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Author(s)	BROCHUT, Fleur Emelyn Christel
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Title of dissertation

Perceptions, attitudes and knowledge regarding the Steller sea lion–fisheries conflict in Hokkaido coastal waters（北海道沿岸におけるトドと漁業の対立に関する認識、態度と知識）

Chapter 1: General introduction

Conflicts between fisheries and pinnipeds occur worldwide with wide-ranging consequences. Operational interactions occur directly during fishing activities, including bycatch, depredation, gear damage, and disturbance, defined as indirect effects of predator presence resulting in reduced catch or increased fishing effort. These interactions have a significant impact on both conservation and fishermen's livelihoods. The need for effective mitigation strategies has led to the development of several technological tools and the implementation of management strategies. However, their effectiveness and acceptability vary widely and depend on the pinniped species involved, the fishing technique used, as well as the cultural, social, and political context in which the conflict occurs.

Steller sea lions (*Eumetopias jubatus*, SSL) migrate in winter from Russia and the Kuril Islands to the coastal waters of the Sea of Japan and the Sea of Okhotsk around Hokkaido. There, they feed on several species that are important to commercial fisheries, resulting in negative interactions. Interactions with coastal fisheries have caused substantial economic damage to the regional fishing sector for several decades. Coastal fishing is economically and culturally important; however, interactions with SSL have directly affected fishermen's livelihoods. Effective management of SSL–fisheries conflicts is therefore essential for the sustainability of coastal fisheries in the region. Despite considerable mitigation efforts, conflict levels are still perceived as unacceptable by fishermen, suggesting that current approaches remain insufficient.

The human dimension of pinniped–fisheries conflicts, encompassing perceptions, attitudes, values, and beliefs, has become increasingly recognised as essential for progress toward coexistence. Socio-economic pressures can amplify the perceived impacts of wildlife-related damage, often shaping responses more strongly than the actual magnitude of the damage itself. The conflict-to-coexistence narrative positions humans as the primary agents in the solution and introduces key concepts, including tolerance and coexistence. Resolving conflicts with wildlife requires addressing issues related to values, power relations, and governance, rather than focusing solely on technical solutions. To address these challenges, the participation of all relevant stakeholders in decision-making processes and consensus-building has frequently been recognised as essential. In addition, the importance of knowledge exchange between fishermen's traditional knowledge and scientific knowledge has been highlighted as a key component of consensus-building in human–wildlife conflict contexts. Moreover, public support is often crucial for policymakers when implementing wildlife management measures. Therefore, understanding

conflicts involving wildlife requires careful consideration of the needs, perceptions, and values of all stakeholders.

Despite the long-standing severity of SSL–fisheries interactions in Hokkaido, the human dimension of this conflict has not been examined so far. In particular, fishermen’s perceptions of both the conflict and existing mitigation measures, as well as public knowledge and attitudes toward both the species and the conflict, have remained unknown, which potentially prevents the resolution of this conflict. In this context, this doctoral thesis explored the SSL–coastal fisheries conflict in Hokkaido through the lens of the human dimension. Using a combination of qualitative and quantitative approaches, this work aimed to clarify stakeholders’ perceptions and attitudes, lay the groundwork for building social consensus on SSL management, and identify approaches toward more socially acceptable and effective conflict mitigation.

Chapter 2: Review of pinniped and fisheries operational interactions and conflict managements

Chapter 2 provides a literature review of the operational interactions between pinnipeds and commercial fisheries and fish farms. It aims to determine unique aspects of interactions with pinnipeds, to assess the impact of these interactions on fisheries of different scales, and to understand how the human dimension has been integrated into the management of the conflict.

Previous reviews have focused on otariids (sea lions and fur seals) only or on all marine mammal taxa. Therefore, it remains unclear whether some aspects of the conflict are unique to pinnipeds. As Japan is home to both phocids (seals) and otariid species, it is necessary to clarify possible common aspects. In addition, the need to resolve human–wildlife conflict and to address the human dimension of the conflict has also been emphasized in the previous literature. This chapter addressed these gaps through a scoping review.

