Full title: Protecting fish and farms: incentivising adoption of modern fish-protection screens for water pumps and gravity-fed diversions in Australia

Short title: Incentivising modern fish screening in Australia

Authors: Thomas S. Rayner* [A, B], John Conallin[B], Craig A. Boys[A, B] and Rodney Price[A]

Affiliations:

A. New South Wales Department of Primary Industries – Fisheries.

B. Institute for Land, Water and Society, Charles Sturt University.

Contributions:

- Rayner: writing, conceptualisation, investigation
- Conallin: conceptualisation, methodology, investigation, writing
- Boys: conceptualisation, investigation, writing, funding acquisition
- Price: investigation, project administration

Corresponding Author: Thomas Rayner, NSW DPI Fisheries, Locked Bag 1, Nelson Bay, NSW 2315. tom.rayner@dpi.nsw.gov.au 0476985155.

Competing Interests: The authors have declared that no competing interests exist.

Funding Information: Funding for this research was provided by the NSW Recreational Fishing Trusts (CB, TR, RP, JC), the NSW Government (CB, TR, RP) and the Australian Government (CB, TR, RP).

Financial Disclosure statement: The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. TR and RP received salary components funded from a combination of all funders.

Abstract

Modern fish-protection screens offer significant potential benefits for Australia. The Commonwealth and New South Wales (NSW) governments have invested over $30m to incentivise early adoption by water users. However, successful adoption requires an understanding of the motivations and abilities of water users, and strategies to overcome key barriers to adoption. Four practices have been used by the NSW Government to strengthen understanding of stakeholders and encourage participation in incentive programs by water users. These are: applying social learning concepts to screening programs; evaluating stakeholder needs; identifying and mapping stakeholders and their relationships; and, integrating science in communication and engagement. Analysing the motivations and abilities of water users revealed three key motivations: to save money, to protect fish, and to improve their reputation or social licence to operate. However, the ability of water users to install a fish-protection screen was found to vary significantly. A range of barriers have been identified by water users in NSW, and solutions or strategies developed to address each one. Today, in Australia, over 2,000 ML/day of water is being delivered through modern fish-protection screens, protecting ~580,000 native fish annually at 31 sites across NSW, Victoria and Queensland (60% being in NSW). Existing investment may see these numbers increase to ~7,000 ML/day and ~2 million native fish/yr by June 2024. The application of the methods to understand and strategically engage with stakeholders should enable improved uptake of screening technologies in other jurisdictions and areas of conservation concern into the future.

Keywords

Diffusion of innovations, fish conservation, incentives, social licence.

Introduction

Modern fish-protection screens for water pumps and diversion channels have the potential to provide significant triple-bottom-line benefits for Australian ecosystems, economies and communities [1]. Designed correctly, modern screens can protect up to 90% of native fish currently being lost to water diversions, reduce damage to water infrastructure, save water, lower energy use and stimulate regional economies through manufacturing, installation, and fisheries tourism [2]. The technology represents a new best practice for industries seeking to reduce their ecological footprint while maintaining access to water, which underpins their profitability. Screening 4,500 pumps in New South Wales (NSW) alone would protect millions of native fish annually and generate a AUD$3.7b boost to regional economies [3] and similar benefits are possible in other States and Territories.

Realising the full benefits of modern screens depends on widespread adoption by water users. Adoption might be achieved via regulation, incentivisation or a mixed-model approach combining both regulatory mechanisms and incentives [4]. While regulation may seem a simple solution, because it removes stakeholder consent, international experience shows it is relatively ineffective and can actually act as a barrier to adoption in the case of modern fish-protection screens [5]. High-priority water diversions that cause significant impacts to fish can remain unscreened due to exemptions based on 'minimum-size-of-diversion' and 'grandfather' clauses that only require new diversions to be screened, combined with a high demand on resources for enforcement. Regulation also does little to answer the question, "Who pays?". This may lead to negative outcomes, such as the installation of low-quality screens, to satisfy 'green tape', which later require replacement and could potentially lead to disenchantment among users.

In Australia, incentivisation of screening has been the preferred method to begin driving uptake of modern screens. The Commonwealth Government has invested AUD$26m in the northern Murray-Darling Basin (MDB; [6]) and the NSW Government has invested AUD$13.5m in the Macquarie River valley. Smaller incentive schemes have also been funded [7]. Today, over 2,000 ML/day of water is being delivered through modern screens during the irrigation season, protecting ~580,000 native fish annually at 31 sites across NSW, Victoria and Queensland (60% being in NSW). These numbers are expected increase to ~7,000 ML/day and ~2 million native fish/yr by June 2024 (Fig 1). An additional investment of AUD~$25m could bring the cumulative total to over 3 million native fish/yr by late 2025,

77 depending on manufacturing capacity and river conditions (Fig1). The number of fish
78 protected will then be approaching the ~5-8 million stocked annually from around 30
79 hatcheries in NSW, Victoria and Queensland [8].

80 The early success of incentive programs can benefit greatly from a strong understanding of
81 stakeholders. Proponents need to know who their stakeholders are, how their stakeholders
82 relate to one another, and how information flows through their stakeholder network. They
83 also need to know what motivates (or demotivates) different types of stakeholders, what
84 abilities different stakeholders have, what might trigger stakeholders to act, and how to
85 address important barriers to stakeholder adoption. Proponents can then design and prioritise
86 scientific research, communication, and engagement activities to build stakeholder consent
87 and capacity. As empirical data of return-on-investment improves, the level of incentivisation
88 may be adjusted using subsidy or co-pay approaches.

89 However, developing a strong understanding of stakeholders can be challenging. Specialised
90 expertise and dedicated resources are required – often beyond the skills and resources of
91 proponents. Here, we describe four practices that have been used to strengthen screening
92 programs in NSW over the past decade. These are: 1. applying social learning concepts
93 described by Diffusion of Innovations theory to screening programs; 2. evaluating
94 stakeholder needs; 3. identifying and mapping stakeholders and their relationships; and, 4.
95 integrating science in communication and engagement. Our hope is that these practices, and
96 our lessons learned, might help other proponents to establish and communicate their own
97 incentivisation programs – as they work towards protecting their first million native fish per
98 year.

