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Fish farmers highlight opportunities and warnings for urban carnivore conservation

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Abstract

As urbanization globally drives mammals and carnivores into compact spaces, they will increasingly come into conflict with development and natural resource extraction pressures. The management of these populations is further complicated by difficulties in monitoring what are often rare and elusive species. We used local ecological knowledge (LEK) to collect data on the historical and current status of Eurasian otter (*Lutra lutra*) in Hong Kong as well as determine how local fish farmers and residents perceived management and conservation issues surrounding the species. We found evidence for small population size and decline in numbers and distribution over recent decades for *L. lutra*. Fish farmers had extensive and familiar experience with otters and expressed largely negative opinions about otter impacts on fish stocks but positive attitudes towards their conservation. However, if otters were to have real or perceived effects on livelihood, then opinions about their conservation were mixed and cautious. In the context of the Pearl River Delta megacity, biodiversity is under high threat from development and urbanization. We here show the value of LEK and human dimensions of conservation in balancing the complex challenges of managing land for both local livelihoods and environmental stewardship.

KEYWORDS

Eurasian otter (*Lutra lutra*), human dimensions in conservation, human-wildlife conflict, local ecological knowledge, rare species management, urbanization

1 | INTRODUCTION

Urbanization and the rise of megacities are causing a massive landscape transformation globally. The transition from natural or production landscapes into high density urban spaces centered upon consumption has far-reaching implications (Seto, Güneralp, & Hutyra, 2012). With expanding urban spaces, rural, and peri-urban communities may struggle to persist in rapidly changing economies (Gregory & Mattingly, 2009). Biodiversity also tends to decline with increasing urbanization; mammalian carnivores are particularly sensitive to urban development (McDonald, Kareiva, & Forman, 2008).

The viability of rare species within urban environments is particularly under-studied (Shwartz, Turbé, Julliard, Simon, & Prévot, 2014) and can be difficult to monitor due to their generally low densities and elusive behavior (Thompson, 2004). Ecological knowledge of local people can provide an alternative approach to traditional ecological survey methods for the collection of data (Anadón, Giménez,

Ballestar, & Pérez, 2009; Turvey et al., 2014) and is known as "indigenous knowledge," "local or community knowledge," or "traditional ecological knowledge" (Johannes, 1989). Local ecological knowledge (LEK) that is collected for wildlife management is typically "current ecological knowledge," which has been acquired during the individual's lifetime (Gilchrist, Mallory, & Merkel, 2005). Its importance as a source of data to inform wildlife management (Henri, Gilchrist, & Peacock, 2010; Turvey et al., 2013) and conservation biology studies is becoming increasingly recognized (Drew, 2005) as it can reveal the status and distribution of rare or declining species (Anadón et al., 2009).

In addition to providing a source of ecological information, local people's perceptions toward a species and management are also an important consideration in species conservation (St. John, Keane, Jones, & Milner-Gulland, 2014). Human dimensions of conservation focuses on how people's knowledge, beliefs, values, and behaviors influence their attitudes toward species and how species management decisions affect humans (Vaske & Manfredo, 2012). Integrating scientific and human dimensions into wildlife management practice, as well as engaging stakeholders in management decisions is also becoming increasingly recognized (Harihar, Veríssimo, & MacMillan, 2015).

The Eurasian otter (*Lutra lutra*), a medium-sized, native carnivore, has managed to survive amongst the densely populated environment of Hong Kong Special Administrative Region of China. While its Hong Kong range once spread from the New Territories to Lantau and Hong Kong Islands (Herklots, 1951) the population declined significantly during the 1900s (Hill & Phillipps, 1981; Marshall, 1967). It is now considered to be restricted to wetland dominated by commercially active and abandoned fishponds and intertidal shrimp ponds (locally called *gei wais*), in the north-west New Territories (Shek, 2006), adjacent to the Shenzhen Special Economic Zone. The broader area has seen rapid urban expansion since the 1980s and now forms part of the world's largest megacity, the Pearl River Delta (PRD), covering an urban area of nearly 7,000 km^2 and supporting more than 42 million people (World Bank Group, 2015). The habitats that the extant population inhabits have experienced significant modifications since the 1920's (Irving & Morton, 1988) and while the fishpond area has been protected from illegal and legal development since the 1980s, it is estimated that 19% of the wetland habitat was lost to urban development between 1973 and 2011 (Chum, 2013).