2.1 Methods

The scope of the review focused on operational interactions, mainly accidental entanglement (bycatch), depredation, damage to fishing gear, and disturbance, and their mitigation strategies. It included research on artisanal (small-scale and coastal) and commercial (all others) fisheries, as well as fish farms.

The literature search was conducted using Web of Science and Google Scholar on the grey and peer-reviewed literature between 1995 and 2023. Keywords included the names of pinniped taxa, the types of interactions, and the human dimension. A pre-selection was carried out based on titles and abstracts, followed by a screening of the full texts.

2.2 Results and discussion

A total of 227 documents were retained for the analysis. The review confirmed that pinniped–fisheries/farm interactions are a global issue, as conflicts were reported in 33 countries and involved 26 of the 34 pinniped species. Grey and harbour seals were the most reported phocids. California sea lions and South American sea lions were the most frequently reported otariids. Damage to artisanal fisheries emerged as the most reported interaction. Passive gears such as

gillnets or trap nets are the most affected by the interactions, largely because they are predominantly used in coastal fisheries that spatially overlap with pinniped foraging areas.

Accidental entanglement and bycatch occur mostly in trawls and gillnets. Bycatch continues to pose major barriers to the recovery of endemic or endangered populations. This is the case for Australian and New Zealand sea lions, the Australian fur seal in Oceania, the South American sea lion and fur seal in South America, the ringed seal lake populations and the Mediterranean monk seal in Europe, and the Kuril harbour seal in Japan.

The intensity and consequences of depredation vary widely across pinniped species and regional contexts. This issue is particularly acute in artisanal coastal fisheries employing passive gear. In particular, the South American sea lion in South America and the recovered grey and harbour seal populations in Europe have been reported to be the cause of substantial economic losses in gillnet and trap fisheries. Depredation further increases the risk of accidental entanglement and can place a substantial burden on artisanal fishermen and fish farmers, highlighting the need for mitigation measures that protect both pinnipeds and vulnerable fishing communities.

The second most reported damage to fisheries is damage to fishing gear. Combined with depredation, the burden on fisheries can be severe. This includes the cost of replacing damaged gear as well as lost fishing time due to gear breakage, repair, and replacement. Gear damage has also been reported in fish farms. One of the most important issues is that damaged nets can result in large-scale fish escapes, leading to particularly high economic losses for fish farmers.

Disturbance occurs when fish are frightened away from fishing areas or gear, resulting in reduced catch efficiency or increased fishing time. Unlike depredation or gear damage, it does not leave physical evidence and is therefore particularly difficult to quantify. In fish farms, the presence of pinnipeds around farms can induce chronic stress in stocked fish, negatively affecting growth, health, and survival.

Because of the significant effects on pinniped conservation and fishermen's livelihoods, several mitigation strategies have been implemented, with varying degrees of success. Lethal management including culling (population control) and target killing (only individuals approaching fishing gear) is often requested by fishermen when other management options are perceived as ineffective or as negatively affecting their livelihoods. However, its effectiveness is contested, and it raises ethical concerns which can lead to further conflict among stakeholders and deepen existing tensions rather than provide a lasting solution.

Deterrence is among the most commonly applied non-lethal strategies, particularly through the use of acoustic deterrent devices (ADDs). Acoustic devices have been implemented in both fisheries and farms to reduce bycatch and depredation by pinnipeds. However, concerns regarding potential negative effects of ADDs, such as habituation, hearing damage, and habitat exclusion of the targeted and non-targeted species, have led to the development of more selective techniques and the recommendation to use ADDs as a complement to other methods. Modified fishing gear, such as reinforced nets or seal exclusion devices (SEDs), has shown promising results in reducing depredation and bycatch. Nevertheless, reinforced gear remains costly and often requires subsidies for successful implementation.

Controlling human behaviour through bycatch quotas or the establishment of marine protected areas (MPAs) represents another strategy to limit bycatch and protect vulnerable pinniped populations. However, when overly restrictive, these strategies can have negative consequences for fishermen, by limiting their capacity to adapt to environmental change.

The Baltic Sea case provides a well-documented example of the complexity of conflict management for successfully recovered grey and harbour seal populations in a multi-level governance context. The restriction of the use of lethal methods promoted the development of a combination of strategies, including the shift from gillnets to trap nets and the development of technological tools such as pontoon traps, SEDs, and ADDs. In addition, the severity of the conflict also led to improved institutional coordination and stakeholder inclusion.