99 **Applying Diffusion of Innovations Theory**

100 Setting out to screen every diversion in a jurisdiction would be a daunting task. Questions
101 arise, such as how can thousands of individuals and organisations be encouraged to adopt the
102 technology? What levels of investment and prioritisation of water diversions for screening are
103 required? And so on. Central to progress in NSW has been application of the concepts
104 described by Diffusion of Innovations Theory. Diffusion of Innovations (DOI; [9]) is a
105 classic conceptual framework that explains how and why a new idea, behaviour or
106 technology spreads through a population of stakeholders (Fig 2). It theorises five types of
107 stakeholders, differentiated by how quickly they are likely to adopt an innovation – their

innovativeness. DOI then divides a population of stakeholders based on these five types (Table 1).

DOI describes a range of useful principles for proponents of modern fish screens. However, the key message is that there is no need to work with or convince every water user to adopt. Instead, focus should be targeted at the innovators and early adopters. These groups are socially-influential (see following sections), more willing to take risks, and more motivated by the kudos, or financial and fringe benefits that can come from adopting early. To 'get off on the right foot', [10] recommend: purposively choosing which stakeholders to work with initially; carefully selecting the locations in which to start a program; and, appreciating what level of early uptake to expect. By recognising that stakeholders vary in their innovativeness, proponents (and funders) can be assured that innovators do, in fact, exist in their stakeholder population, and that early uptake is possible. Proponents can focus on identifying and increasing the capacity of those groups, while avoiding wasting time trying to convince laggards. Similarly, appreciating that innovators are excited by novelty, proponents can tailor their key messages accordingly.

The NSW Government has been applying DOI concepts to screening for over a decade. The focus has been on using strategic dissemination – how communicating and engagement is undertaken with water users (and other stakeholders) to initiate implementation (see [10]). During this time, the following valuable lessons have been learnt in NSW and could be applied to screening in other areas.

- Adopt a long-term approach, taking time to carefully consider how, where, when and to whom screens (and incentive programs) are promoted.
- Identify and work with innovators (including scientists, anglers and screen manufacturers), to drive development of screens that are tailored for local waterways, water users and fish.
- Define the total size of the stakeholder population (i.e., the number of water licence holders), then estimate the number of early adopters. Scale proposals for funding to suit.
- Build general awareness of screening benefits among water users, and provide them with opportunities to self-select for implementation incentives (e.g., an expression of interest).

- Engage directly with the most 'impactful' stakeholders (i.e., champions of the technology, and influential water users) to build consent for screens at high-volume water diversions.
- Create productive partnerships. Work with early adopters to establish showcase sites that demonstrate the benefits of screening under local conditions using local voices.
- Establish collaborative governance structures that involve stakeholders with broad expertise and experience, including water users, to guide consistent approaches across jurisdictions (e.g., development of the Australian Fish Screening Advisory Panel).
- Build awareness of implementation goals among policy and decision makers. Engaging with these stakeholders early in the process provides opportunities for them to 'own' and promote incentive programs.

A critical caveat in DOI is that most innovations fail once 16% of the population is saturated (i.e., the innovators plus early adopters). Moving into the early majority (termed by economists as 'crossing the chasm' of diffusion; [9]) will need local showcases detailing the outcomes experienced by early adopters to build a strong case that overcomes more firmly-held objections. Here, research proving the return on investment is important, as is genuine communication that communicates these findings in relevant and realistic ways. Proponents who do not understand the return on investment for stakeholders risk applying ineffective incentives, unsuitable messaging, or both. This is where understanding water user needs is essential.

Understanding water user needs

All stakeholders have needs. These needs are determined by their motivations and abilities. What type of DOI stakeholder are they? Are they ready to install a modern fish-protection screen? If not, do they need support to improve their understanding of how screens work or the benefits of screening? Do they need to know how a screen might meet their specific needs (e.g., a sustainability certification), and align with triple bottom line outcomes? Are they motivated, but lack the ability to install a screen? Do they need money to pay for installation? Do they need project management support because they are too busy to take on another project? Can they help drive the uptake of screening more broadly, by using their social or financial capital?

The Motivation and Ability Framework (MOTA) is a social research method that provides a framework for proponents to understand the needs of their various stakeholders and answer the questions above ([11, 12]; Fig 3). Proponents ask what motivates different types of stakeholders (positively or negatively) and examine whether stakeholders have the capacity to adopt a new idea or technology. MOTA includes assessment of the triggers for, and barriers to, adoption by stakeholders and can be combined with mapping of stakeholders (see next section). It provides a guide for proponents to begin developing engagement approaches and communication actions (e.g., types of meetings and key messages used) to improve stakeholder consent and capacity – for the different types of stakeholders – ultimately driving delivery and uptake of their technology or idea.

The use of MOTA has strengthened current initiatives and helped develop new screening incentivisation programs in NSW. The approach has been to use a simplified version of MOTA that focusses on discussions with high-priority irrigators, fisheries managers, government staff, decision makers and screen manufacturers. To date, 20+ on-farm meetings have been held with around 60 irrigators to promote the concept of screening, understand water user operations and concerns, and 'sign-up' water users to participate in the program (plus over 80 other stakeholder interactions). During this process, a variety of engagement approaches have been applied and key messages refined by seeking and incorporating feedback from stakeholders (i.e., by asking them what they need and how they want to be engaged).