Some fish farmers operating/managing ponds in the area have reported sightings of otters and therefore have the potential to provide local knowledge regarding their observations. As the otter habitats are dominated by commercial fishponds, human dimensions (with respect to the people living/working in the area) are particularly relevant when considering otter management to facilitate population recovery. In many places, human-wildlife conflicts are increasing where species are recovering and recolonizing parts of their range, resulting in competition with humans for the use of space and biological resources (Václavíková, Václavík, & Kostkan, 2011). These conflicts are often associated with direct wildlife damage (Dickman, 2010) and subsequent costs to humans. The human dimensions of otter conservation are therefore an important consideration given its carnivorous diet and apparent reliance on human-dominated, wetland habitats.

Otter in Hong Kong therefore provides an opportunity to investigate the importance of LEK and human dimensions when considering management and conservation of rare and difficult to study species. We conducted an interview study to determine if fishermen who live, work or visit the study area have LEK of the otter population, which could potentially be used to contribute toward our understanding of: (a) past and present otter distribution; (b) any historical changes to the otter population; and (c) otter habitat utilization and potential threats. Further, (d) the study also explored local perceptions toward otter including the potential for human-otter conflict, to better understand, and provide an opportunity to incorporate, human dimensions into otter conservation.

2 | METHODS

2.1 | Study area

The interview survey focused on fishpond areas contiguous with the Mai Po Nature Reserve (22°29′56″N 114°02′45″E), where otter has been previously recorded (Shek, 2006) (Figure 1, Inset A). This area located along the east coast of Inner Deep Bay in the PRD comprises a mosaic of commercially active and abandoned fishponds and reedbeds, dissected by freshwater and intertidal watercourses, and fringed by coastal mangal and mudflat habitats. The commercial fishponds have been managed and operated since the 1930s (Irving & Morton, 1988) and predominantly engage in polyculture including various carp species with grey mullet (*Mugil cephalus*). In 2018, an estimated 660 aquaculture fish farmers operated ponds in the area (Hong Kong Agriculture, Fisheries and Conservation Department *pers comm.*). The majority are men and many live amongst the fishponds in small dwellings. They typically start work at the ponds well before sunrise and finish after sunset with a break around mid-day, and will often spend some time checking their ponds at night-time.

Although located within the developed environment of the PRD, the extensive wetland area is of high ecological value primarily due to the migratory and resident birds it

