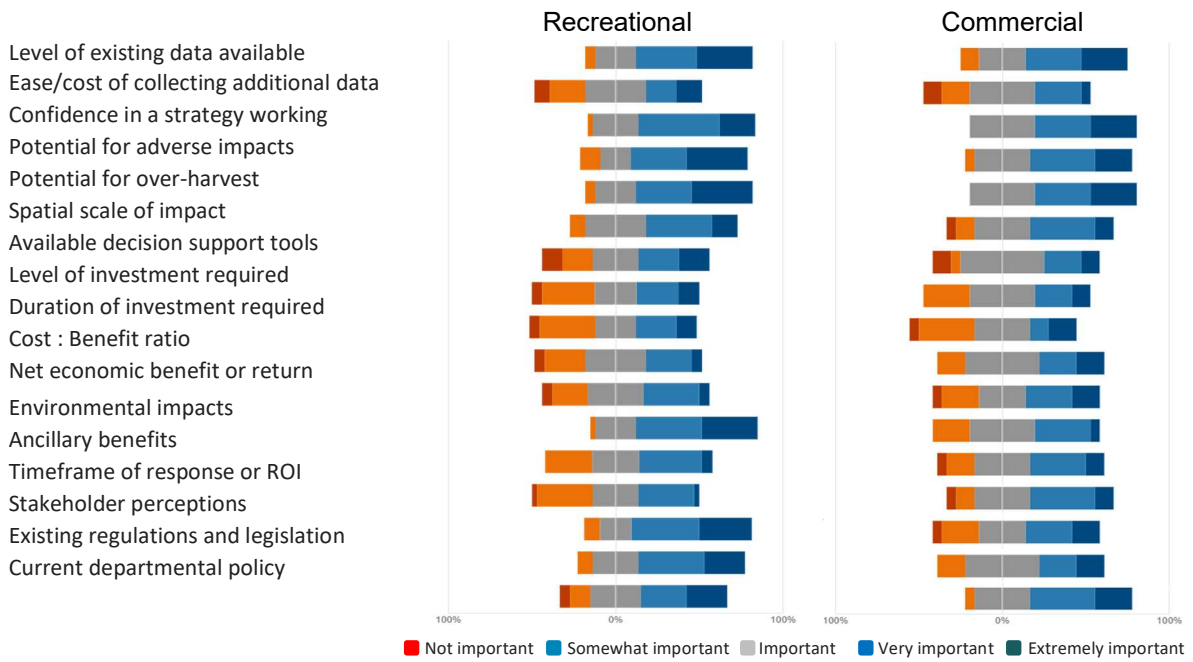**Figure 6** *Importance when recommending actions to manage harvest.*

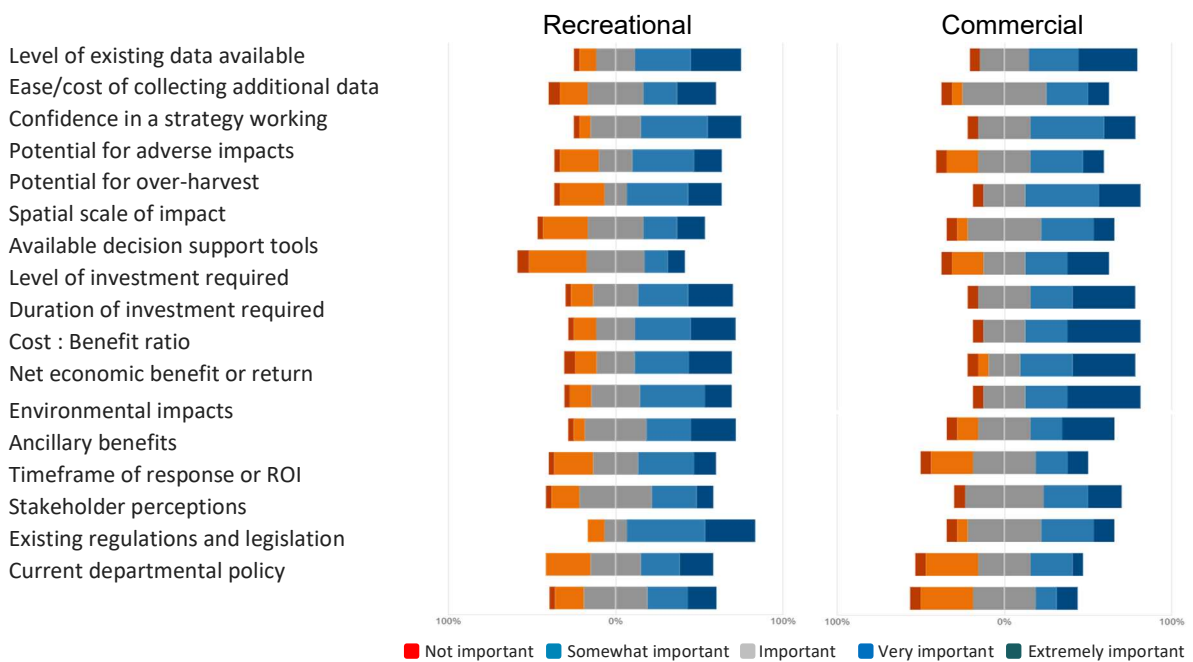**Figure 7** *Importance when recommending actions to manage policy changes.*