Research on the human dimension first focused on conflicts between endangered species and fisheries in low-income communities such as those involving the Galapagos sea lion and the Mediterranean monk seal. Recently, the need to examine the social and economic factors shaping perceptions of pinniped–fisheries conflicts has increased. Addressing the broader socio-economic challenges associated with the conflict can help identify pathways to coexistence. However, the human dimension approach remains relatively new, highly dependent on the local context and focused on stakeholders directly involved in the conflict or policymaking.

Chapter 3: Perceptions and attitudes of fishermen

Chapter 3 investigated fishermen’s (1) attitudes toward existing and potential mitigation measures, (2) attitudes toward SSL, and (3) perceptions of SSL’s ecological role. It compared gillnet and set net fishermen who are most affected by the conflict with SSL, but for whom the impacts of the conflict on their livelihoods differ.

Previous studies on the human dimension of seal–fisheries conflicts stressed that understanding attitudes toward mitigation measures and their impact on stakeholders’ livelihoods is an important component of conflict resolution, and that these attitudes are shaped by people’s attitudes toward the conflicting wildlife and perceived ecological roles, including evaluations of both risks and benefits posed by predators.

To capture a wide range of perspectives from the fishing community, face-to-face interviews were conducted in 12 fishing villages within SSL distribution areas. This study aimed to provide the first detailed assessment of the human dimension of this conflict, laying essential groundwork for trust-building and the development of socially supported pathways toward pinniped–fisheries coexistence.

3.1 Methods

An interview form was compiled to cover most aspects of the interactions with SSL. From these questions, 12 items, grouped into four constructs, “perceived ecological role of SSL”, “attitudes toward SSL”, “attitudes toward management measures”, and “conditions for coexistence with SSL”, are the focus of this study.

From April 2023 to August 2024, a total of 29 fishermen (17 gillnet, 11 set net, and 1 using both) were interviewed. The interviews were conducted in Japanese by the principal investigator with

one fisherman at a time, when possible. To minimize the language barrier, at least one Japanese person assisted during the interview.

The interviews were transcribed and translated into English. The internal consistency of the constructs was verified using Cronbach's alpha reliability test. To detect differences in perception and attitude between gillnet and set net fishermen, the Potential Conflict Index (PCI₂) was used as a quantitative visualization tool for the closed-ended questions. To test whether the two groups of fishermen were significantly different, the Mann–Whitney *U* test was used, with *p*-value < 0.05 considered statistically significant.

In addition, to understand the possible drivers shaping fishermen's attitudes and perceptions of the SSL–fisheries conflict, the recurrent themes that emerged from the open-ended questions were summarized using thematic content analysis. Respondents' answers were coded into topics, which were then grouped into themes.

3.2 Results

Fishermen were generally in favour of population control as a mitigation measure and considered it to be the only effective method to deal with the damage. Target removal to protect the catch was also mentioned as a possible mitigation tool. Fishermen were generally open to the development of non-lethal methods, mostly as an additional support to the current situation. However, they were sceptical about the possibility of finding such alternatives.

Fishermen showed a lukewarm attitude toward damage compensation and possible better catches, showing that the main need of the fishermen is the satisfaction of practising fishing in good conditions rather than just the financial aspect.

All fishermen agreed that SSL are a natural part of the environment and that SSL decrease fish abundance in the sea. For the latter, set net fishermen showed a higher Potential Conflict Index within the group (0.58). Similarly, both groups considered an environment with SSL as healthy, but gillnet fishermen presented a higher potential for conflict (0.43).

Gillnet fishermen were significantly less tolerant toward SSL, as they wished for SSL to be gone from Japanese waters and tolerated only a small number of SSL. Set net fishermen were more accepting of SSL, as they did not wish for a total disappearance of SSL from Japanese waters and agreed to coexistence unless there were too many SSL. The conflict within groups was limited. The main issue was the severity of damage to the fishing gear.

Among other recurrent themes, fishermen expressed the harshness of their profession and how the conflict with SSL was painfully adding to their burdens. A negative attitude toward the government was also revealed.