The use of MOTA by the NSW Government has generated some important insights in relation to stakeholder motivations, abilities, triggers for action and barriers to adoption (Table 2). Firstly, water users share three main motivations with respect to screening. These are to: make or save money; protect native fish; and, improve their social licence to operate. Secondly, the abilities of water users vary depending on their financial, institutional, technical and social capacity and expertise. Thirdly, triggers for action are mostly related to government funding and outreach efforts, support for complementary measures to maximise benefits of environmental flows, and social licence to operate. Many of these triggers are also linked to, and interact with, the motivations of individual stakeholders. And, lastly, a series of common barriers to adoption exist. These include water user concerns about water supply, pump efficiency, ongoing maintenance costs and ownership, a mistrust of government and a lack of experience with fish and debris impacts. The NSW Government has worked for 10

201 years to develop solutions to each of these barriers, plus additional, more-detailed barriers
202 encountered less frequently (Table 3).

203 In general, almost all water users are keen to receive information on fish screens that
204 addresses barriers to adoption [13]. They are interested in the data on fish losses, if a screen
205 might suit their operation, what the value proposition is (in terms of reliability of water
206 supply, energy savings, native fish benefits and social reputation), and to be provided with
207 connections to screen suppliers and installers. Proponents can employ authentic
208 communication and engagement to deliver this information. This includes working to address
209 barriers through new scientific research, by demonstrating the experiences of early adopters
210 and by collaborating with manufacturers. Though this process, water users can access
211 opportunities to participate in the development of screening programs.
212

213 **Identifying and mapping stakeholders**

214 Identifying stakeholders is critical. Proponents need to know who their stakeholders are
215 before they can start prioritising and planning engagement efforts. In NSW, three broad types
216 of stakeholders for screening incentive programs were identified using expert elicitation
217 workshops (Table 4). These stakeholders were: implementers, influencers and facilitators. It
218 should be noted that DOI can be applied primarily to implementers (those installing screens),
219 but also to other types of stakeholders that vary in their role. Further, these categories could
220 be applied in other areas where screening programs are underway or proposed. Lastly,
221 proponents might recognise themselves in each of the three groups.

222 Stakeholder relationships can then be mapped. Proponents can group stakeholders based on
223 shared interests, goals, motivations and values (e.g., irrigators, fishing groups and
224 government departments). Links can be added to represent the variety of relationships
225 between stakeholders, ranging from informal social contacts to formal governance
226 arrangements. This process helps proponents visualise the number, type and strength of
227 relationships between different stakeholders and how information might spread through their
228 stakeholder population. This improves the efficiency of engagement efforts, by helping to
229 identify the most important targets for communication. The process also helps proponents
230 consider how conflict might be avoided and collaboration encouraged.

231 In NSW, expert opinion was used as the main source of data and stakeholders were mapped
232 using two methods: social capital mapping [14] and motivations and abilities mapping [11].

These methods revealed: (1) the network of relationships and lines of communication between stakeholders; and, (2) which stakeholders hold similar attitudes or positions on screening and might play similar roles in relation to our incentive programs. The initial social capital mapping indicated that there were well established groups of stakeholders, which were linked to one another by interest, sector, and responsibilities. Clear opposers and supporters of screening were also identified based on their motivations and abilities.

The insights gained through mapping allowed further refinement of the stakeholder engagement approach. Specifically, maps were used to help decide which stakeholders to engage with first, and what information to present (tailoring information to their interests). Stakeholders were then prioritised for engagement based on three factors: maximising uptake (how can the most screens be installed in the next three years and how can the biggest benefits be delivered?); study area (are the stakeholders physically located within the study area?)' and, receptiveness (which stakeholders are most likely to be motivated to install a screen and be receptive to engagement?). Key messages were tailored prior to any planned presentations and stakeholder engagement (i.e., contacting stakeholders directly or presenting information to stakeholders indirectly).

Integrate science with comms & engagement

The NSW Government has worked to integrate science with communication and engagement efforts. This integration can be defined simply as, 'undertaking science that generates strong, evidence-based key messages and that also responds to stakeholder needs for information'. This process involves taking communication from the end of the project timeline and embedding it into the scientific practice of the project itself. It represents a transition away from the deficit model to dialogue and participatory models of stakeholder engagement. Through a DOI lens, such integration involves deploying communications backed by science to engage early adopters, documenting their experiences, and then using *that* information to 'cross the chasm' to the early majority. There is also a dynamic wherein late majority and laggard stakeholders begin to see the experiences of innovators and early adopters, although this is difficult to quantify.

In NSW, there has been increasing integration of biophysical science with social research, and communication and engagement in screening programs. The following lessons have been learnt.

- Test key messages to provide nuance and framing that suit different audiences. Emphasise relevant benefits – irrigation efficiencies, biodiversity protection, economic or social good.
- Utilise early adopter experiences by establishing 'showcase' sites that demonstrate the benefits of screening in accessible language using a diversity of voices.
- Prioritise communication that helps establish relationships, build trust and provide 'continuity of care'; rather than 'town hall' meetings that can become distracted.
- Utilise existing networks (e.g., water user associations) that allow stakeholders to self-organise, by partnering with advocacy, industry, and community groups.
- Seek and respond honestly to feedback from stakeholders, particularly in relation to new and emerging knowledge gaps. Answering these questions will help 'cross the chasm'.
- Similarly, adapt to new information. Incorporate knowledge (e.g., from science or MOTA activities with stakeholders) into the management and delivery of screening programs.
- Conduct high-quality evaluations of screening costs and benefits (economic, environmental, social and cultural) to quantify and clarify the value proposition.
- Be solution oriented early. Use the evidence that is available (e.g., on fish losses and the availability and benefits of modern screens) to take action.
- Anticipate the information needs of industries and decision makers, providing data in accessible language and formats. Identify emerging communication opportunities.
- Assist manufacturers in developing screen technology, by providing up-to-date specifications and clear guidance for native fish protection.
- Establish structures that inform decision makers and support interactions between screening agencies and jurisdictions, guiding new actors as they join programs.