Figure 8 *Importance when recommending actions to manage investment strategy.*

Decision support tools (DST)

Currently, only 44% of survey participants were using decision support tools to assist in fishery management decisions. Harvest strategies were the most commonly used tool (38% of DST users), whilst only a few respondents used high levels DST such as Enhancefish, Fishpath and bespoke bio-economic modelling. Several respondents indicated that use of DSTs can produce undesirable if applied inappropriately and discouraged their use. The specific features of a DST that users liked most were modelling capacity to assess and compare various management strategies, clear process, timeframes and data requirements, transparency of the process, and risk assessment capabilities.

The features of DSTs that users liked the least were the lack of technical support for their use, uncertainty regarding recruitment variability, inability to capture cross-sector input, program instability and complex input data requirements.

The majority of survey participants (62%) felt that they currently did not have access to sufficient information to include enhancement strategies when making management recommendations or decisions. The primary request was for quantified information on the impact and success if different enhancement strategies. Information on cost-benefit, scale required to achieve particular outcomes (catch increases) and other socio-economic data were all desired by respondents. Additional information on the ecological and socio-economic impacts and more comprehensive monitoring would increase the likelihood of survey participants using enhancement strategies in managing their fisheries.

If a suitable DST could be developed, 61% of respondents would be somewhat likely or very likely to use such a tool (Figure 9).
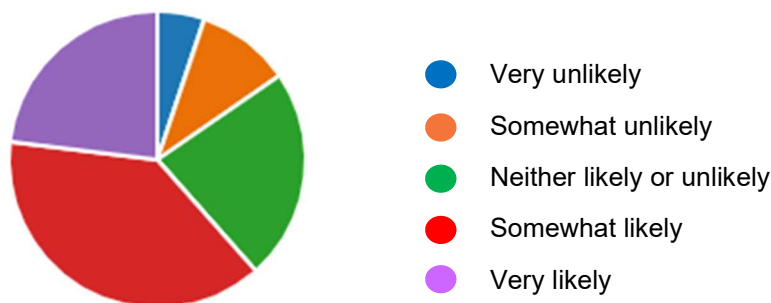

● Very unlikely

● Somewhat unlikely

● Neither likely or unlikely

● Somewhat likely

● Very likely

Figure 9 *Likelihood of survey participants to use a decision support tool on fisheries enhancement if a suitable one was developed.*

There was no consensus on the style of enhancement DST preferred by respondents. Desirability of a DST style decreased with increasing tool complexity. Overall, survey respondents traded output precision for simplicity of use, preferring a DST that identified suitable strategies, but could not estimate quantitative outcomes (Figure 10). The most preferred type was a DST that identifies which enhancement techniques were most suitable for a fishery and provides broad possible outcomes from implementation. A complex DST design containing a stock model and the ability to examine a wide range of parameters to deliver highly detailed predictive outputs, were substantially less preferable.
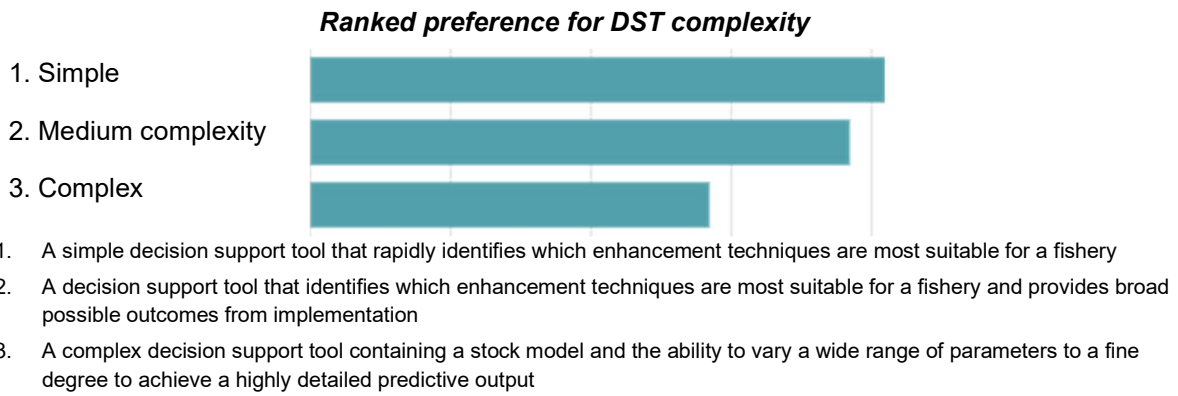
Ranked preference for DST complexity