3.3 Discussion

The findings on fishermen's attitudes toward population control and other mitigation strategies are consistent with the conclusions of previous studies. In Japan, most of the efforts dedicated to SSL–fisheries conflict mitigation lie in population control, partially explaining the current position of fishermen concerning population control. Nevertheless, both gillnet and set net fishermen clearly voiced the necessity to develop other measures, as an alternative or in addition to

population control. The most promising non-lethal method has been the introduction of reinforced gillnets in the Sea of Japan. However, the high cost remains a problem, and public subsidies are essential for their introduction.

Fishermen's attitudes toward damage compensation reflect the need to run a business and practice fishing activities in good conditions, as well as concerns that they would lose their identity as fishermen if they heavily relied on subsidies. However, compensation can be effective if the damage is not too extensive and is used as a short-term solution, and not as a replacement for other damage-prevention tools.

Fishermen made an important distinction between appreciating the value of the presence of sea lions in the area and the struggle caused by the negative interactions they experience, reflected in their mixed perception of SSL's ecological role. In addition, their perception was affected by changes in SSL distribution, revealed by a few contrasting answers in some specific locations. Contrary to findings in other studies that associated negative perceptions of ecological roles with positive attitudes toward lethal management, the nuanced perception of ecological role in this study did not lead to a more nuanced attitude. This could be explained by the Japanese concept of *Satoumi*, where considering a predator as both a sign of a healthy environment and a risk for human activity is not mutually exclusive. Therefore, the present findings suggest that, in the Japanese context, the perceived role of SSL has only a limited influence on fishermen's attitudes toward lethal management.

The more negative attitude of gillnet fishermen toward SSL compared to set net fishermen can be explained by the possibly heavier damage from SSL and a stronger impact of the interaction on their livelihoods due to their different economic systems. Despite this difference in tolerance toward SSL, no difference in attitudes toward mitigation measures was found. This suggests that personal negative experiences related to impacts on livelihoods, rather than attitudes toward SSL, influenced preferences for mitigation methods.

The conflict between SSL and fishermen is embedded in the broader context of fishermen's livelihoods and the harshness of the fishing profession, especially for gillnet fishermen. The perceived minimization of their issues and lack of communication from the government led to a lack of trust in authorities. Appropriate communication and collaboration between fishermen, government, and the scientific community have recently been recognized as necessary and effective for fisheries–pinniped conflict management and can help the public develop a better perception of predator species. Including fishermen in the solution-making process would also help identify solutions that are useful for fishermen. Finally, improving communication and knowledge sharing (both scientific and cultural) between stakeholders would enable progress toward sustainable fisheries and SSL management. This would also open a path to building trust with fishing communities, which is an initial step toward identifying strategies adapted to their needs and constraints.

Chapter 4: Public knowledge about Steller sea lions and attitudes toward mitigation measures

Chapter 4 focuses on the general public. Among the stakeholders involved in the SSL–fisheries conflict, the public is the stakeholder least impacted by the conflict and its mitigation measures.

Still, previous studies have pointed to the necessity to understand public attitudes toward mitigation measures, as a lack of support can have important consequences for the implementation of policies. Hokkaido citizens' attitudes toward conflict mitigation measures are presently unknown.

Knowledge has been recognized as a factor shaping people's attitudes toward wildlife and its management. However, public knowledge of SSL and the conflict is unknown and is expected to be low. This chapter aims to address these gaps through questionnaire surveys inquiring about people's attitudes toward mitigation methods and the possible social and psychological factors shaping them, conducted in the Sapporo urban area.

4.1 Methods

The questionnaire form included 23 closed- and open-ended questions inquiring about people's socio-demographics, interest in nature and the Sustainable Development Goals (SDGs), interest in SSL, attitudes toward SSL, knowledge of marine mammals and SSL, sources of knowledge, awareness of the conflict between SSL and fisheries, and attitudes toward mitigation measures.

The questionnaire surveys were conducted during educational events between October 2022 and January 2025. Respondents were recruited on a voluntary basis among visitors of these events. The form was offered in both paper and electronic versions.

