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Seeking consilience: Traditional ecological knowledge and Western social science contributions to orca conservation knowledge

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ABSTRACT

Consilience is the integration of disciplinary knowledges in search of a more complete truth. In the complex context of conservation, where human activities are increasingly impacting the population status of many species, this endeavor is particularly important. Yet, to date, we have had limited attempts at unifying diverse sources of knowledge around a conservation issue. Focusing on orca conservation specifically, we share the perspectives of five scholars from five disciplines to demonstrate how Indigenous Knowledges and Social Sciences can inform the conservation of Southern Resident Killer Whales (SRKWs). We see Traditional Ecological Knowledge (TEK) as an original consilient knowledge and Western social sciences as the fields that can best identify and describe the norms and patterns of how to engage conservation. The integration of these broader knowledge systems, driven by individuals trained in their respective fields, with the already existing biophysical data around SRKWs, can help us make better decisions for SRKW conservation.

1. Introduction

In his seminal book, Consilience: The Unity of Knowledge, conservation biologist E.O. Wilson posited that 'the greatest enterprise of the mind has always been and always will be the attempted linkage of the sciences and humanities" with the appeal that most issues affecting humanity "cannot be solved without integrating knowledge" and that doing so will result in "understanding the human condition with a higher degree of certainty" (Wilson, 1998). He provided the example of a quadrant made of four isolated fields (adapted in Fig. 1): environmental policy, social science, ethics, and biology which are at the heart of understanding any natural resource issue, yet whose disciplinary boundaries (manifested by unique language, modes of analysis, and standards of validation) have prevented their consilience toward a unified knowledge of the context. The further out in the quadrant a scientist stays, the more comfortable they are with these quadrant-specific norms. The closer to the center of the quadrant, where the complex problem (such as orca conservation) lies, the more likely scientists are to find a holistic truth. Close reading of the book demonstrates that Wilson perceived reductionism as the cutting edge of science and that the physical sciences were the true knowledge sources that could contribute to improving the social sciences and humanities. In the year of his passing, and over two decades since the book's publication, we were motivated to consider the extent to which this vision has been or could be incorporated in conservation decision making, specifically in the context of Southern Resident Killer Whales (SRKWs).

The 2000s have seen a growth toward consilience in conservation knowledge. There has been broad discussion about the need for interdisciplinarity, multidisciplinarity, and transdisciplinarity to solve complex conservation problems (Dick et al., 2017). One example is the growing acceptance of Western social sciences as contributions to conservation science (Bennett et al., 2017) and their consideration in social ecological systems research (Stojanovic et al., 2016). Social sciences often fall under the category of Human Dimensions and include foundational social sciences, such as psychology, sociology, economics, and anthropology, as well as applied fields such as public policy and communications (Bennett et al., 2017; Spalding et al., 2017). Between 1990 and 2019, the number of social science articles published in the journals

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Conservation Biology and Biological Conservation increased over ten-fold cumulatively. These articles spanned two somewhat distinct types: 1) essays and reviews on the need for and challenges to social science training and integration (e.g., Jacobson & McDuff, 1998; Sievanen et al., 2012; Bennett et al., 2017) and 2) empirical results of social-scientific studies ranging from public perceptions research (e.g., Gramza et al., 2016), to values and cultural ecosystem services (e.g., Gould et al., 2015), to property rights (Mascia & Claus, 2009). While these efforts substantively enhance the scientific dialogue in conservation sciences that have been historically dominated by biophysical sciences, there is still a lack of knowledge integration both among the social sciences and between the social and natural sciences when making conservation decisions (Pooley et al., 2014; Sutherland et al., 2018).

In addition to Western social science, Traditional Ecological Knowledge (TEK) research has also been identified as a critical contributor to conservation decisions, especially those being made around culturally significant ecosystems for indigenous communities (Pilbeam et al., 2019; Wheeler & Root-Bernstein, 2020). In fact, the White House issued a statement regarding the important role of TEK in federal decision making in 2021 (White House OST and DEQ 2021). Nonetheless, as with the social sciences, we recognize the continued exclusion of TEK from conservation decision making.

The exclusion of TEK researchers, just as the inclusion of only one social scientist, may result from a lack of vision about how the diversity of knowledge from these fields can contribute to achieving the best possible conservation outcomes (Bennett et al., 2017). We attempt to address this ambiguity in this paper, by providing specific examples of how SRKW conservation could be informed by TEK's interdisciplinary approach along with four fields of Western social science: public policy, environmental economics, psychology, and human geography. We briefly describe each field and provide a specific framework and analysis that could inform orca conservation decisions. By focusing on a specific conservation issue, we exemplify some, but not all, of the social and indigenous sciences that could be at the table when making conservation decisions. Each section was written by an expert in their field; we mostly retained the original author's style of writing to build the muscle of interdisciplinary communication necessary for consilience (Pooley et al., 2014).

2. Southern Resident Killer Whale conservation context

The Committee on the Status of Endangered Wildlife in Canada designated SRKWs as endangered in 2001 (Government of Canada, 2018a) and the National Marine Fisheries Service in the United States followed suit with an endangered listing under the Endangered Species Act (ESA) in 2005 (U.S. Department of Commerce, 2005). From spring through fall, SRKWs have historically been seen in the protected inshore waters of the Salish Sea, including Puget Sound and the Strait of Juan de Fuca in Washington State and the Strait of Georgia in British Columbia. These charismatic marine mammals have come to symbolize what people love about the region and have long been a species of importance to Coast Salish Tribes. Biologists estimate the historic population of SRKW to be around 200 animals, however, they are presently in real danger of extinction (NOAA, 2021). The 2020 census returned a count of only seventy-two whales, with one additional individual remaining in captivity in Florida.