Conclusion

Modern fish-protection screens on water pumps and gravity-fed diversions offer a range of public and private benefits. However, the technology is a new concept for most water users in Australia. Like any new idea or innovation, significant effort is required to raise awareness of

incentive programs and generate uptake. Proponents need to develop a strong understanding of their stakeholders and work with innovators and early adopters (*sensu* [9]) to address the barriers to adoption faced by both these groups and more sceptical stakeholders. Using local showcases paired with rigorous, responsive and integrated science and clear communication, tapping into social learning, understanding connections, utilising champions and building real relationships will help modern screening cross the chasm of diffusion and establish the use of this technology as a standard best practice in Australian water use. These methods also have significant potential for application in other areas of implementation across conservation management.

Acknowledgements

The authors acknowledge the Traditional Owners of the lands and rivers where this work took place and pay their respect to Elders past, present and emerging. We thank the recreational anglers of NSW for their support, through the NSW Recreational Fishing Trusts and OzFish Unlimited. We also acknowledge the: enthusiastic participation of farmers and other water users in this study over many years; the contextual understanding provided by our colleagues at Charles Sturt University, Nick Pawsey and Tahmid Nayeem; advice from international experts in New Zealand and the United States with experience in modern screening; and, members of the Australian Fish Screening Advisory Panel. Marita Pearson provided comments on a draft of this manuscript. The authors declare no conflicts of interest.

References

1. Boys CA, Rayner TS, Baumgartner LJ, Doyle KE. Native fish losses due to water extraction in Australian rivers: Evidence, impacts and a solution in modern fish- and farm-friendly screens. Ecological Management & Restoration 2021;22(2): 134-144.
2. Boys CA. Design specifications for fish-protection screens in Australia. 1st ed. Taylors Beach: New South Wales Department of Primary Industries; 2021.
3. Rayner TS, Boys CA. Fish screens: a $3.7 billion boost for regional towns. 2020 [cited 13 September 2022]. In: Fish Screens Australia blog [Internet]. Available from: https://fishscreens.org.au/farming/fish-screens-a-3-7-billion-boost-for-regional-australia/
4. Selinske MJ, Cooke B, Torabi N, Hardy MJ, Knight AT, Bekessy SA. Locating financial incentives among diverse motivations for long-term private land conservation. Ecology and Society 2017;22(2): 7.
5. Baumgartner LJ, Boys CA. Reducing the perversion of diversion: applying world-standard fish screening practices to the Murray-Darling Basin. Ecological Management & Restoration 2012;13(2): 135-143.
6. Murray Darling Basin Authority. Northern Basin projects. 2022 [cited 13 September 2022]. Available from: https://www.mdba.gov.au/basin-plan/northern-basin-projects.
7. New South Wales Government. Fish screen program to provide financial and environmental benefits to farmers. 2022 [cited 13 September 2022]. Available from: https://www.lls.nsw.gov.au/regions/western/latest-news-and-newsletters/w-news/2023/fish-screen-program-to-provide-financial-and-environmental-benefits-to-farmers.
8. Gillanders BM, Elsdon TS, Munro AR. Impacts of native fish stocking on fish within the Murray-Darling Basin. Adelaide: University of Adelaide; 2006.
9. Rogers E. Diffusion of innovations. 5th ed. New York: Free Press; 2003.
10. Dearing JW, Cox JG. Diffusion of Innovations Theory, Principles, and Practice. *Health Affairs* 2018;37(2): 175-336.
11. Conallin J, Ning N, Bond J, Pawsey N, Baumgartner LJ, Atminarso D, McPherson H, Robinson W, Thorncraft, G. A review of the applicability of the motivations and abilities (MOTA) framework for assessing the implementation success of water resources management plans and policies. Hydrol. Earth Syst. Sci. 2022;26(5): 1357-1370.

12. Quan N, Guerra J, Korbee D, Luan P, Dung T, Hung D, Loc H, Hermans L. Manual for Application of the MOTA Framework: Theory and Practice. Ho Chi Minh City: Center of Water Management and Climate Change, Vietnam National University; 2019.
13. Nayeem T, Pawsey N. New South Wales irrigators' attitudes towards irrigation pump fish screening. In: Research for a Changing World: Institute for Land Water and Society Online Conferences; 2020 [cited 13 September 2022]. Available from: https://researchoutput.csu.edu.au/en/publications/new-south-wales-irrigators-attitudes-towards-irrigation-pump-fish.
14. Hearne D, Powell B. Too much of a good thing? Building social capital through knowledge transfer and collaborative networks in the southern Philippines. International Journal of Water Resources Development 2014;30(3): 495-514.
15. Boys CA, Rayner TS, Kelly B, Doyle KE, Baumgartner LJ. A guide to modern fish-protection screening in Australia. Taylors Beach: New South Wales Department of Primary Industries Fisheries; 2021.

Fig 1. Past and future expected uptake of modern screen technology in Australia. Charts show: (a) the cumulative number of screening sites; (b) the cumulative volume of water screened; and, (c) the cumulative number of native fish protected per year. These figures represent uptake by early adopters, mostly in the Northern Murray-Darling Basin. The estimated cumulative number of native fish protected per year is based on 3.5 native fish entrained per ML of water extracted and a 90 day pumping season [1]. Past data includes all jurisdictions. Future installations and volumes are based on the best available data for NSW, including expressions of interest received by the NSW Government from water users. There is clear potential to protect millions of native fish per year. However, progress beyond June 2024 in NSW is dependent on further funding.

Fig 2. Diffusion of Innovations as it relates to modern fish-protection screens. With successive groups of consumers adopting the new technology (shown in black) through time, an innovation's market share (grey) will eventually reach the saturation level. The black curve is broken into sections of adopters. Note the use of an Expression of Interest program to allow innovators and early adopters to "self-select" as participants, and a reduction through time in the amount of incentivisation provided to stakeholders. Research and communications are required to "cross the chasm" of diffusion to the majority of stakeholders, in this case water users. Figure after [9].