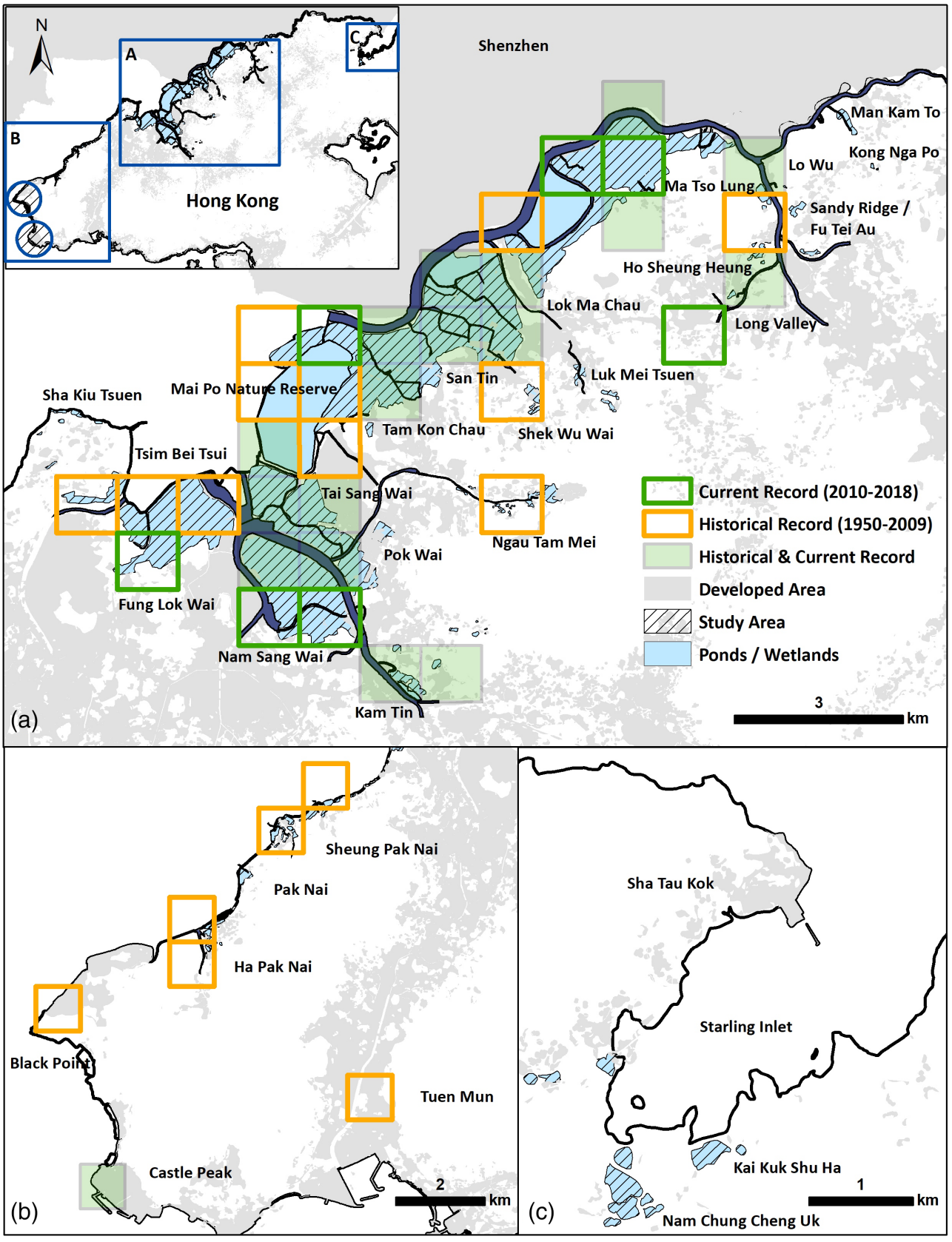

FIGURE 1 Study area covered for interview surveys and interviewee's historical and recent otter sightings (1950–2018)

supports. As such, parts of the area have formal designation to provide protection and management, including Mai Po Nature Reserve, which forms part of the larger Mai Po Inner Deep Bay Ramsar Site (comprising 1,513 ha of mudflat, fishpond, marsh, and mangal habitats). Other fishpond areas to the south and east as well as coastal rocky habitat in the south-west New Territories were also included to explore the extent of the otter distribution (Figure 1, Inset B and C).