While endangered designations for SRKWs have afforded the species special protections under federal law, their main food source, Chinook salmon, have also been listed as threatened in Puget Sound, the Snake River, and the Lower Columbia River, and as endangered in the Upper Columbia River (U.S. Federal Register, 1999). Multiple Chinook populations have been listed as threatened and endangered in Canadian waters (Government of Canada, 2020). The major threats to SRKWs are threefold: 1) too little to eat; 2) noise pollution; and 3) toxics pollution (Government of Canada, 2018b). SRKWs strongly prefer a robust diet of Chinook salmon, yet Chinook and other salmon populations in and around the Salish Sea no longer have the necessary habitat to grow and thrive, resulting in not enough fish available for SRKWs (Hanson et al., 2021). Additionally, vessel traffic noise in the transportation waterways around the Salish Sea disrupt the whales' normal use of echolocation, making it difficult to locate their prey (Holt, 2008). Lastly, various toxic chemicals from human development flow into streams and rivers, and out to the sea, making their way into the food chain (Mongillo et al., 2016).

The Governor of Washington State convened a special Orca Task Force (OTF) to take action in 2018. In an Executive Order (EO), he stated that "extinction is not an option" for SRKWs. The EO identified

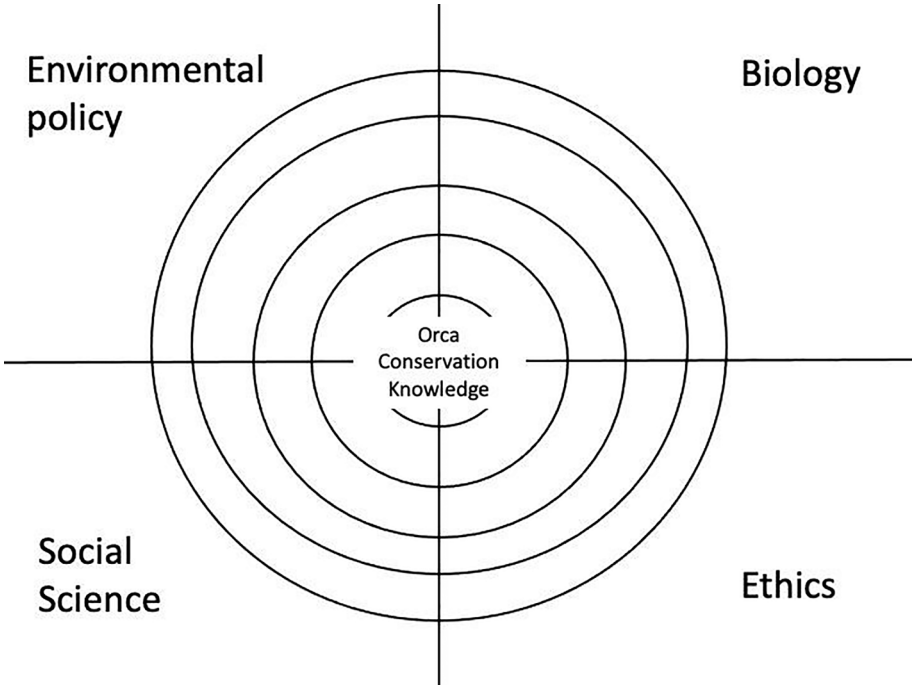

Fig. 1. Adapted from Wilson, E.O. 1998.

immediate actions for state agencies to take, including establishment of the OTF to be charged with developing an action plan to recover the SRKW population. Over fifty members comprised the OTF, including Washington State legislators, federal agencies, Tribes, local governments, ports, environmental non-profits, commercial and recreational fishers, marine trade associations, the whale watching industry, agriculture, and forestry. The social sciences were only represented by an economist. Washington State agencies were tasked with convening and supporting the work of the OTF over a two-year time. The facilitating agencies that normally worked within their respective regional or state jurisdictions were tasked with convening transboundary state-to-state and international work groups. OTF meetings grew so large that facilitators had trouble finding locations to hold all the participants. Questions of legitimacy in carrying out any OTF recommendations outside of Washington State remained a question, given that the OTF was a single state mandate and not a national or international agreement. However, the Government of Canada did maintain an observation seat on the OTF (Cascadia Consulting Group, 2019). Notably, several Tribes participated in the OTF in good faith, but asserted and maintained the need for increased government-to-government consultation that recognized their individual tribal sovereignty and importance of treaty rights.

Final recommendations for orca conservation from the OTF were provided according to the three primary threats (Cascadia Consulting Group, 2019). To increase prey availability, it was recommended to accelerate funding and regulatory measures for habitat projects and protections; increase hatchery production for Chinook salmon population; implement a plan for reestablishing Chinook runs above dams on the Columbia River between Washington and Oregon State, and on the Green and Puyallup Rivers in Puget Sound; explore the social impacts associated with potential removal of the Lower Snake River Dam; and investigate mitigation for pinniped predation on Chinook salmon. To reduce toxic contaminants, the OTF recommended prevention measures, treatment and cleanup of current contaminants, and increased monitoring going forward, with a price tag of at least $300 million. Lastly, to reduce disturbance from vessels the OTF recommended that tankers be required to provide additional information about oil movements in and out of Washington State; Vessels of a certain weight and class comply with tug escorts; implement commercial whale-watching licenses to boaters and kayakers; and enforce stricter distance and speed regulations around SRKWs for all boaters.

