Animal Minds, Social Change, and the Future of Fisheries Science

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INTRODUCTION

Since its inception (Lee, 1912; Baranov, 1916; Beverton and Holt, 1957), fisheries science has tried to answer the question: "How can we maximize the benefits of fisheries for humanity?" Historically, those benefits have included yield and profit, as well as socially and ecologically sustainable systems (Olver et al., 1995; Mardle et al., 2002; Pascoe et al., 2017). So, fisheries science and management have always been driven by a set of values—that humanity should utilize marine resources to benefit itself (Partelow, 2018). What would happen if those values, which have formed the foundation of fisheries science and management for a century, were transformed by a new governance mind-set?

FISH SENTIENCE: PHILOSOPHICAL AND SCIENTIFIC DEBATES

In mainstream society in modern, industrialized countries, it is broadly accepted that humans have morally relevant interests. The Universal Declaration of Human Rights "articulated the rights and freedoms to which every human being is equally and inalienably entitled" (United Nations., 2015). However, this broadly accepted view excludes non-human animals—a position that is challenged in science and philosophy. Philosopher Bentham (1789) argued that having morally relevant interests requires merely the capacity for enjoyment and suffering. Many contemporary philosophers agree that an organism's moral status should be determined by one criterion only: that organism's sentience (Singer, 2011a; Gruen, 2017). Here, we define "sentience" as the "capacity for emotion, pleasure and pain" (Boyle, 2009), while acknowledging that there is no widely accepted definition of sentience (Proctor et al., 2013).

When it comes to fish[1], research, and academic debate on sentience has mostly focused on negative feelings, specifically pain (Proctor, 2012; Vettese et al., 2020). Researchers who support that fish feel pain begin with two key considerations: if fish can experience pain, fish should respond to noxious stimuli differently to innocuous stimuli (e.g., physiological reactions, protective responses), and fish should exhibit long-term behavioral (e.g., motivational) changes that imply higher-order processing (Braithwaite, 2010; Sneddon et al., 2014; Sneddon, 2020). Since the foundational studies on fish pain (Ehrensing et al., 1982; Chervova, 1997; Chervova and Lapshin, 2000; Sneddon et al., 2003a,b; Dunlop and Laming, 2005; Dunlop et al., 2006; Nordgreen et al., 2007), the body of evidence has developed such that the two key considerations are now considered well-supported (Sneddon, 2015, 2020; reviewed in Brown, 2015; Elwood, 2021).

Conversely, some scientists remain skeptical of pain in fish. These skeptics mainly point to differences in brain structure between humans and fish and alleged methodological, conceptual, and logical flaws in empirical studies on fish pain (Rose et al., 2014; Key, 2016a; Browman et al., 2019). Skeptics also offer counter examples of studies, notably not designed to answer this question, where potentially noxious stimuli seemingly failed to cause behavioral changes (Rose et al., 2014; but see Arlinghaus et al., 2007; Brownscombe et al., 2017).

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[1]We focus on fish as defined biologically. Most of our arguments readily extend to other exploited groups of animals (e.g., crustaceans, mammals), although the empirical evidence on sentience in those groups introduces further complexity.

Many outside the debate have recognized that the evidence is not balanced; skeptics are reluctant to accept even a disproportionately large body of evidence, often seeking absolute proof (Proctor, 2012). Compared to other areas of science, which are comfortable with ambiguity, this attitude has been labeled a "double standard" (Griffin, 2001) and a taboo that restricts progress (Griffin, 2013).

Empirical research on sentience, combined with a philosophical emphasis on sentience rather than species, leads many people to question the separation of *Homo sapiens* and other species of sentient animals (Donaldson and Kymlicka, 2011). One solution offered is to adapt society's institutions to recognize and protect the interests[2] of sentient animals, and political theory illustrates how such a change could be made (Stone, 2010; Donaldson and Kymlicka, 2011; Andrews et al., 2018; Vink, 2020; Freeling and Connell, 2021).

Regardless of method, the legal protection of animals would change the fabric of society. Modern social, industrial, and economic systems assume that the use of animals is permissible, whether for food, fabrics, land management, or medical testing. Where society has historically undergone profound economic transformations, humans' everyday lives have been altered in significant ways; the abolition of state-sanctioned slavery is one example (Goldin, 1973; Katz-Hyman, 2008). For these reasons, Browman et al. (2019) wisely express caution about granting legal protection to animals purely on the basis of unclear science. However, this major societal conversation involves many factors outside an objective reading of empirical data.

Browman et al. (2019) assume that humans and fish are fundamentally different, and that any potential similarities are merely tentative until conclusively proven. To accept that fish feel pain departs from the *status quo* of society, so the burden of proof lies with those who believe fish feel pain (Key, 2016b). However, other authors begin at a different perspective: that humans and fish are fundamentally similar, and that it is the potential *differences* that are merely tentative until conclusively proven (Safina, 2016).