1. Simple
2. Medium complexity
3. Complex

1. A simple decision support tool that rapidly identifies which enhancement techniques are most suitable for a fishery
2. A decision support tool that identifies which enhancement techniques are most suitable for a fishery and provides broad possible outcomes from implementation
3. A complex decision support tool containing a stock model and the ability to vary a wide range of parameters to a fine degree to achieve a highly detailed predictive output

Figure 10 *Importance when recommending actions to manage investment strategy.*

There was also a strong preference for a DST to be a stand-alone tool, although the second most popular selection was for one that could partially integrate with current decision making tools and processes (Figure 11).
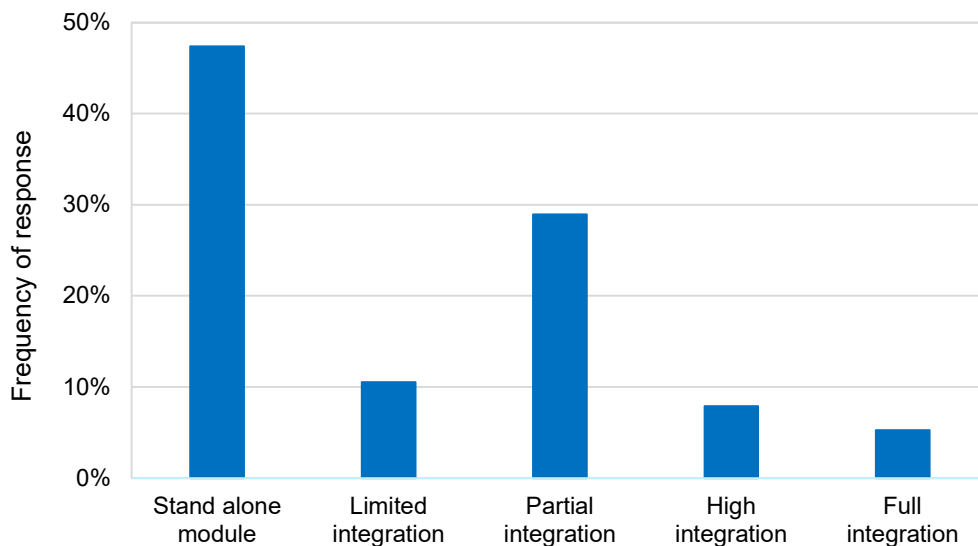

Figure 11 *Importance when recommending actions to manage investment strategy.*

A mixed response was obtained regarding the specific features preferred in a fishery enhancement DST. The most preferred features include the ability to modify and weight key variables, rapidly identify suitable options for a specific scenario, rank effectiveness of potential enhancement options, predict net economic benefit and inclusion of a stock model to predict biological outcomes (Figure 12). Features least preferred included a code-based interface, limited data input requirements and qualitative outputs.
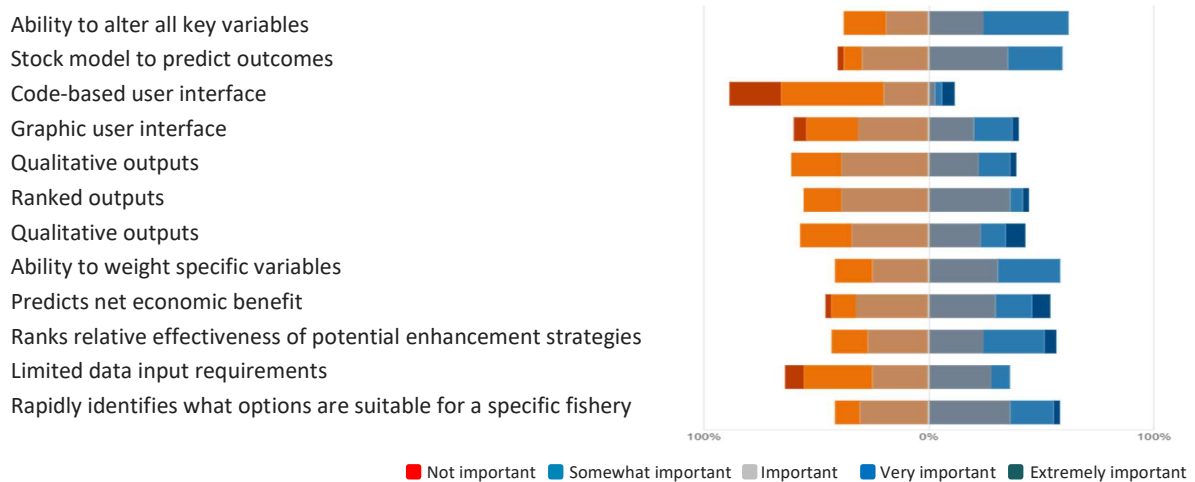
Figure 12 *Preference for specific features in a fishery enhancement decision support tool.*