3. The Lenses

3.1. Traditional ecological knowledge (TEK)

The original consilience lens on orca conservation

While Tribal representatives formed part of the OTF, it is unclear the extent to which TEK research was incorporated in the discussions. Regardless, for the purposes of demonstration, we provide a description here of TEK and how it could inform conservation decision making related to orcas or other species. Indigenous Knowledge (IK) has been utilized by Indigenous communities since time immemorial. This overarching information system includes the field of Traditional Ecological Knowledge (TEK), which is a recognized academic discipline (Drew & Henne, 2006). Prior to its recognition, (IK) and Indigenous Science (IS) were brushed off as entertaining, storytelling, and anecdotal at best (Krech, 1999). In the past twenty years, however, TEK has been proven to be verifiable, reliable, and accurate (Sepie, 2017; Smithers, 2015; Snively & Corsiglia, 2001). Oral database documentation dates back as far as when the Vikings made first contact with North American Indigenous populations (Paterson, 2011). These oral histories, encoded as stories, precede and are consistent with evidence generated by western science. For example, the 1700 Cascadia earthquake and tsunami are documented in the story of the epic battle between whale and thunderbird (Hamblyn, 2014). Such TEK is likely to elucidate events, gradual environmental changes, and potential options for adaptation by human systems, whether Tribal or largely non-Indigenous (Smit & Pilifosova, 2003).

TEK research is developed and implemented in co-production with Indigenous communities. It is more than the inclusion of Tribal representatives in decision making spaces (although this is also crucial). It is a systematic process that includes in-depth interviews, participant observation, and analysis of artefacts that are conducted by a trained TEK scholar. The methodology is based in oral tradition yet has a review system like that of Western scientific peer review. While TEK review processes are oral, they are collective processes that have stood the test of time and must pass scrutiny of the eldest members who hold the vast detailed knowledge (Butler, 2004; Calamia, 1999). TEK scholars are trained in the unique worldviews that guide the interpretation, consolidation, and sharing of this knowledge. While TEK research uses methods common in the social sciences, it is not a social scientific effort. Instead, it is a precise documentation of integrated knowledge that includes components of biology, ecology, phenology, other biophysical attributes related to the topic of interest, including long-term observations of human impacts on the natural world. As such, TEK research is a unique tool that can accurately assess and bridge fields related to conservation (Brodnig & Mayer-Schönberger, 2000; Usher, 2000). Yet this misunderstood field of ecology has been underutilized and largely discounted within western science applications (Pierotti & Wildcat, 2000; Shackeroff & Campbell, 2007).

Such is the case with TEK on orca populations in the U.S. Pacific Northwest. Although Pacific Northwest Coastal tribes have long been honoring, observing, and protecting orcas in what is currently recognized as Washington state, there has been minimal written documentation of TEK in relation to orca populations (with the exception of, for example, Higdon et al., 2013), and none specific to SRKWs. Coast Salish-speaking tribes, along with all Northwest coastal tribes have been ocean-faring since time immemorial (Jones et al., 2021, Wilson, 2020, personal knowledge). All Coast Salish tribes have a wealth of TEK regarding honorings of whales (Ruby & Brown, 1988; Underhill, 1945) and long-standing stories where whales are a central, integrating aspect of Coast Salish culture. Orcas, like many other whale species, are highly respected and are an integral aspect of Tribal life (Gorgia Strait Alliance, 2022, Personal Experience). Clan systems have been founded after orcas, as have songs, dances, art, sculpture, and understanding of the seas (Krause, 2019). Many Coast Salish Tribal systems view orcas as family and honor them. The longstanding relationship Coast Salish Tribes have maintained with orcas provides a unique and comprehensive information system that c/should be being utilized to the orcas' benefit, rather than being ignored by Western scientific fields (Gaydos et al., 2015).

Coast Salish Tribes took notice of the SRKWs plight long before it became a mainstream conversation. The Lummi Nation began a program in which it assisted the population by raising salmon for the sole purpose of feeding the whales (Guernsey et al., 2021). This effort evoked controversy at the time due to the adjacent concern for salmon population declines (Morris, 2019). The Lummi Nation's suggestion to feed salmon to the orcas was based on their TEK, their long-held understanding of the whales' needs and the role humans can play in meeting them, as well as the role humans have played in creating them. Moreover, the Indigenous worldview established that feeding orcas is akin to feeding family and was thus a priority, leading to a particularly innovative solution among all conservation strategies being considered. This was just one TEK solution suggested by one Tribe in the region. In an interrelated context, the Northwest coastal Tribes have been restoring traditional clam gardens as one of the original aquaculture practices (Turner, 2020, Holmes et al., 2020, Spiler, 2021; Wickham et al., 2022). These restoration efforts have led to more richly diversified and healthier ecosystems, taking a systematic view to place-based restoration. Each Tribe operates under different treaty rights, traditional practices, and other contextual factors that influence preferred approaches to conservation, but approaches such as these are effective when applied (Charnley et al., 2007; Frickey, 1990; King, 2013; Nie, 2008).