Fig 3. MOTA framework with explanation showing how it works with screening. The MOTA framework showing the relationships between the trigger for change, how stakeholders perceive the trigger (as an opportunity or a threat), their ability to respond and their motivations to do so. These elements combine to determine what action a stakeholder might take and the resulting outcome. The solid arrows indicate the influence of one element on another, and the dashed arrows indicate a potential influence (e.g., positive outcomes for one stakeholder may trigger another stakeholder to adopt a technology). Barriers are not shown in this figure but are mentioned in the text and relate to stakeholder abilities and perceptions (e.g., a poor opinion of the technology could demotivate a stakeholder, make them identify it as a threat and therefore act as barrier to adoption). Figure after [11].

389 **Table 1.** The composition of a population of stakeholders, defined by their degree of
390 innovativeness or willingness to adopt new ideas and technologies (after [9]).

Category	Percentage of stakeholder population	Description
Innovators	2.5%	Enthusiastic adopters of the latest technologies and ideas, ready to try new things.
Early adopters	13.5%	Those receptive to change and often considered opinion leaders in their communities.
Early majority	34.0%	Stakeholders who value evidence and the experiences of early adopters before 'buying-in'.
Late majority	34.0%	Relatively sceptical unless faced with a risk of missing out entirely. Require more effort to encourage than the early majority.
Laggards	16.0%	Very conservative stakeholders that may never adopt and prove difficult to sway.

391

392 **Table 2.** Application of the MOTA framework to water users in the Northern Murray-Darling
393 Basin by the NSW Government revealed a series of common motivations, abilities, triggers
394 for action and key barriers to the adoption of modern fish-protection screens.

Category	Description
Motivations	Make or save money: Modern screens eliminate virtually all debris from diverted water, reducing the need to backflush pumps, replace inline filters, and unblock sprinklers. This leads to cost savings in energy consumption, staff time, and replacement of parts and/or whole pumps.
	Protect native fish: Modern screens are proven to protect up to 90% of native fish at an individual diversion. Every screen protects fish, and there are cumulative benefits to screening multiple pumps in a single river reach. Most water users want to protect native fish and improve recreational fishing.
	Enhance reputation: Modern screen installations demonstrate water users' commitment to Environmental, Social, and Governance (ESG) goals and intergenerational equity through responsible custodianship of ecosystems. ESG commitments represent a competitive advantage for businesses and are required by some retailers of agricultural products. Stakeholders can use screens to maintain and enhance their overall social license to operate. Early adopters have already reported benefits to their public profile and general reputation (Shane Smith, Water Operations Manager, Trangie-Nevertire Irrigation Scheme *pers. comm*.).
Abilities	Financial: The financial ability of irrigator groups and individuals is generally good. They have shown that they are willing to invest in business initiatives, technologies, and partnerships that are profitable and sustainable. Some water users have financial capacity to purchase and install modern screens without government funding. However, in most cases, financial support is needed to drive initial adoption of screens.
	Institutional: Irrigators are generally well-organised, well-connected to one another, and have governance and financial structures in place to handle contracting and other agreements. Irrigator groups and individual irrigators in the Murray-Darling Basin have the institutional capacity to participate in

	modern screen installations. Further, local associations of water users can facilitate discussions and agreements with their members.
	Technical: Irrigation technology in the Murray-Darling Basin is well developed and modernised with a high-technology basis. Automation is common, and the technical capacity of irrigators and local irrigation support services is high. Irrigators are accustomed to high-tech products and well-proven solutions that integrate well with their existing operations.
	Social: Irrigators are well connected socially across their industries and local communities. Irrigators share their interpretations and opinions of a situation or technology. During engagement processes, they engage in conversation, are polite, attentive, and generous with their perspectives. They are willing to share their opinions with others to progress the project.
Triggers for action	Government outreach and engagement: Actively promoting adoption of modern screens by water users has been the first and most important trigger to date.
	Support for complementary measures: Some irrigators reported not wanting to lose any more water through buy-backs for environmental flows. They view measures like modern screens as a tool to maintain water for agriculture while still meeting environmental objectives.
	Social license to operate: Large irrigators, especially cotton farmers, want to change their 'bad reputation for not looking after the environment and water resources.' They see modern screens as one way to achieve this.
	Screening 'may become compulsory': Some irrigators think the government will make modern screens compulsory and want to act prior to any future legislative change.
	Potential cost savings for specialist irrigation: Backflushing and blockages are costly to irrigation enterprises, particularly those that use specialist drip or pivot sprinkler systems. Modern screens are a potential cost-saving measure.
	Economic stimulus funding: Irrigators recognise that financial support is available now, in the initial phases of diversion screening, and that funding may not be available in the future.

	Timing (delay and opportunity cost): This trigger is linked to others, with irrigators wanting to take advantage of incentives currently on offer and enhance their reputation as 'green' and 'sustainable.'
Key barriers to adoption	Risk to enterprise: Concerns include the loss of pumping ability, interruption to water operations, and breakdown of screens. This is the key concern where funding is available.
	Costs: Concerns include the initial installation cost, lifespan of screens, and ongoing maintenance, including access to screens and replacement of parts. This is the key concern where funding is not available.
	Lack of trust in government: Concerns stem from past failed and currently stalled government programs, including those seen as short-term or politically-motivated projects.
	Ownership: Concerns include the burden of project management, reduced capacity to undertake other farming duties, and the long-term potential for this asset to become a liability.

395

396 **Table 3.** Barriers to adoption of modern fish-protection screens identified by water users in
397 the NSW portion of the Murray-Darling Basin, and some of the solutions developed and
398 implemented by the NSW Government.