Discussion

Fisheries enhancement strategies can expand the options available to fisheries managers beyond the use of traditional input-output controls and can provide opportunities for significant socio-economic benefits. However, the strategies need to be well understood by managers, incorporated into management decision making frameworks and be supported by stakeholders if they are to be broadly applied.

Different fisheries stakeholders can be strongly divided in their perception of the utility of fishery enhancement strategies (Hilborn 1999, Leber 2002, Arlinghaus and Mehner 2005, Lorenzen 2005, Hasler *et al.* 2011). The survey results indicated that enhancement strategies were used almost twice as commonly in recreational fisheries than the commercial sector. Stakeholder and political support are likely significant drivers behind this difference. There is strong belief amongst anglers that enhancement projects will improve recreational fisheries (Hilborn 1999, Hasler *et al.* 2011, van Poorten *et al.* 2011). Anglers also typically have a high willingness to pay for using enhancement strategies because the cost to the individual is typically low (Garlock and Lorenzen 2017). Enhancement approaches are also often politically seen as socially preferably because they have the potential to help manage the sometimes high social costs associated with harvest restrictions under traditional management approaches (Beard *et al.* 2003, Johnston *et al.* 2011, Haglund *et al.* 2016). In contrast, the potentially high per-user cost, and the lack of demonstrated quantitative economic outcomes from past commercial fishery enhancement trials, likely limits confidence in value and use of enhancement strategies in the commercial sector. Therefore, commercial stakeholder pressure for their implementation is lower.

A common theme observed in the survey responses was the perceived lack of quantitative data available on fisheries enhancement projects. A similar response has previously been observed in survey of managers on the use of artificial reefs in the USA (Murray 1994). Bortone (2011a) pointed out that one of the most common reasons that artificial reefs are not deployed as a fisheries enhancement tool by managers in suitable situations, is the relative lack of reports or published examples which properly quantify impacts of reef deployments. This leads to managers overlooking the use of artificial reefs as suitable management options (Layman *et al.* 2016, Becker *et al.* 2018). Quantitative assessment of enhancement contributions to fisheries management goals, such as

increases in population abundance, yield, or economic rent, is essential for incorporating these strategies into management actions.

Key review papers on fisheries enhancement all lament the lack of empirical data that has been collected (e.g. Blankenship and Leber 2008, Lorenzen *et al.* 2010, Lorenzen 2014, Taylor *et al.* 2017, Becker *et al.* 2018, Florisson *et al.* 2018, Hunt and Jones 2018, Kitada 2020), and highlight the importance for enhancement projects to quantitatively demonstrate cost-effectiveness. Such assessment is critical for effective fisheries management because it permits the efficient allocation of management resources and enables comparisons between alternative management options. Well-conducted research can provide the supporting lines of evidence that support decision-making regarding the use and/or appropriateness of enhancement strategies (Claudet and Pelletier 2004, Grove and Wilson 1994, Bortone 2011b). Improving manager access to quantitative data on the outcomes of enhancement projects will improve their confidence in utilising enhancement strategies and likely lead to greater consideration and uptake. This can only occur if future enhancement projects more comprehensively collect socio-economic data on project outcomes.

Another common theme amongst survey responses was that high implementation costs and resource limitations were a barrier to uptake. Interestingly, the level and duration of investment was not deemed to be of high importance. These results suggest that the lack of predictable economic return on the investment is therefore potentially the limiting factor, rather than the absolute investment required. More cost-benefit analysis results may shift the focus away from initial and on-going investment by providing a greater focus on the overall economic outcomes achievable.

The survey indicated that there was a strong desire for access to specific decision support tools to better incorporate fisheries enhancement options into current fisheries management decision frameworks. However, there was no consensus on the design and level of complexity of such decision support tools that would be universally appropriate. The level of detail required by managers, ranged from simple decision matrices to help identify which enhancement approaches were appropriate to a particular fishery, through to highly detailed bio-economic models whose parameters could be manipulated to estimate the fishery and socio-economic outcomes across various management options and response scenarios. Disagreement also existed on whether such tools should be stand-alone or able to fully integrate into existing frameworks.