The systematic documentation of holistic knowledge, when collected across many Tribal Nations with varying beliefs and experiences, can provide information that cannot be garnered from Western scientific methods. In this way, a consilient knowledge system for orca conservation would benefit from, and arguably requires, the TEK approach. Inclusiveness of TEK is far more than just inviting a Tribal person to the table. For one, conditions need to be facilitated such that Tribes trust sharing their TEK. Many Tribes are Sovereign, and have political and internal governmental policies and processes in place, which include or rely on TEK. Merging these into a conservation plan is not a quick process. Many factors need to be considered, including, but not limited to: have the Tribal policies and Tribal conservation plans been discussed and melded? Have Tribal concerns been addressed or resolved? Has the conservation proposal been seated in a way that is inviting and inclusive of the Tribes? When Tribal concerns and TEK aspects of a plan have not been fully discussed, then the plan has not truly incorporated TEK. While these additional interactions may seem daunting, when TEK is accurately incorporated it can result in conservation options that are beneficial, cost effective, and outside the commonly repeated practices.

3.2. Public policy

Analysis of the OTF policy window

While TEK scholarship can offer holistic information about orcas over generations and unique solutions, orca conservation is still embedded in a Westernized resource management system. The field of public policy, a highly multi- and inter-disciplinary science that applies many Western social science lenses, can build our understanding of this context. The public policy field includes widely diverse objectives, methods, and outcomes set within inter-woven social, economic, and biophysical systems (Easton, 1957). Hence, the interpretation of orca conservation policy in the Puget Sound by diverse disciplinary lenses is both exemplary of the complexity of policy studies as a field and a notable opportunity for consilience. This section will look to some key events and outcomes of the SRKW policy-making process to introduce and uphold claims by select public policy theorists, as well as to reinforce our shared understanding of SRKW conservation.

Despite being listed under the ESA in 2005, SRKWs did not benefit from exceptional state-level policy attention until March 2018, when there was a flurry of activity beginning with the governor's EO that established the OTF. The timing of the EO was prompted by the November 2017 publication and public presentation of the 2017 State of the Sound report (Puget Sound Partnership, 2017), which highlighted the notable decline in the SRKW population. Coincidentally, the EO was followed by observations of a matriarch orca, Tahlequah, carrying her dead calf for seventeen days, which catalyzed public sentiment for orca protection, international visibility, and pressure for urgent action (Knoth, 2019). Combined with the 2019–2021 state budgetary and 2019 legislative session deadlines, the OTF quickly moved from concept to implementation, marking a policy milestone in the history of Puget Sound Recovery.

Viewed from a disciplinary lens, the confluence of events prompting policy action on SRKW conservation is a clear example of how policy decisions interact with, and are directly influenced by, wider political and social systems. In this case, the overlap of contextual events, government deadlines, increased public interest and pressure, and other behind-the-scenes factors led to rapid action on orca conservation, after thirteen years of status quo. This supports one theory that certain conditions arise that "punctuate" policy equilibrium with episodes of profound change, often resulting from large shifts in public understanding over short periods of time (Baumgartner & Jones, 2009). These periods of rapid change result in policy windows within which conservation scientists can put new strategies in place.

The exemplification of "punctuated equilibrium" in the area of SRKW conservation policy also upholds that policy-making is not a linear process, but is ongoing, changing, and disorderly. This is contrary to an idealized policy view that the policy process follows systematic stages, as upheld by the Rational Choice/Stage-heuristic Model (e.g, 1. Agenda-setting, 2. Policy formation, 3. Decision-making, 4. Policy implementation, 5. Policy evaluation) (Howlett & Ramesh, 2009), and that policy makers are able to make policy decisions by following established steps (e.g., 1. Establish goals and objectives, 2. Explore all alternatives, 3. Predict consequences, 4. Choice based on most efficient alternatives). Instead, every possible policy outcome is dependent on myriad shifting circumstances and decision makers have limited knowledge and cognitive abilities, making it impossible to predict the exact costs, benefits, and consequences ahead of time (Herbert, 1986). Relatedly, the opinions of groups involved in the policy-making process are not based on complete and unbiased information, but rather on incomplete information that can be distorted by value-laden images and emotions (Stone, 2012). As contexts change, actors deliberate and struggle over the criteria, boundaries of categories, and definitions of ideas to influence the policy process and justify actions.

The constant shifting of policy priorities that results from the ebb and flow of context, public interest, economics, and other factors results in tradeoffs being made between different policy priorities including species conservation, humans, and other societal goals (McShane et al., 2011). In the case of SRKW conservation, the quick shift of policy priorities to orca conservation resulted in perceived tradeoffs between other species based on limited information. For example, calls for the creation of salmon hatcheries resulted in concern from the scientific community due to the uncertain impacts on wild salmon populations and from a policy perspective as it seemed to force tradeoffs between two species protected by the ESA (Dunagan, 2020). Similarly, the protection of pinnipeds, a known competitor with orca for food sources, are protected by the Marine Mammal Protection Act, generating yet another controversial issue of interspecies tradeoffs (Buch, 2018). A final case of limited information in policy processes was the restrictions on vessel berth adopted by the OTF, which represented the best interpretation of minimally-available science.

These examples reflect the constantly evolving interplay between the already evolving spheres of policy and science, adding a layer of complexity to policy-making processes with serious implications to conservation outcomes. These public policy processes may be considered too intangible or uncertain to integrate into our thinking, resulting in dismissing the policy process as non-scientific and irrelevant to the conservation of orcas. We share it as a critical piece of information that can help better take advantage of policy windows when they occur. In fact, the creation of the OTF is a great example of how conservationists acted quickly upon a temporary confluence of enabling social and ecological conditions. While the OTF made improvements in prior decision making, however, by bringing Tribal representatives to the table, there was a visible lack of social scientific knowledge that could have facilitated making decisions based on more comprehensive knowledge of the social system. Many have suggested that this understanding of the social system results in more efficient, long-lasting, and equitable solutions (Bennett et al., 2017). Adopting this understanding of policy processes would encourage planning for who could be at the table when a conservation policy window opens. We encourage that this include natural scientists, stakeholders, and TEK and social scientists holding relevant data and tools.