Barrier	Solution
Fine mesh screens will get blocked and interrupt water supply or damage infrastructure.	10+ years of local research and development to ensure modern screens do work for native fish species and farming operations. Screens are tailored to individual water diversions and operations, ensuring no impact on pump performance. Concerns that pump performance and water supply would be interrupted have been alleviated by conveying experiences of water users at showcase sites (e.g. Trangie-Nevertire Irrigation Scheme and Porker Citrus).
Financial cost too high (inc. capital, installation, running costs, maintenance and replacement costs).	Identified that water users are unaware of the actual costs of modern screen maintenance, which are significantly lower than traditional screens. Government is providing financial incentives, such as seed funding or total funding, for screen installations to encourage early adoption. This has helped alleviate the financial burden to water users and facilitated uptake by early adopters.
Loss of native fish from waterways not perceived to be real.	Identified that water users are generally unaware of the scientific evidence that is available. Perception exists that the numbers of fish lost from waterways is small, especially relative to the cost of screens ('we see very few fish, and only carp'). Research shows this is incorrect. There is extensive historical and contemporary evidence indicating native fish losses are in the many millions per year [1]. The solution was to consolidate the evidence and present it in the peer-reviewed literature, then communicate the findings in accessible language to water users, inviting sceptics to produce better estimates if possible. Many stakeholders, particularly peak bodies engaged in the implementation of modern screen technology, accept that fish losses can be significant but vary between diversions.

Trust in governments due to past negative experiences.	Some stakeholders have a general mistrust in governments and perception that government incentivised schemes are risky due to past negative experiences. Some water users feel that government schemes can be unpredictable and influenced by ministerial changes ('left holding the baby'). Fears of government volatility have mostly been allayed by the long-term commitment, and long-term experienced staff managing screening programs.
Return on investment perceived to be too low.	There is strong anecdotal support of good economic outcomes from modern screening. However, detailed empirical evidence is required. This knowledge gap is to be addressed through a research project by for an economic analysis of modern screen installations (in partnership with the Fisheries Research Development Corporation and the Cotton Research Development Corporation).
Modern screens perceived to have a short lifespan.	Production of published guidelines [15] and design specifications for modern fish screens [2], in partnership with screen manufacturers. These recommend the use of high-quality, stainless-steel wedge wire with a long lifespan. Self-cleaning mechanisms and screen retraction systems, which allow screens to be removed from the water for servicing, also extend the lifespan of a modern screen.
Technology perceived to be unproven or unreliable, or not proven (e.g. break down regularly) and that piloting was risky ("guinea pigs").	Alleviated through showcasing USA, NZ and AU sites through communications channels. This clearly demonstrates that screens are reliable, the science is rigorous and the technology sound. Local demonstration sites also provide important proof that modern screens work. Working with reputable engineers to manufacture screens using well-established technologies.
Seasonal aspects and farming operations impacting engagement and installation activities.	Seasonal farming operations impact the motivation and ability of water users to be involved in ventures that are not seen as core business (i.e., screening programs). The impact of this barrier may be larger for smaller producers. This has

	been incorporated into engagement by acknowledging and working around peak harvest, planting and irrigation times, weather events and commodity prices.
Reluctance to be vocal champions of the technology. Modern screens viewed as potential depreciating asset, especially if there is no screen fitted currently.	With any new technology, ownership and championing from the intended owners/implementers is key to adoption. Ownership and championing by water users is emerging (e.g. irrigators), taking away any 'sales' stigma of projects and replacing it with credible experts in water supply, infrastructure management and operation. This is particularly true as water users become more comfortable with the technology, after operating their modern screen over a number of farming seasons.