Knowledge questions were coded into a knowledge score. Descriptive statistical tests were used to detect factors influencing the knowledge score. To analyse which factors influenced people's attitudes toward lethal management, a stepwise ordinal regression analysis was conducted with the attitude as the response variable and all the other questions as explanatory variables. Open-ended questions were translated into English and analysed with a morphological analysis. The Jaccard index was calculated for the most recurrent words from each attitude (agree, neutral, disagree), and a correspondence analysis (CA) was performed using the pool of words obtained. In addition, thematic analysis was also performed following the same methods as described in the previous chapter. Quantitative analyses were performed in Orange Data Mining and R (version 4.5.1), using the packages MASS, DescTools, vegan, FactoMineR, and factoextra. Significance was defined as p -values < 0.05 .

4.2 Results

A total of 486 valid questionnaires were collected. Among the respondents, 55% identified as female and 44% as male. From the question on attitudes toward SSL (multiple answers possible), the most commonly chosen feeling was "cute" (65.5%), followed by "interesting" (36%), "scary" (29%), and "annoying" (15%). The mean score for knowledge was 5.02 out of 7. This score was weakly correlated with interest in SDGs, the number of nature-related activities, willingness to learn about SSL, and conflict awareness.

The public had a relatively negative attitude toward the lethal management of SSL, with 42% answering that they disagreed, 25% agreed, and 34% remained neutral. The majority agreed on the importance of developing non-lethal methods. According to the regression model, opposition to population control was associated with being a woman, having a family member in fisheries,

having a higher interest in SDGs, and finding SSL cute. In contrast, approval of population control was related to finding SSL annoying, a higher knowledge score, and conflict awareness.

A pool of 28 words was used for the CA. Dimension 1 on the horizontal axis had a score of 82.6%, indicating that the majority of the differences in the words respondents used can be explained by the distinction between those who agreed and those who disagreed with population control. Attitude “agree” was linked to the words “extermination”, “fish”, “fishermen”, and “population”. Attitude “disagree” was linked to the words “creature”, “ecosystem”, “human”, “life”, “nature”, and “way”. Attitude “neutral” was linked to the words “consider”, “difficult”, “fishery”, and “help”.

The thematic analysis retained twelve recurrent themes across all attitudes. Themes associated with a positive attitude toward lethal management were concern for fisheries and fishermen’s livelihoods, a feeling of helplessness, considering humans as regulators of the natural environment, considering killing as necessary, and the impact of SSL on the environment. Themes associated with a negative attitude were concern for human impacts on the environment, empathy toward SSL, disagreement with the idea of killing, respect for life and living beings, a wish to use alternative methods, a wish for coexistence with wildlife, and a critique of the human-centred mindset.

4.3 Discussion

Knowledge scores were unexpectedly high, which contrasts with the literature on public knowledge of marine mammals. Nevertheless, the public lacked knowledge of SSL’s ecological role.

The generally positive view of SSL and the negative attitude toward lethal management are consistent with the current literature on marine and terrestrial animals. Women and people with higher interest in SDGs were more opposed to lethal management, which is consistent with the findings of other studies. A surprising finding was that people with family members working in fisheries were also more opposed. This might be explained by the fact that these family members can provide direct positive experiences with nature. Higher knowledge was surprisingly associated with a more positive attitude toward lethal management. These people also tended to be more aware of the SSL–fisheries conflict. Conclusions from previous studies suggest that the type of knowledge, rather than the level, could influence attitudes.

The findings of the present study, in relation to the studies mentioned above, showed that the factors affecting people’s attitudes toward lethal management are varied and differ depending on the context.

The analysis of the open-ended questions revealed that people’s attitudes toward the natural environment can be categorized into Kellert’s typology of attitudes toward wildlife. Respondents approving of lethal management showed mostly dominionistic and utilitarian views. In contrast, respondents opposing lethal management showed mostly naturalistic and ecological views, and a few also showed humanistic and moralistic views.

Compared with previous studies on public attitudes toward wildlife and management methods, the respondents of this study seemed to have a more positive view of wildlife. The results suggest either a shift in mindset from utilitarian views to animal welfare awareness in Hokkaido or a more

nuanced position of the Japanese toward wildlife in relation to their perception of Satoumi and their understanding of human–wildlife interactions.