3.3. Economics

Non-market analysis of orca conservation

Economics is a social science that studies human behavior and decision making in the context of scarcity (Backhouse & Medema, 2009). This includes how people choose among alternatives, such as the conservation strategies originally posed in the OTF (Backhouse & Medema, 2009). The foundation of neoclassical economic theory is that people seek to maximize benefits and minimize losses when making decisions. Yet when those bearing the costs of conservation are not the same as

those receiving the benefits, conservation requires some support to make and implement decisions at a societal scale. As with most conservation efforts, the costs and benefits of SRKW conservation are disproportionately distributed (Green et al., 2018). Benefits accrue to most of the general population whereas the costs are borne primarily by individuals or smaller groups. For example, whale watching industries and marine vessels will bear the costs for reducing noise; commercial, recreational, and tribal salmon fishing will bear the costs of any fisheries closures; and hydropower industry would bear the cost of restrictions on infrastructure. Economists consider these types of contexts, where the full benefits and costs of an action are not received by those engaging in the action, to be an economic market failure (Ledyard, 1989). In the face of market failures, public policies may be required. Without any policy intervention, the achieved level of species conservation would be 'underprovided' relative to any notion of a social optimum (Ando & Langpap, 2018): policy intervention that improves conservation outcomes of SRKWs would likely increase net economic benefits.

Determining which policy interventions produce the greatest social benefit requires a nuanced assessment of the trade-offs among competing options. Economists rely on a set of frameworks and tools to evaluate these trade-offs, highlighting actions that provide the greatest potential net conservation benefits to stakeholders (Ando & Langpap, 2018; Polasky & Solow, 2001), and evaluating the distribution of these benefits across different groups. Two primary frameworks include: cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA). The selection of either CEA or CBA depends on the stated goal of the policy-making process. CBA evaluates candidate policies based on the maximization of net benefits; policies with the highest levels of expected conservation benefits minus their respective costs would be the most efficient to enact, from an economic perspective. In contrast, CEA evaluates alternative policies based on minimizing the expected cost of achieving a particular level of SRKW conservation benefits.

Conducting a CBA to evaluate SRKW policy alternatives requires an estimation of the expected conservation benefits as well as the direct or indirect costs. In practice, estimating either of these metrics is a formidable task. The economic benefits of SRKW conservation describe how stakeholder preferences characterize a willingness to give up other goods and services for increased conservation. Some understanding of the biological impacts of SRKW policies is a prerequisite for this valuation process. As SRKW conservation benefits are not observed through prices in corresponding economic markets, a general technique referred to as nonmarket valuation is required. Wallmo and Lew (2015) used a form of nonmarket valuation to estimate public willingness to pay for a particular SRKW conservation outcome: a delisting of SRKWs. While this application usefully demonstrated that willingness to pay for SRKW conservation was exhibited by households throughout the US, the framing of the valuation question was restricted to a single conservation outcome that currently seems to be a lofty goal. The policy relevance of this study is somewhat more limited than if the analysis had, for example, examined trade-offs for changes in SRKW population size that would not trigger a delisting. To illustrate the challenge of predicting the costs of SRKW conservation policies, note that these costs can take many forms, from increased taxes and increased costs of goods and services that are incurred by the general US population, to a reduction in profits to the whale watching industry if patronage is reduced as an effect of wider vessel berth regulations. Notably, most of the OTF policy options considered received limited economic analysis. As such, we have no scientifically-based determination that these strategies are most likely to create the greatest net social benefit.

Moreover, as a public entity, the state of Washington would be interested to know that the costs are not unjustly absorbed by one social group over another. Although the net social benefits of SRKW policy options may exceed their costs, economic theory suggests that the distribution of these net benefits across different groups is important to ensure that long-lasting conservation actions are supported by current and future generations (Bishop, 1993). As an example, increased restrictions placed on the whale watching industry would likely generate positive net economic benefits for all stakeholders who value SRKWs, as long as there is an expected biological benefit to SRKWs from reduced whale watching. However, these restrictions would reduce profits for the whale watching industry and local businesses that are partially supported by this tourism spending. To economists, this context can suggest that further institutional arrangements – such as transfers from stakeholders who would benefit from a particular policy to stakeholders who would be better off under the status quo – might be necessary to provide sufficient support for intended conservation actions.

The integration of economic information and tools in conservation contexts such as SRKW conservation would contribute to the overall scientific process of conservation decision making. While multi-stakeholder processes may increase the number of people physically in the room, they can also result in decisions biases towards those with more power (Denney et al., 2018). The increased transparency offered through a carefully conducted economic analysis can be more objective and representative, relative to other methods used to elicit stakeholder preferences (Steelman & Ascher, 1997).

3.4. Psychology

Emotion analysis of public response to orca conservation

Psychologists also study how individuals perceive, assess, and act on information related to conservation (Saunders, 2003). Whereas economists tend to focus on the outcomes of individual decisions, psychologists are interested in the individual processes of decision making. Understanding the psychological processes that inform people's perceptions of benefits and willingness to accept losses further contributes to our understanding of whether orca conservation initiatives will be supported, both at the policy table and across the general population. Psychologists in this realm often focus on one of many subfields, though the most applied to conservation are cognitive psychology (the study of mental processes), social psychology (the study of social interactions), environmental psychology (the study of humans and their surroundings), and the most recent field of conservation psychology (the study of humans and nature, with a focus on how to encourage conservation behaviors). Together, these fields have identified how environmental values, attitudes, social norms, social identity, emotions, and the structure of natural environments, among many other variables, affect environmental behaviors, including support for conservation strategies (Steg, 2018).