Decision-support frameworks and modelling tools already exist which could be readily adapted to assess the outcomes of fisheries enhancement scenarios (*e.g.* Lorenzen 2008), and evaluate the ability of hatchery releases to integrate and add-value to habitat rehabilitation or enhancement. Application of these tools to evaluate the potential for multiplicative gains and the relative costs and benefits of such endeavours, will allow informed decision making prior to any large investments being made. However, until sufficient data is available in Australia to support these existing tools, it is recommended that a suitability matrix for fisheries enhancement options should be developed for all fisheries in Australia to provide managers with a rapid method for identifying appropriate enhancement strategies. Such a matrix could be based on the constraints across various life-history stages for target species and be used to identify and prioritise where enhancement activities will have the greatest benefits (Grant *et al.* 2017, Florisson *et al.* 2018). Much of the biological data required to drive such a matrix is likely already available and used in existing stock population models.

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Appendix A – Survey form

Understanding how fishery enhancement strategies are incorporated into fishery management

Participant information sheet

Why is this study being conducted?

This survey forms part of FRDC project *2020-102: A review of fishery enhancement methods to promote profitability and sustainability in Australian fisheries*. The research is investigating the relative cost-benefits of different fishery enhancement techniques and how uptake can be improved to increase fisheries productivity and sustainability in Australia. This research includes a survey on how mangers currently make decisions regarding the use of fishery enhancement techniques and what are considered critical characteristics of decision support tools to improve uptake and application of such strategies.

The study is being conducted by Dr Andrew Norris, a Principal Scientist (Fisheries) with the Queensland Department of Agriculture and Fisheries and the results of the survey will be used to develop a broadly applicable decision support tool to enhance consideration of fishery enhancement techniques into fisheries management decisions.

You are invited to participate in this project because of your role as a fisheries manager, policy analyst, policy maker or key input provider for State or Territory fisheries management decisions.

Your participation in this online survey will inform the development of a decision support tool to increase incorporation of fishery enhancement strategies in fisheries management decisions within Australia.

If you know of others who would be interested in this study or believe could make a valuable

contribution, please pass on this information sheet to them. Alternatively contact the project leader and they will arrange access for them to participate. The broader the field of survey respondents, the more informative and applicable the results will be.

What participation involves

Participation will involve an online survey and potentially a follow-up phone interview from the project leader. Only a small number of selected people will be asked to participate in the follow-up phone interviews in order to clarify specific cases or scenarios.

In this online survey, you will be asked about the following:

- your role in fisheries management

- your knowledge on and use of fishery enhancement strategies

- criteria important to you when making fisheries decisions

- the process by which you currently make fisheries decisions

- your use of decision support tools

- your preferences for the design of decision support tool on incorporating fishery enhancement strategies into you decision making process.

The online survey will take approximately 30-40 min of your time. Where possible, the question formats are multiple choice or ranking in order to minimise the amount of time taken to complete the survey.

This project has received support from fisheries management agencies in all states; however, your participation in the survey is voluntary. If you do participate in the survey and subsequently wish to review or withdraw your responses, you can do so within five business days from when your answers are submitted by contacting the project's Principal Investigator.

What are the possible benefits if you participate?

A key expected benefit of this research is improved fisheries productivity and sustainability through greater incorporation of fishery enhancement strategies into management decisions. By participating in the survey, you ensure that your requirements (data and functionality) will be considered in the decision support tool design that will be developed.

Privacy and confidentiality

Privacy and confidentiality

Only the project leader, Dr Andrew Norris (DAF QLD) will have access to the raw data collected, including your personal information. Every effort will be made to ensure that any personal data you provide cannot be traced back to you in reports, publications, and presentations. We will not use your name or make reference to specific details without your personal consent.

This project is partly funded by FRDC, and they will have access to data obtained during the project in a de-identifiable form. A report with the main results will also be provided to FRDC.

Any data collected will be stored as per DAF's privacy and confidentiality policy. Data will be stored for a minimum of 5 years and can be disclosed if it is to protect yourself or others from harm, if specifically required by law, or if a regulatory or monitoring body such as an ethics committee requests it.

Consent to participate

Agreeing to undertake the online survey will be taken as an indication of your consent to participate in this research project.

Further information.

If you have any questions or require further information, please contact the project leader: Dr Andrew Norris Andrew.norris@daf.qld.gov.au (mailto:Andrew.norris@daf.qld.gov.au)

  (07) 3471 0919

Complaints

If you have any concerns regarding the ethical conduct of the study, please contact Queensland Health's Metro North Human Research Ethics Governance Unit ((07) 3139 4500, ResearchTPCH@health.qld.gov.au (ResearchTPCH@health.qld.gov.au)) citing Human Research Ethics Approval number HREC/2022/QPCH/83892.