WHAT DETERMINES SOCIETY'S DECISION?

The conclusion that a scientist draws from a piece of evidence may sometimes depend more on the paradigm within which initial assumptions are made than the evidence itself (Kuhn, 1996; Nuzzo, 2015; Andersen et al., 2019; but see Nickles, 2017). Cognitive biases encourage people to selectively focus on evidence that supports their existing beliefs (Tetlock, 2003; Kahneman, 2012). Beyond the scientific debate, the two divergent assumptions in the scientific literature serve different groups in broader society (Vettese et al., 2020).

The two divergent assumptions about where the burden of proof lies may be explained using the *moral circle*. Humans use the moral circle to separate beings into two groups: those who have morally relevant interests, and those who do not (Laham, 2009; Singer, 2011b). In this way, a person whose moral circle includes fish may place the burden on scientists to prove that fish are not sentient; as such, they may conclude that the evidence supports fish sentience. Conversely, a person whose moral circle does not include fish may place the burden on people who support that fish are sentient, and accordingly conclude that the evidence does not yet support fish sentience. In other words, the conclusion that a person draws may be primarily determined by their pre-existing beliefs—for scientists (Koehler, 1993) as well as members of the public (Kahan, 2012) but see Tappin et al. (2020). Of course, an alternative interpretation is that a person's moral circle may be determined by their reading of the evidence on sentience in different animals, or a complex interaction between the evidence and their pre-existing beliefs (Helton and Helton, 2005). However, prejudices against animals appear to stem from the same origin as prejudices against other humans, suggesting at least some resistance to evidence (Dhont and Hodson, 2014; Dhont et al., 2016).

Even under uncertainty, progress may arise from the expected utility principle; fish could be assigned a moral value that incorporates the probability that they are sentient, a probability that can be obtained through deliberation between all parties (Sebo, 2015). Such a probability could be incorporated in a welfare function (below). This represents a rational middle-ground between the risky in cautionary principle (assuming non-sentience) and the pre-cautionary principle (assuming sentience) (Birch, 2017; Sebo, 2018).

Regardless, the continued existence of two polar-opposite readings of the same set of evidence suggests that, unless a transformational piece of research arises that conclusively settles the debate, these two divergent positions are likely to co-exist for the foreseeable future. What implications might this continued co-existence hold for the societal conversation?

If our explanation is true, then the primary determinant of whether a society legally protects animals' interests may not be the direction of the empirical evidence, but whether that society's moral circle is expanding or contracting (Arlinghaus et al., 2007). Humanity's moral circle has appeared to have broadened throughout modern history, and developed countries in the twenty-first century have achieved a level of egalitarianism among humans that would have seemed impossible just a few centuries ago (Pinker, 2012), although some potential exceptions have been identified (Branwen, 2019). Also, we emphasize that moral circle expansion depends on many complex, interrelated factors, including scientific evidence but also economic progress, technology, social contexts, psychological prejudices, and historical path-dependence (Pinker, 2018; Anthis and Paez, 2021), all of which influence the pathway from science to moral circle expansion and policy change.

Nevertheless, there does appear to be a historical trajectory toward greater compassion for terrestrial and aquatic animals by the general public (Reese, 2018; Ryba and Connell, 2020; Anthis and Paez, 2021). Recently, multiple research groups have

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[2]For clarity, when discussing the moral status of sentient organisms, we refer to "interests," which we believe is an appropriate way to envision the aggregative, potentially conflicting needs of all sentient organisms (Gruen, 2017). When discussing legal and political form that aims to protect those interests, we speak of "legal rights".

emerged with stated aims to reduce suffering in fish and other wild animals (Billington, 2019; Wild Animal Initiative, 2019; Bench et al., 2020). Public opinion surveys often estimate that a majority of respondents believe fish to be sentient and capable of experiencing emotions, as shown in the European Union (ComRes., 2018) and South America (Rucinque et al., 2017), although results are sometimes mixed (Kupsala et al., 2013; Šimčikas, 2020).

If public support for the protection of fish continues to grow, then the societal conversation on the legal protection of aquatic animals may become urgent. While mainstream discourse centers on more humane methods of catching fish (e.g., Veldhuizen, 2018), the legal protections we envision here are more profound. An emerging body of thought is investigating how sentient organisms can be enfranchised and represented in political institutions and recognized as bearers of legal rights and freedoms—simply put, a generalization of human rights to sentient rights (Donaldson and Kymlicka, 2011; Cochrane, 2018; Vink, 2020; Freeling and Connell, 2021; Paez, 2021). As with the economic sacrifices involved with abolishing slavery (Conrad and Meyer, 1958), the path of granting constitutional protection to fish may necessitate serious sacrifices in wealth, employment, and food security (Browman et al., 2019). Conversely, fish production does involve complex relationships with social and environmental problems (e.g. Lima dos Santos and Howgate, 2011; Reis et al., 2021), so granting protection to fish may actually help overcome problems in food security and public health.