Although emotional processes have long been known to influence human perceptions and behaviors, this field of study has less frequently been applied to environmental conservation (Batavia et al., 2021). Emotions are a fundamental step in forming knowledge, memories, and judgements (Feldman Barrett, 2017). Evolutionary psychologists specifically recognize basic emotions as mental processes that are grounded in cultural experience and subconsciously influence our assessment of contexts and, eventually, our decisions (Hunt, 2007). While there are many lists of the basic emotions, one framework identifies eight of them: anger, sadness, fear, disgust, surprise, anticipation, trust, and joy (Plutchik, 1994). Of the few studies related to conservation, researchers have found that emotional responses to wildlife are significantly related to willingness to support wildlife management policies (Slagle et al., 2012; Straka et al., 2020). For example, people who fear wolves are less likely to pay for their conservation (Notaro & Grilli, 2022). To understand, therefore, why or how people support orca conservation strategies, one piece of the puzzle is to identify the variation of emotional responses to proposed policies.

Following the creation of the OTF, the governor of Washington requested public responses to the proposed strategies. An analysis of the emotional content of the over 14,000 public responses found mixed emotional responses to orca conservation strategies (Kehoe-Thommen et al., 2021). The majority were associated with trust (22%),

anticipation (18%) and fear (15%), though the other five were all represented. Interestingly, the individual public responses to orca conservation frequently represented different, often opposing, emotions, with the most common combinations of emotions being disgust-surprise, sadness-surprise, disgust-joy, and disgust-trust. By diving deeper into the specific quotes, the authors noticed that positive affect was derived from people's appreciation of SRKWs and their pride in being human stewards of the Puget Sound. They described majestic creatures living in a sea that provided clean jobs, outdoor activities, and opportunities to fish. Yet they would follow these descriptions with a sense of urgency about the political will to mitigate the stressors to the things they loved. As such, the positive emotions were associated more with the biophysical system and the negative emotions with the process of management. This did not mean, however, that there was agreement around who was at fault for SRKWs decline and who should be managed. On the contrary, much of the emotional negativity seemed to stem from disparities associated with the impacts of conservation strategies. These emotional responses showed that people clearly care about orcas, which can often be the first perceived challenge to conservationists. But they also highlighted that the conservation process was equally, if not more, emotionally-laden and could impact people's support for conservation, independent of their foundational connection to the object of conservation.

Understanding and managing emotions is a critical component of decision making (Brackett, 2019). Identifying public emotional dispositions related to orca conservation can help with developing conservation strategies to better address concerns. It can also inform the framing of strategies so they don't ineffectively trigger a negative emotional response. Bringing scientists and practitioners skilled at interpreting and applying the implications of emotion data into the decision space can facilitate dialogue and trust building, ensuring greater transparency in the role of emotions influencing the selection of strategies by the task force as well as potential implications across sections of society. Importantly, the goal of decision makers should not be to remove emotion from conservation decisions, as that is not only impossible (it is a critical component to the cognitive process), but to understand the variation of emotional responses and how those are likely influencing perceptions and assessments of conservation actions.

3.5. Human geography

Sense of place connected to orcas

Another factor influencing policy development and acceptance is how humans conceptualize their interaction with the conservation place or species. Human geography examines human interactions with, uses of, and bonds to the natural environment (Cox, 2014). One of the primary frameworks that translates these human-environment bonds to conservation is sense of place (Smith, 2018; Tuan, 1979). Sense of place is multidimensional and includes: place attachment, demonstrated by people–place bonds; place identity, illustrated through place-based identification that is connected to nature, landscapes, countries, or place names; place dependence, defined as the instrumental or beneficial relationships that permit need and goal achievement; and place meaning, referring to the place-based descriptions that define a place and the imagery a place evokes (Masterson et al., 2017; Smith, 2018). Each is mutually constitutive and informing. For example, place meaning informs place attachment, which in turn informs place-based behaviors (Masterson et al., 2017). Sense of place derives from and includes cognitive, emotional, and practice components (Smith, 2018). It illustrates and informs an individual's or group's understanding of place, responses to place change, and place-based behaviors such as stewardship, and is often reflected in place meanings, images, descriptions, and names (Trimbach & Biedenweg, 2021). Of the few studies that have examined the sense of place of place-based species, researchers have found that species do inform and are reflected in people's sense of place (Breslow, 2014; Forristal et al., 2014; Poe et al., 2016). To expand our understanding of SRKW conservation, we describe a sense of place lens that can be used to enhance orca conservation efforts.

Human geographers often rely on human artifacts to address their research question. In the case of SRKWs and sense of place, there are multiple artifacts that allow us to characterize the relationship between SRKWs and sense of place in the Puget Sound region with unobtrusive approaches. Specifically, systematic analyses of place names can identify place identities while discourse analyses of media content (e.g., political or cultural stories) can identify the place meanings or attachments among the region's residents (Dittmer, 2010; Tent, 2015; Trimbach et al., 2021). These mixed approaches can reflect how SRKWs are discursively and toponymically reflected in the region, illustrating the symbolic power and connections among the region's residents, place names, and place meanings as reflected in residents' own words and place names on the landscape.