Thank you for helping us with this research project, we really appreciate your input and time

1. Do you consent to participating in the survey *

○ Yes
○ No

About your role in the fishery

This first section of questions will capture information about what your role is in fisheries management. This information will help us understand if answers differ between the different levels of fishery management.

2. What is the Unique Identifier Code that you were allocated for this study? *

3. Which of the following best describes your role within your organisation? *

○   Advocate or lobbyist
○   Manager of a fishery
○   Fisheries policy
○   Industry Representative
○   Researcher
○   Other ....

4. Which jurisdiction(s) does your fisheries work relate to?

○   Australian Capital Territory
○   New South Wales
○   Northern Territory
○   Queensland
○   South Australia
○   Tasmania
○   Victoria
○   Western Australia
○   Commonwealth

5. What specific fisheries do you manage or provide input into?

6. Are the fishery or fisheries you are involved with: *

○   Recreational
○   Commercial
○   Both

Awareness and use of fishery enhancement techniques for recreational fisheries

The following questions relate to management of **recreational** fisheries.

There is potential to enhance fisheries by improving the level of fish stocks or harvest efficiency. Fishery enhancement strategies can be broadly classified into three groups:

Stock supplementation - release of fish to supplement wild stocks or create new populations for fishers to target

Habitat rehabilitation - rehabilitating the natural environment to improve fish stocks

Habitat enhancement - installation of fish attractors and artificial reefs to aggregate fish or improve productivity

The following questions will help us understand the current level of knowledge on fishery enhancement techniques amongst recreational fisheries managers.

7. Have you used any of the above enhancement techniques in the Recreational fishery(s) you manage?

○ Yes
○ No

8. Please provide brief details on the specific enhancement strategies you have used.

9. Why did you choose those particular enhancement strategies ? (You can select more than 1 answer)

○ Departmental policy
○ Thought it would be an effective approach
○ Has been successfully used elsewhere in a similar scenario
○ Sufficient information was available to assess the potential costs and benefits
○ Low level risks that could be managed or mitigated
○ Cost-effective approach
○ Decision support tools were available
○ Modelling recommended the approach would be beneficial
○ Research or trial use
○ Stakeholder demand
○ Public perception
○ Other

10. Overall, how effective have the fishery enhancement strategies that you have used been at achieving their objectives for that recreational fishery?

	Very ineffective	Somewhat ineffective	Neither effective or ineffective	Very effective	Extremely effective	Unable to tell	Not applicable
Habitat enhancement	○	○	○	○	○	○	○
Stock enhancement	○	○	○	○	○	○	○
Habitat rehabilitation	○	○	○	○	○	○	○

11. Are you aware of any (other) fishery enhancement techniques that could be used in your fishery?

○ Yes
○ No

12. If Yes, please list.

13. Do you think recreational stakeholder perceptions currently support using fisheries enhancement strategies?

○ Yes
○ No

14. How confident are you about employing fishery enhancement strategies when making the following types of management recommendations or decisions regarding the recreational fishery?

	Not at all confident	Not so confident	Somewhat confident	Very confident	Extremely confident	Not applicable
Stock management	○	○	○	○	○	○
Establishing harvest strategies	○	○	○	○	○	○
Policy decisions	○	○	○	○	○	○
Investment strategies	○	○	○	○	○	○

15. What do you think are the three main barriers to broader uptake and adoption of using fishery enhancement strategies in Australia for recreational fisheries?

16. What enhancement strategies would you not consider using to help manage your fishery (e.g. marine stocking)? Please list.

17. Which of the following do you consider valid reasons **against** using **stock supplementation** to enhance your recreational fishery(s) (you can select more than 1 answer)?

○ Not needed
○ Not appropriate to the fishery
○ Lack of evidence to support it is effective
○ Legislative restrictions
○ Against current policy
○ Insufficient resources
○ More effective management options are available
○ Lack of stakeholder support
○ Return on investment is too low
○ The risk of adverse impacts to the environment
○ The risk of adverse outcomes for the fishery
○ Potential impacts on other fisheries
○ Difficult to incorporate into the current decision making process
○ Scale of benefits would be too small
○ Public perception
○ Risk of over harvest
○ Other

18. Which of the following do you consider valid reasons **against** using **habitat rehabilitation** to enhance your recreational fishery(s) (you can select more than 1 answer)?