While the dialogue between science and society can help overcome many challenges (Sonnino et al., 2021), social change may be determined by forces outside of the control of any individuals, even scientists (Arlinghaus et al., 2007; Pinker, 2018). A more tractable frontier is, if society *does* undergo a major shift in its relationship with aquatic ecosystems, whether fisheries scientists and managers will be prepared to support society in meeting society's chosen objectives. If society adopts the mind-set that fish should be afforded legal protection to a degree comparable to humans, fisheries science may need to evolve once more.

DISCUSSION

Today, as fish populations are generally managed for the sake of human welfare [e.g., *via* economic growth (Ortiz-Ospina and Roser, 2013; Pascoe et al., 2017)], the fishery manager might aim to select a fishing effort that corresponds to the maximum profit:

$$\max_{E} PROFIT = REV - COST$$

Likewise, for a future fish population that is managed to optimize the total welfare of sentient organisms, the manager could aim to maximize an inclusive welfare function:

$$\max_{E} WELFARE = ?$$

Here, we adopt the view of welfare that emphasizes the subjective experiences of sentient animals (discussed in Browning, 2020). This welfare would include not only fish that constitute the population, but also all other sentient beings connected with the ecosystem, including humans. The state of an ecosystem that maximizes the welfare of sentient beings, if they are indeed capable of experiencing emotion, is a question ripe for study. Also, note that the above welfare function is a consequentialist mechanism; in contrast, deontological (rule-based) approaches may advocate for different actions in how fish are considered.

Generally, fisheries are managed to meet objectives under three categories: economic, social, and environmental sustainability (Pascoe et al., 2017). Discourse on "natural resource management," and indeed viewing other organisms as a resource, remains anthropocentric (Treves et al., 2019) and potentially speciesist (Horta, 2010). From this perspective, efforts to improve fish welfare (e.g. Moore et al., 2009; Kennelly and Broadhurst, 2021) are generally secondary to the primary goal of exploiting the fishery for food or profit.

However, under a sentient-inclusive welfare function, maximizing the total welfare of sentient beings would be the core objective—even at the expense of humanity's exploitation of non-human organisms. As such, catching a large-bodied shark to sustain many members of an artisanal fishing community could be a welfare-maximizing strategy, while catching many small-bodied fish to produce replaceable goods for developed countries may not (Gruen, 2017). Note that some researchers propose that wild animals experience lives not worth living; while this does not conflict with improving animal welfare, it may introduce complexities in doing so (Fischer, 2018).

A handful of researchers have begun to identify what conditions might maximize the welfare of fish at the population level. One stream of research considers physiology and behavior, often studying fish in laboratories or the field. This approach aims to determine which indicators could shed light on the inner state of fish minds, and considers how observations of the animals (e.g. respiration rates) correspond to observations of their environment (e.g. dissolved oxygen) (Martins et al., 2012; Beausoleil et al., 2018; Noble et al., 2018; Cerqueira and Billington, 2020). A key motivation is to improve conditions for fish in aquaculture or fisheries.

A second, theoretical stream of research adopts quantitative modeling. One question is whether fish welfare can be measured quantitatively, and how researchers could approach doing so (Singer, 2011a; Hecht, 2019a; e.g., Bateson, 2016; Brennan, 2018; Teng et al., 2018). Beyond this key question, preliminary forays have suggested that individual fish welfare within a population may be maximized at a specific population density (Hecht, 2019b), and that the total welfare in a population could be influenced by the age-structure (Hecht, 2019a). These intriguingly counter-intuitive ideas clarify that the optimal fishing effort, in terms of total welfare of sentient organisms, may be non-zero and could also involve complex relationships with population dynamics. Furthermore, beyond the relief from suffering, sentient organisms have an interest in remaining alive (Doğan, 2011); the management of wild populations for the benefit of all sentient organisms would also need to consider this interest in life.

These quantitative, empirical questions are ripe for investigation by fisheries science. The two streams of research

can also feed into decision-making. Policymakers could apply empirical findings to update existing tools in welfare economics to account for non-humans (Johansson-Stenman, 2018). This would enable policymakers to achieve a mandate of promoting the interests of all sentient organisms, should society choose to prioritize those interests.

Since the publication of the seminal texts that founded modern fisheries science (e.g., Lee, 1912; Baranov, 1916; Beverton and Holt, 1957), society has experienced immense transformation. In deciding whether the rights of fish should be protected by law, society faces a choice. This choice may primarily consider existing worldviews rather than any scientific consensus. If society pursues the path of legally enshrining the interests of sentient organisms, fisheries science can support society in doing so. The question of how fish populations can be managed to explicitly protect their interests represent this exciting frontier for fisheries science.

AUTHOR CONTRIBUTIONS

FUNDING

ACKNOWLEDGMENTS

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