These types of analyses will frequently demonstrate how different communities have understood and interacted with SRKWs. For example, some indigenous communities, such as Lummi Nation and the Tulalip Tribes, have historical ties to SRKWs (Gomez, 2019; Ryan, 2018). The Tulalip emblem and flag includes a SRKW (Kalliber, 2019) and members of Lummi Nation have referred to SRKWs as "our relatives under the sea," (Gomez, 2019). Yet documentation shows that white settler colonial communities have shifted their associations with orcas over time, from a threat or pest to a regional icon (Colby, 2013). The 20th century debate around orca captures has been grounded in newly formed environmentalist values and identities to the regions where orcas naturally thrive (Colby, 2013). This shifted pattern is also reflected in how SRKWs are discussed in contemporary political or media discourse, including the broader public reaction to Tahlequah and WA Governor Inslee's framing of the importance of orca to Washington State. In 2019, Governor Inslee noted that "It's difficult to imagine a Washington without orcas or salmon. These species are part of the cultural identity, fishing economy and tourism industry of our region," (Washington Governor's Office, 2019). This state-level identity is reinforced as SRKWs are the official marine mammal of WA (La Corte, 2005), meaning SRKWs are a representation of place itself.

This connection is also represented on the landscape through place names. According to the US Board on Geographic Names Information System (as of 9/5/2019), there were approximately 30 geographic locations in WA named "orca." The locations ranged from schools to geologic features on the landscape. According to the WA Office of the Secretary of State's Corporations and Charities Filing System (as of 9/5/2019), there were over 500 "orca" named businesses, 2 "killer whale" named businesses or nonprofits, and over 25 "blackfish" named businesses. These entities ranged from brewing companies, coffee-related businesses, research institutes, to childcare facilities. Orca is a ubiquitous place name, but also a common visual in the region, including via murals, advertisements, and brand logos.

Given that SRKWs are highly local and place-dependent to Puget Sound, they represent a unique, likely non-substitutable contribution to people's sense of place. This makes SRKWs a cultural keystone species and the Puget Sound a cultural keystone place that people are highly motivated to protect (Currier et al., 2015). It may seem like a fine balance between maintaining the relationships that fuel motivation and protecting species from humans entirely. Bringing a nuanced understanding of the diverse ways that people in the region identify with and create meaning from SRKWs to the policymaking space can help decision makers design strategies more likely to keep the sense of place conditions intact. While an economist could establish a strategy to identify net social benefits and the bearers of costs, a geographer who has implemented a systematic investigation of sense of place related to SRKs could present the diversity of ways that a strategy could impede upon or enhance the sense of place of different groups. Moreover, this perspective would play a substantive role in communicating, educating, engaging, and collaborating with regional stakeholders for conservation

(Kibler et al., 2018).

4. Discussion

It is our hope that this presentation of knowledge from different fields of social science along with TEK science demonstrates how the consilience of orca conservation knowledge for decision making benefits from, and arguably requires, the inclusion of diverse social scientific and indigenous knowledges. General terms like "human dimensions" and "social science" can be ambiguous and appear irrelevant when shared in the abstract, as they often are (see the original use of 'social science' in Fig. 1). In fact, these generalized terms represent many established fields of inquiry, just as the term biophysical sciences in our Fig. 2 would encompass fields such as biology, oceanography, and ecology, among others. We move beyond the original assumptions of Consilience that the physical sciences provide the truest sources of knowledge; in our vision of consilience, *all* forms of knowledge offer unique contributions to conservation decision making. Because the social sciences are frequently still lumped together and TEK research is rarely considered a science, we find it helpful to specify the contributions of a few fields of knowledge in a specific conservation issue to facilitate their future consideration in decision contexts.

Like the Indian parable about the blind men who could only identify an elephant by each of them sharing their experiences with one part of the body, conservation contexts can only be fully understood by understanding the social, ecological, and social-ecological systems within which they exist (Fig. 2). No one person could know all the parts; and lacking an essential part could result in a fundamental misunderstanding of the problem. Considering the knowledges of geographers, psychologists, economists, public policy analysts, and TEK scholars in the context of orca conservation, for example, is just as important as considering the knowledges of four natural scientists who study the effects of water quality, SRKW social behavior, SRKW feeding habits, and ecological implications of dam removal to orca conservation. Moreover, while including representatives of different social groups in the policy process is crucial to participatory decision making, it is not a replacement for integrating those who can represent scientific understandings of the social system. Social scientists contribute a social system-level understanding of the pros and cons of processes for making decisions, the likely factors affecting the identification and selection of conservation strategies, the factors that will influence support for selected strategies, and could ultimately provide new ideas that generate strategies more likely to result in net social and ecological benefits. TEK researchers, on the other hand, present a holistic knowledge based on generations of human-environment interactions. For example, TEK holders don't think about population genetics, pollution transport, and food webs as separate components. Instead, they see interwoven connections and can describe trends from these relationships over long periods of time. In that sense, we are not quite satisfied with our representation of TEK scholarship as its own piece of the consilience pie (Fig. 2), but we hope to represent the importance of this lens.

Also present in our Fig. 2 are dashed lines separating the fields. While our presentation of the lenses above suggests silos, the reality is that social scientific fields frequently borrow methods and analyses from each other, resulting in blurred distinctions. Moreover, knowledge from one social scientific field can improve knowledge from another. For example, the nonmarket valuation techniques used to estimate conservation values (economics) are improved by having a better understanding of the aspects of place that different people value (human geography) and the emotions people are responding to when confronted with potential solutions (psychology). Moreover, the suite of policy options is informed by a systematic understanding of the policy context (public policy), the creative solutions that have been attempted in indigenous traditions (TEK), and the likely effects of these policy options on SRKW populations (biophysical sciences). From these sources of knowledge, groups such as the OTF can create more systematic and relevant analyses that can inform the selection of SRKW conservation policies.