○ Not needed
○ Not appropriate to the fishery
○ Lack of evidence to support it is effective
○ Legislative restrictions
○ Against current policy
○ Insufficient resources
○ More effective management options are available
○ Lack of stakeholder support
○ Return on investment is too low
○ The risk of adverse impacts to the environment
○ The risk of adverse outcomes for the fishery
○ Potential impacts on other fisheries
○ Difficult to incorporate into the current decision making process
○ Scale of benefits would be too small
○ Public perception
○ Risk of over harvest
○ Other

19. Which of the following do you consider valid reasons **against** using **habitat enhancement** to enhance your recreational fishery(s) (you can select more than 1 answer)?

○ Not needed
○ Not appropriate to the fishery
○ Lack of evidence to support it is effective
○ Legislative restrictions
○ Against current policy
○ Insufficient resources
○ More effective management options are available
○ Lack of stakeholder support
○ Return on investment is too low
○ The risk of adverse impacts to the environment
○ The risk of adverse outcomes for the fishery
○ Potential impacts on other fisheries
○ Difficult to incorporate into the current decision making process
○ Scale of benefits would be too small
○ Public perception
○ Risk of over harvest
○ Other

20. Please list any projects or management initiatives for recreational fisheries that you are aware of that have used enhancement techniques.

21. Please list any key reports or papers (published or unpublished) you are aware of that may contain data on the cost and benefits of these fishery enhancement activities. This information will be used to help us conduct a cost-benefit comparison between different strategies and different fisheries

Decision making in Recreational fisheries

The following questions look at what you find important when making **Recreational** fisheries management recommendations or decisions and the process that you use.

Decision support tools are mechanisms for integrating, analysing and displaying information to assist decision makers when making decisions. They are typically based on the rational approach and provide insight into the likely consequences of different management strategies or help identify the strategy that best achieves a particular goal. They can range from relatively simple and informal tools to help identify suitable strategies (e.g. tables or ranked indices) to highly complex and predictive (e.g. *EnhanceFish, FishPath and Displace*).

Information on current fishery decision-making processes will help us identify what could possibly be done to better incorporate information on enhancement strategies into the process.

22. Please rate the importance of each of the following factors when recommending actions to manage **stock structures** in your recreational fishery.

	Not important	Somewhat important	Important	Very important	Extremely important
Level of existing data available	○	○	○	○	○
Ease/cost of collecting additional data	○	○	○	○	○
Confidence in a strategy working	○	○	○	○	○
Potential for adverse impacts	○	○	○	○	○
Potential for overharvest	○	○	○	○	○
Spatial scale of impact	○	○	○	○	○
Available decision support tools	○	○	○	○	○
Level of investment required	○	○	○	○	○
Duration of investment required	○	○	○	○	○
Cost : Benefit ratio	○	○	○	○	○
Net economic benefit or return	○	○	○	○	○
Environmental impacts	○	○	○	○	○
Ancillary benefits (e.g. non-core economic, environmental and social benefits)	○	○	○	○	○
Timeframe of response or return on investment	○	○	○	○	○
Stakeholder perceptions	○	○	○	○	○
Existing regulations and legislation	○	○	○	○	○
Current departmental policy	○	○	○	○	○

23. Please rate the importance of each of the following factors when recommending actions to manage **harvest (mortality)** in your recreational fishery.

	Not important	Somewhat important	Important	Very important	Extremely important
Level of existing data available	○	○	○	○	○
Ease/cost of collecting additional data	○	○	○	○	○
Confidence in a strategy working	○	○	○	○	○
Potential for adverse impacts	○	○	○	○	○
Potential for overharvest	○	○	○	○	○
Spatial scale of impact	○	○	○	○	○
Available decision support tools	○	○	○	○	○
Level of investment required	○	○	○	○	○
Duration of investment required	○	○	○	○	○
Cost : Benefit ratio	○	○	○	○	○
Net economic benefit or return	○	○	○	○	○
Environmental impacts	○	○	○	○	○
Ancillary benefits (e.g. non-core economic, environmental and social benefits)	○	○	○	○	○
Timeframe of response or return on investment	○	○	○	○	○
Stakeholder perceptions	○	○	○	○	○
Existing regulations and legislation	○	○	○	○	○
Current departmental policy	○	○	○	○	○

24. Please rate the importance of each of the following factors when recommending **policy changes** in your recreational fishery.