2.2 | Interview survey

Interviews were undertaken between May 2017 and February 2018. Commercial fish farmers operating/managing ponds and recreational fishermen in the study area were the main subjects of the interview survey. However, people residing within the fishpond areas (living there, but generally working outside the area) were also interviewed when encountered. As many of the interviewees, particularly fish farmers living/working in the study area, are now more than 60 years old the survey may represent one of the last opportunities to collect data from this demographic. Multiple methods were used to connect with the interviewees, with the main method being representative sampling (76.30% of total interviewees interviewed) where the authors (T.C.W and S.E.M.) traversed around the fishponds of the study area during daytime and where people were randomly encountered, they were approached and asked to complete the interview survey. As most of the fishermen in the north-west New Territories are members of the Hong Kong New Territories Fish Culture Association we also visited Fish Culture Association meetings to maximize the number of people interviewed and increase the efficiency of connecting with fish farmers from the study area. Any fish farmers attending a meeting were invited to participate in the study (9.48% of total interviewees interviewed). In addition, local fishermen were also telephoned to arrange an interview (14.22% of total interviewees interviewed) where contact information was available.

At the outset of the interview, the interviewees were verbally informed that the research subject was a mammal study to avoid biasing responses, and interviewers did not specifically target people identified as having seen otter. Interview protocols were approved by the University of Hong Kong Human Research Ethics Committee before fieldwork began. All interviewees were assured that the data would be kept anonymous and informed consent was received. All respondents were interviewed individually, in informal settings (e.g., in the field where they were encountered). While three, trained interviewers were involved in conducting the interviews usually in pairs, most of the interviews (98%) were undertaken by the same male interviewer, in Cantonese, assisted by a female interviewer. A semi-structured interview approach was used, where standard (closed and open) questions were asked following an interview guide (herein referred to as the "questionnaire" [Appendix S1]); however, there was also flexibility to ask additional questions if interesting points arose. The questionnaire was designed to ascertain the sociological characteristics of interviewees, collect and verify records of otter observations, collect pond management information, and determine local perceptions and any threats towards otter (Appendix S1). The interview method and data analysis was designed to check and validate the accuracy of any otter records received (Appendix S1 and S2). On average, the interview took approximately 25 min to complete.

2.3 | Last sighting dates

Last sighting data (i.e., the last time the interviewee sighted an otter/s) has been used to understand species abundance and declines (Turvey, Risley, Barrett, Yujiang, & Ding, 2012; Turvey et al., 2015) by comparing the shape and slopes of species frequency distributions. Last sighting dates as per Turvey et al. (2012) were acquired and data analyzed following the method undertaken in Turvey et al. (2015) to enable comparison with other species and provide context for the otter population in Hong Kong.

2.4 | Data analysis

Conventional content analysis (Hsieh & Shannon, 2005) was used for open-ended questions regarding local perceptions toward otters. Interviewee's clarifications to their answers were coded and then categorized to collate similar statements (Erlingsson & Brysiewicz, 2017) (e.g., collation of statements containing similar key-words-in-context [Leech & Onwuegbuzie, 2007]). The categories were then collated under themes (Hsieh & Shannon, 2005) (Table 1), which provides further context to the interviewee's responses. Coding and definition of categories/themes was initially undertaken by the first author (S.E.M.) and checked and agreed by the second author (T.C.W.).

The complexity of local perceptions toward otter is represented by the number of different categories (excluding "no clarification provided") under which the interviewee's clarifications could be collated. Smaller numbers of categories indicate less diversity of local perceptions on a particular topic, while a greater number of categories demonstrate a greater diversity and complexity of attitudes amongst the interviewees. The percentages of interviewees that mentioned a given answer are presented to describe differences between demographic, otter sighting record, and otter threats data collected during interviews. Most interviewees answered all questions; however, in cases where they did

TABLE 1 Themes under which interviewee's clarifications were categorized

Themes	Theme description	Example of clarification/statement
Positive	Positive statements about otters, biodiversity or conservation	"It is sad that they are not found here now"
Negative	Negative statements about otters, biodiversity or conservation	"Otters eat all of my fish"
Neutral	Statements that were neither positive or negative	"There's no need for management, otters can naturally survive here"
Warning sign	Conditional statements indicating that if the current situation were to change, the perception toward otters may become negative	"If the otter number is not high, it is ok to protect them…"

not, descriptive statistics are based on the number of responses received, relevant to that question and are indicated in brackets after the statistic is given. Factors influencing the incidence of otter sightings and threats to otter, as well as differences in interviewees responses regarding local attitudes, were investigated using a chi-square test and Fisher's exact test (if $n \leq 5$). Data were analyzed using R version 3.3.2 (The R Foundation for Statistical Computing, 2016).