Finally, this study revealed that even though the public was in opposition to fishermen regarding lethal management, they also voiced their sympathy for fishermen’s livelihoods. Both fishermen and the public considered it important to develop non-lethal methods, demonstrating a commitment to finding solutions with low environmental impacts, which should be beneficial for both fishermen and SSL.

Some studies have shown that informing people about the benefits of lethal management could lead to greater acceptance of the methods. However, even though SSL cause serious damage to fisheries, they are not a lethal threat to either the public or the fishermen. In addition, the environmental consequences of SSL population control are still uncertain. Social trust is an important factor for a positive response to government decisions. Therefore, implementing a cull could lead to decreased social acceptance toward fisheries rather than bringing a lasting solution. However, involving the public in the revitalization of rural areas might benefit local communities. Further studies should explore whether the public would be willing to support initiatives that support fishermen’s livelihoods and promote coexistence between fishermen and SSL.

Chapter 5: General discussion

This doctoral thesis explored the human dimension of the SSL–fisheries conflict occurring in Hokkaido. Chapter 2 summarised the previous literature on pinniped–fisheries conflicts and the management measures used to mitigate these conflicts. The key conclusions from this review confirmed the global extent of the conflict and that it undoubtedly harms both sides involved. The review also highlighted that the human dimension of pinniped–fisheries conflicts is emerging and understudied, yet is necessary for consensus-building among stakeholders and the elaboration of mitigation measures feasible for fishermen.

Therefore, this doctoral thesis addressed, for the first time, the human dimension of the SSL–fisheries conflict in Hokkaido. The mixed-method approach combining qualitative and quantitative data allowed the comparison of two seemingly opposite stakeholder groups, fishermen and the general public, within the same framework.

The major findings from the fishermen interviews revealed the nuanced perceptions of fishermen regarding SSL’s ecological role and that they were open to adopting new measures to achieve coexistence with SSL. Finally, trust-building and fishermen inclusion in the decision-making process are key for the feasibility and long-term effectiveness of mitigation measures. The public surveys identified the factors and narratives shaping Hokkaido citizens’ attitudes toward SSL and lethal management.

The chapters on fishermen and the public demonstrated that, through the human dimension approach, human–human conflicts underlying the SSL–fisheries conflict could be identified, and possibilities for consensus-building could be found through common values and pride related to fishing culture. Therefore, fostering these values should be the direction to pursue to identify consensus among a diversity of stakeholders. Establishing relationships between fishing communities and stakeholders involved in the decision-making process is crucial for the implementation of conflict mitigation measures. In addition, strategies to revitalize remote rural

areas have the potential to revive this pride among fishermen and provide them with the strength and means to seek solutions. The present study indicates that citizens can be involved in activities aiming at such revitalization, which has already been demonstrated to be beneficial to all in previous Japanese studies.

The major limitation of this thesis was the recruitment of participants. Indeed, because the subject of conflict with SSL is difficult to discuss for fishermen, this added constraints to recruiting fishermen willing to participate in the interviews. Similarly, the subject is also delicate for the public, and budget constraints led to the use of an approach maximizing response rates. Therefore, in both cases, participants were likely to have stronger interests and opinions about the conflict, which could have biased the results. Nevertheless, the text analysis also adds weight to the findings by providing a broader context to people's perceptions and attitudes toward the conflict.

Studies on the human dimension of marine mammals and small-scale fisheries have been scarce. This doctoral thesis represents the initial step in understanding the human dimension of the SSL–fisheries conflict in Japan. Rather than focusing solely on the ecology of the animals involved in the conflict, the present study included fishermen's ecological knowledge and provided insight into the circumstances surrounding wildlife damage. Now that the door is open, further studies should involve more participants and address themes that could not be examined in this study, given the novelty of the approach with fishermen and the public. In addition, the themes raised in this research should serve as a basis for further studies and be addressed when selecting appropriate conflict-resolution strategies.

In this rapidly changing world, especially in Japan, with reduced fish landings, an aging population, and rural depopulation, conflicts with terrestrial and marine wildlife are likely to continue to intensify. Therefore, investing effort and working together to identify mitigation strategies adapted to the needs of the majority will be key to coexistence.