With SRKW conservation in the Puget Sound, legislative action has been taken based on OTF recommendations. For example, the Quiet Sound Initiative (quietsound.org, accessed December 2022) restricts the number of commercial vessels within a half mile of the whales and

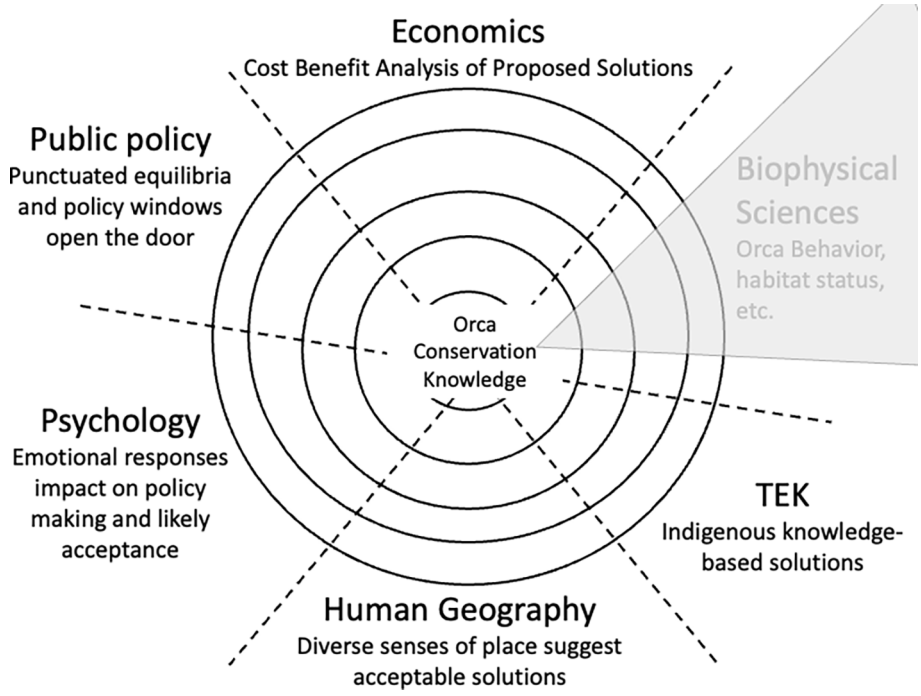

Fig. 2. Image representing the different lenses to orca consilience offered from four social sciences and TEK research. Biophysical sciences are grayed to demonstrate we don't cover this suite of lenses in this paper. Dotted lines represent the fact that there aren't always clear distinctions between fields; they inform and complement each other.

restricts whale watching to four specified hours in the day. These initiatives were developed based on data from biological and social scientists, as well as input from Tribal representatives and stakeholders. The OTF composition that informed this strategy followed a common approach of including a representative of each 'type' of constituent, based on categories that don't necessarily represent the breadth of knowledge in those types. For example, it included a single economist and no other social scientists. It is unlikely that a single economist can truly consider and apply the diverse knowledges the field has to offer, and it is certain that a single economist (no matter how much we respect them) cannot represent knowledge from the other social sciences described here. Similarly, each Tribe can only represent the TEK held by their Tribe, and not all Tribal representatives can represent TEK. For example, Tribal fish biologists are appropriate representatives of the fisheries management program, but they do not necessarily have knowledge of TEK around SRKW. We assess that the OTF was an attempt at inclusion, but not at consilience.

In the end, the primary goal of orca conservation knowledge is to ensure the protection of orcas. Each of our fields provides different tools for understanding the holistic conservation context in which we find ourselves. Yet to date, despite the numerous calls for conservation social science over the past two decades (e.g., Mascia et al., 2003, Sandbrook et al., 2013, Moon & Blackman, 2014), the primary science that is considered orca conservation science, and is therefore used when orca conservation decisions are made, are those of the biophysical sciences. A recent orca conservation paper, for example, stated that "the role of science in these situations is to quantify the conditions in an endangered species' critical habitat and relate those conditions to the species' behavior, physiology, body condition, vital rates, or trend in abundance and thereby provide indicators or thresholds to inform more effective management decisions" (Williams et al., 2022). This statement reflects a limited view in the conservation field that does not recognize how TEK and social scientific knowledge can expand upon biological knowledge to better achieve our goals.

This movement toward consilience implies the need for supporting co-production of knowledge and boundary spanning efforts, with sufficient time to delve into the philosophical underpinnings of each field's research, methods, concepts, and theories to find a larger lesson (Pooley et al., 2014). Moreover, this interdisciplinary work needs to occur among the social sciences just as much as between the social and biophysical sciences and other sources of knowledge, such as TEK research. Importantly, the specific expertise developed by professionals in these fields must also be respected and integrated, rather than co-opted. Too frequently, TEK research and social science are conducted by well-meaning conservationists and scientists who do not have discipline-specific training (Joks & Law, 2017; Kimmerer, 2012; Ween & Riseth, 2011). At best these actions omit the reliability, rigor and ethical approaches built into disciplinary paradigms and at worst they produce inadequate applications that lack nuance and can even cause harm. Several articles already describe how to engage in multidisciplinary approaches that can lead toward consilience (e.g., Djenontin & Meadow, 2018, Pooley et al., 2014). We just need the institutional structures and individual leaders to move these collaborations forward.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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