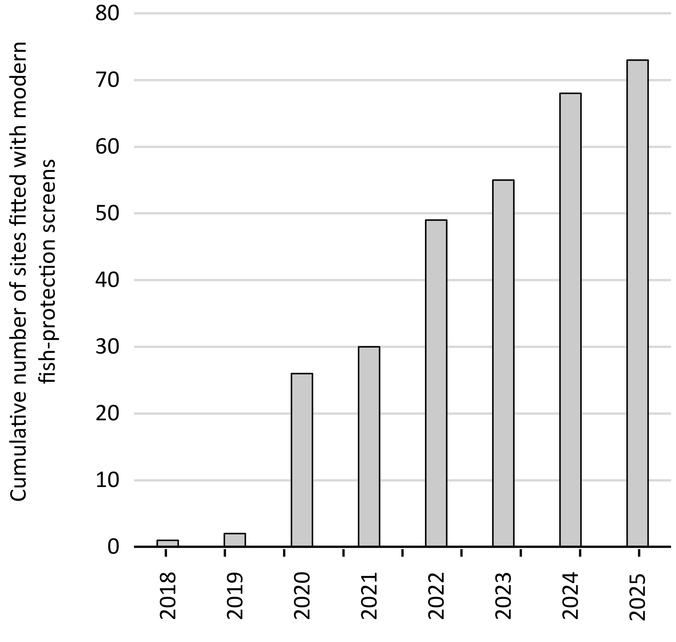
399

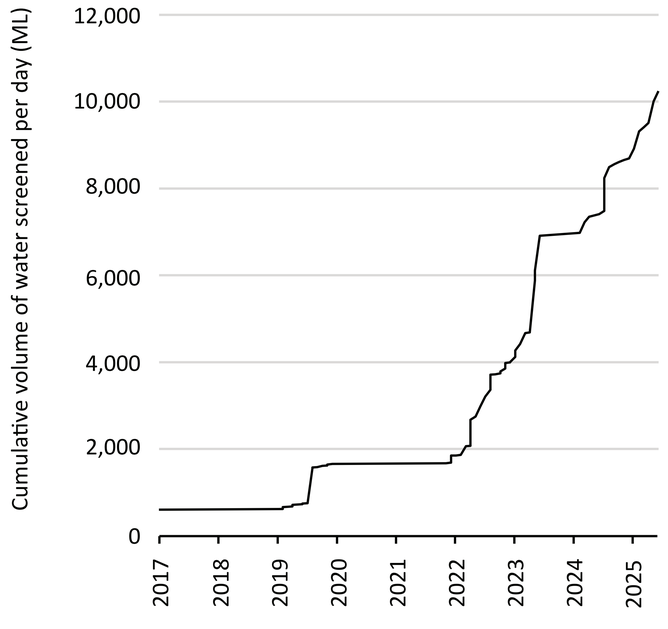
400

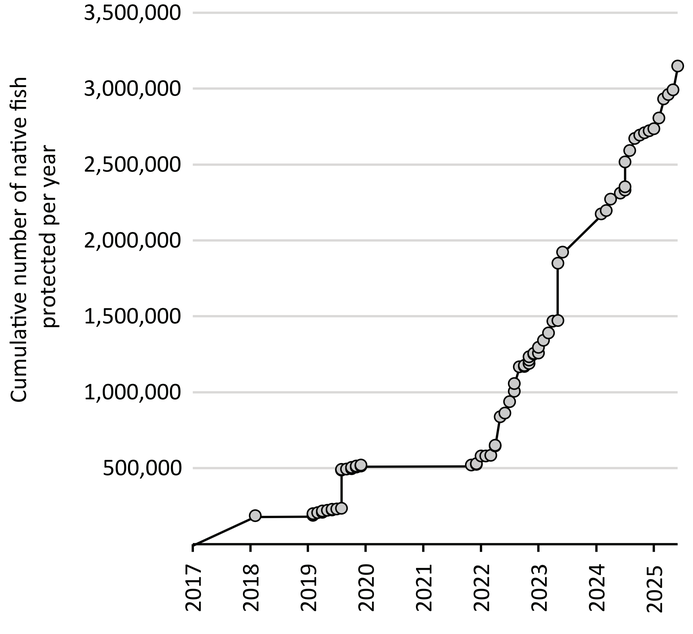
401 **Table 4.** The three types of stakeholders, identified by the NSW Government, which have
402 varying levels of involvement and influence on the implementation of incentive programs for
403 modern fish-protection screens.

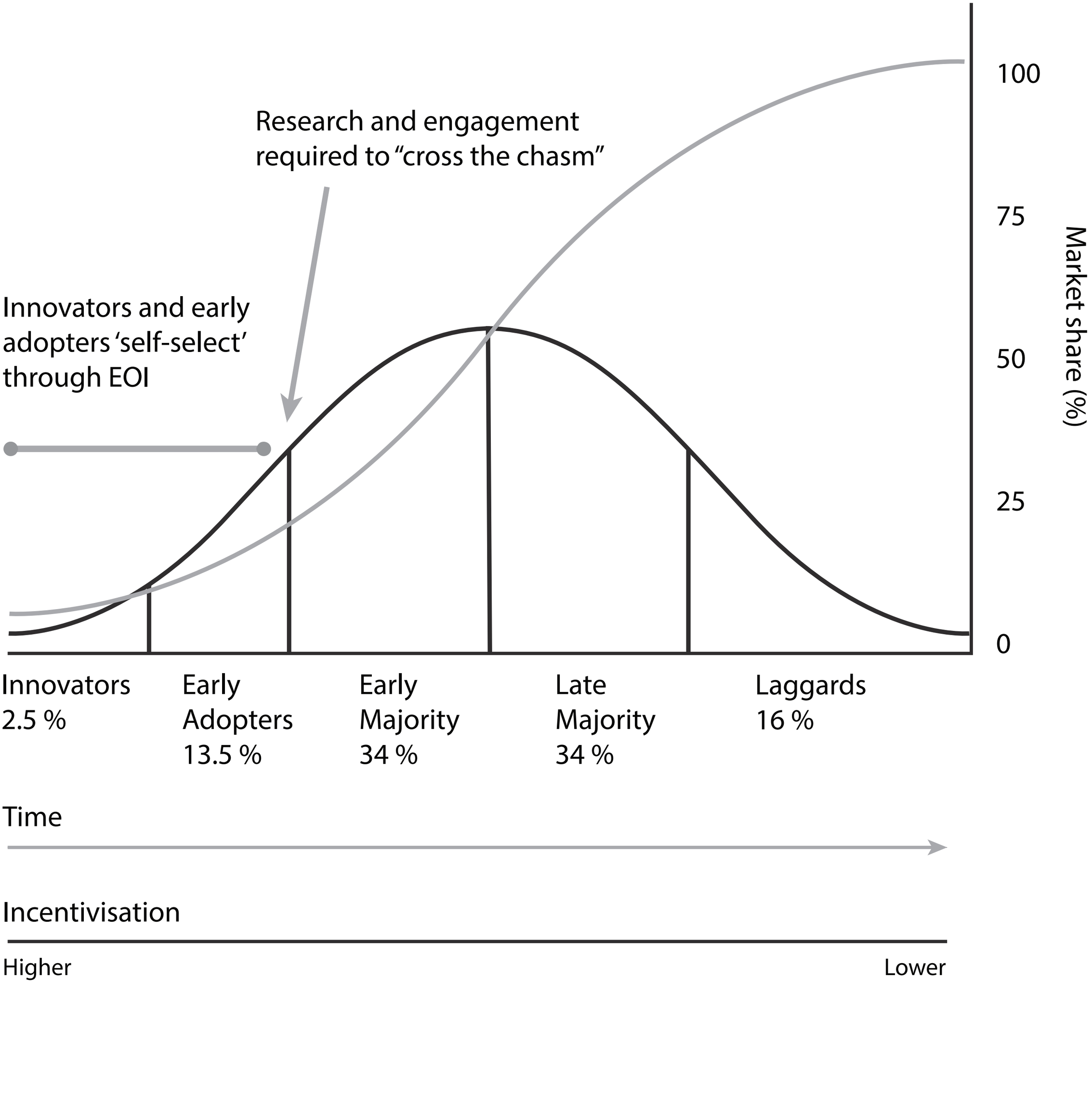
Stakeholder group	Description
Implementers	Water users directly impacted by screening programs. They are actively involved in the implementation of screens and have a high level of interest in the nature and delivery of incentives. This group includes individual irrigators, corporate irrigators, irrigation schemes, urban water providers, and other water users such as golf courses. They play a crucial role in the actual installation of screens and are directly affected by the outcomes of screening programs.
Influencers	Stakeholders with a high level of control over the success or failure of screening programs. Their actions have the potential to accelerate, catalyse, or delay progress and can significantly influence the management of incentive programs. This group comprises screen manufacturers (both current and future), fisheries and natural resource managers, government executives, relevant decision makers at state and federal levels (including Ministers), and agencies responsible for infrastructure, water, agriculture, fish, and the environment. Influencers have the power to promote or block the direction and implementation of screening programs through their decision-making authority and expertise in relevant areas.
Facilitators	Stakeholders with a high capacity to support and enable screening programs. They play a crucial role in building awareness among water users and the general public, providing support for engagement activities, and coordinating water users at local scales. This group includes champions who have already installed modern screens, farming associations and lobby groups, conservation organisations, fishing peak bodies, and other community groups. Facilitators contribute to the success of screening programs by advocating for their benefits, mobilising resources and support, and facilitating cooperation and collaboration among stakeholders.