	Not important	Somewhat important	Important	Very important	Extremely important
Level of existing data available	○	○	○	○	○
Ease/cost of collecting additional data	○	○	○	○	○
Confidence in a strategy working	○	○	○	○	○
Potential for adverse impacts	○	○	○	○	○
Potential for overharvest	○	○	○	○	○
Spatial scale of impact	○	○	○	○	○
Available decision support tools	○	○	○	○	○
Level of investment required	○	○	○	○	○
Duration of investment required	○	○	○	○	○
Cost : Benefit ratio	○	○	○	○	○
Net economic benefit or return	○	○	○	○	○
Environmental impacts	○	○	○	○	○
Ancillary benefits (e.g. non-core economic, environmental and social benefits)	○	○	○	○	○
Timeframe of response or return on investment	○	○	○	○	○
Stakeholder perceptions	○	○	○	○	○
Existing regulations and legislation	○	○	○	○	○
Current departmental policy	○	○	○	○	○

25. Please rate the importance of each of the following factors when recommending changes to the **investment strategy** in your recreational fishery.

	Not important	Somewhat important	Important	Very important	Extremely important
Level of existing data available	○	○	○	○	○
Ease/cost of collecting additional data	○	○	○	○	○
Confidence in a strategy working	○	○	○	○	○
Potential for adverse impacts	○	○	○	○	○
Potential for overharvest	○	○	○	○	○
Spatial scale of impact	○	○	○	○	○
Available decision support tools	○	○	○	○	○
Level of investment required	○	○	○	○	○
Duration of investment required	○	○	○	○	○
Cost : Benefit ratio	○	○	○	○	○
Net economic benefit or return	○	○	○	○	○
Environmental impacts	○	○	○	○	○
Ancillary benefits (e.g. non-core economic, environmental and social benefits)	○	○	○	○	○
Timeframe of response or return on investment	○	○	○	○	○
Stakeholder perceptions	○	○	○	○	○
Existing regulations and legislation	○	○	○	○	○
Current departmental policy	○	○	○	○	○

26. Do you also manage or provide key input into any commercial fisheries?

○   Yes
○   No

If Yes, questions 7-25 repeat for Commercial Fisheries (Questions 27-45)

If No, survey goes to Question 46.

Fishery enhancement strategies decision support tool

The following questions will help us determine the structure and features of new decision support tools to determine the suitability of fishery enhancement techniques.

46. Do you currently use any decision support tools for decisions on major fisheries management reforms, setting harvest and stock level restrictions, developing policy instruments or determining investment strategies?

○   Yes
○   No

47. What decision support tools do you use? Please list.

48. Which features of these tools do you like the most? Please list

49. Which features do you like the least? Please list.

50. Do you feel that you currently have access to sufficient information on fishery enhancement strategies when making management recommendations or decisions?

○   Yes
○   No

51. Please list any additional information that you would like to be able to better consider fishery enhancement strategies when making management decisions.

52. What would improve the likelihood of you using fishery enhancement strategies? Please list.

53. If a suitable **decision support tool** for fishery enhancement techniques was developed, how likely would you be to use it?

○   Very unlikely
○   Somewhat unlikely
○   Neither likely nor unlikely
○   Somewhat likely
○   Very likely

54. Which do you think would be more useful to you for fishery enhancement decision making? Please rank from 1 to 3, with 1 being your most preferred and 3 being your least preferred option.

☐   A simple decision support tool that rapidly identifies which enhancement techniques are most suitable for a fishery

☐   A decision support tool that identifies which enhancement techniques are most suitable for a fishery and provides broad possible outcomes from implementation

☐   A complex decision support tool containing a stock model and the ability to vary a wide range of parameters to a fine degree to achieve a highly detailed predictive output

55. How well would a fishery enhancement decision support tool need to be able to integrate into current decision support tools or processes? Or should it be a standalone module?

○   Stand-alone module
○   Limited integration
○   Partial integration
○   High integration
○   Full integration

56. Which features would you prefer in a fisheries enhancement decision support tool?

	Not important	Somewhat important	Important	Very important	Extremely important	Not applicable
Ability to alter all key variables	○	○	○	○	○	○
Stock model to predict outcomes	○	○	○	○	○	○
Code-based user interface	○	○	○	○	○	○
Graphic user interface	○	○	○	○	○	○
Qualitative outputs	○	○	○	○	○	○
Ranked outputs	○	○	○	○	○	○
Quantitative outputs	○	○	○	○	○	○
Ability to weight specific variables	○	○	○	○	○	○
Predicts net economic benefit	○	○	○	○	○	○
Ranks relative effectiveness of potential enhancement strategies	○	○	○	○	○	○
Limited data input requirements	○	○	○	○	○	○
Rapidly identifies what options are suitable for a specific fishery	○	○	○	○	○	○

57. Do you have any other comments regarding the use of fishery enhancement strategies and the potential value of developing a decision support tool?

That concludes the survey. We really appreciated your participation.

Thank you again for your time

If you would like to be updated on the results of this project, please indicate in the box below.

○ Yes
○ No