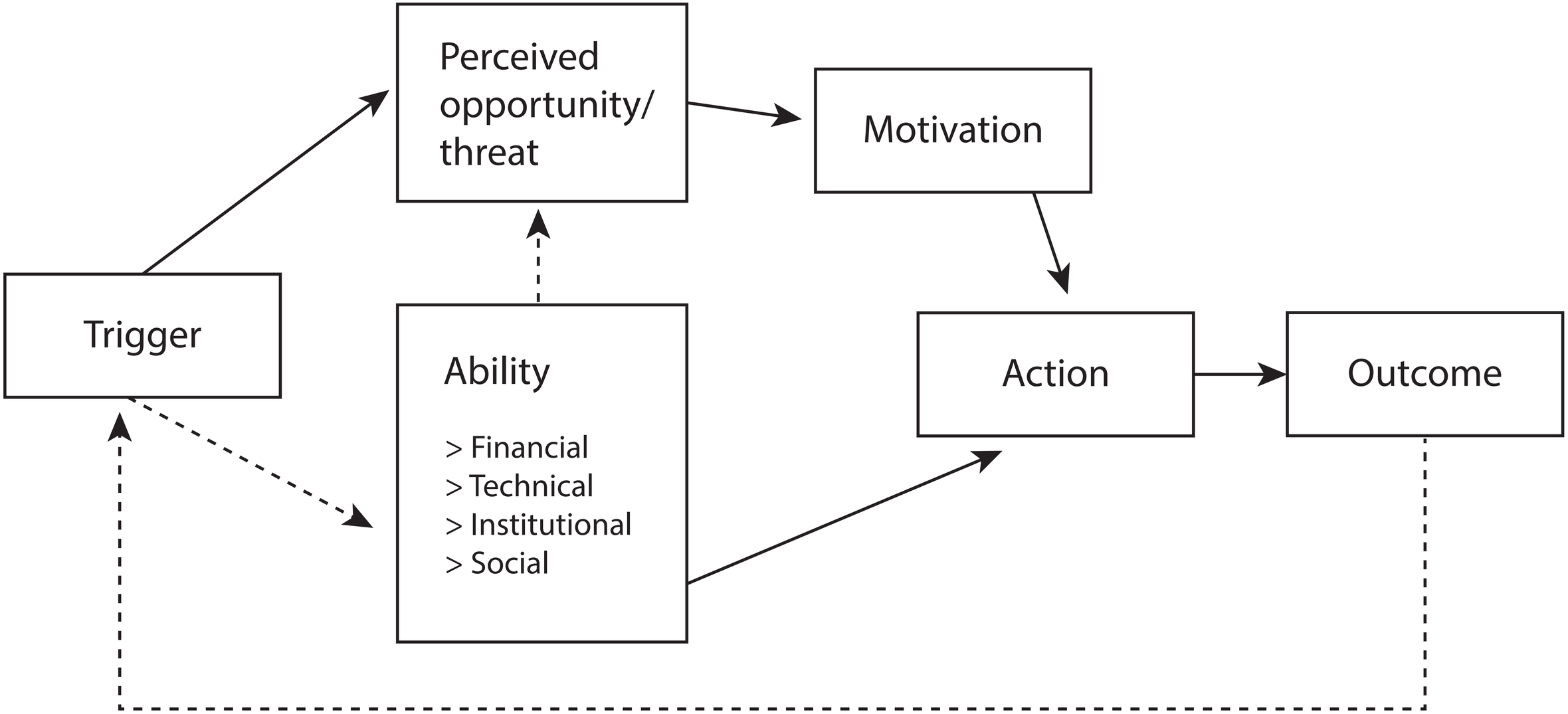
They act as intermediaries and champions for screening initiatives, facilitating the adoption and implementation process.


Cumulative number of sites fitted with modern fish-protection screens
80
70
60
50
40
30
20
10
0
2018
2019
2020
2021
2022
2023
2024
2025


Cumulative volume of water screened per day (ML)
12,000
10,000
8,000
6,000
4,000
2,000
0
2017
2018
2019
2020
2021
2022
2023
2024
2025


Cumulative number of native fish protected per year
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
2017
2018
2019
2020
2021
2022
2023
2024
2025


Research and engagement
required to “cross the chasm”
Innovators and early
adopters ‘self-select’
through EOI
100
75
50
25
0
Market share (%)
Innovators
2.5 %
Early
Adopters
13.5 %
Early
Majority
34 %
Late
Majority
34 %
Laggards
16 %
Time
Incentivisation
Higher
Lower


Perceived opportunity/ threat
Motivation
Trigger
Ability
> Financial
> Technical
> Institutional
> Social
Action
Outcome