3 | RESULTS

A total of 211 interviews were conducted across the study area (79.62% response rate) accounting for approximately one-third of aquaculture fish farmers in the area. Interviewees were predominantly commercial fish farmers (70.14%, $n = 211$, where "n" refers to the number of responses relevant to the question), followed by residents (11.85%, $n = 211$), agricultural farmers (9.48%, $n = 211$), and recreational fishermen (8.53%, $n = 211$). Ninety-two interviewees (43.60%, $n = 211$) had positive otter records (i.e., had sighted otter at least once). Interviewees with positive records were predominantly commercial fish farmers (80.43%, $n = 92$), male (88.04%, $n = 92$), greater than 60 years of age (77.17%, $n = 92$) and the majority had lived/worked in the area for 20+ years (73.93%, $n = 92$) (Appendix S3). One hundred and nineteen (56.40%, $n = 211$) interviewees had negative records. About a third of these included interviewees that knew what an otter was but had not sighted one in Hong Kong (38.66%, $n = 119$). The remainder included interviewees that reported seeing otter but their record could not be validated under the criteria (12.60%, $n = 119$), or they could not recognize/name otter from the image and therefore had not seen the species (48.74%, $n = 119$). Of all people interviewed ($n = 211$), 34.12% did not know that otter was native to Hong Kong.

Commercial fish farmers had a significantly greater number of otter sightings (80.43% of positive otter sightings, $n = 92$) compared to recreational fishermen, residents, and agricultural farmers (9.78, 6.52, and 3.26% of positive otter sightings, respectively, $n = 92$) ($x^2 = 13.32$, df = 3, $p < .001$). The incidence of sighting an otter was 50% for fishermen (i.e., commercial fish farmer, recreational fishermen); however, the incidence of sighting an otter decreased for agricultural farmers and residents (15%, $n = 20$ and 24%, $n = 25$ positive otter records, respectively) (Appendix S3). The length of time the interviewee had spent working, living, or recreating in the study area did not significantly influence whether an interviewee had sighted an otter ($p = .22$, Fisher's exact test). Interviewees that spent time in the study area during night-time (e.g., interviewees checking commercial fish ponds at night-time; recreational fishing at night-time) had greater positive records (62.5%, $n = 80$) than negative records ($x^2 = 20.78$, df = 2, $p < .001$) (Appendix S3).

3.1 | Otter status

Interviewees provided details of 155 otter sightings extending over a time period from the 1950s to present (Figure 1). Historical otter sightings (1950–2009) ($n = 88$) were wide ranging across the study area while recent otter sightings (2010–2018) ($n = 67$) were concentrated around the Mai Po wetlands. No otter sightings were reported from the eastern New Territories at Starling Inlet. Many of the interviewees that had sighted otter believed that the otter population had "significantly declined" or "declined" (64.29 and 5.71%, respectively, $n = 70$) over time. Fourteen interviewees (20%, $n = 70$) said they could not comment (answering "N/A"), mostly due to the fact that they had only seen otter once. Only three (4.29%, $n = 70$) thought that the population was "stable," and another four interviewees (5.71%, $n = 70$) thought it had increased (Appendix S4).

Ninety-one last sighting dates were provided by interviewees. The number of last sightings in any given year was low and ranged from 1 to 10/year (average 1.38/year). The slope of the last sighting otter data frequency distribution (Figure 2) was not steep (transformed data slope = 0.15) and was shaped by increasing numbers of recent last sighting dates. As per Turvey et al. (2015) we also used a conservative approach and removed the last 5% of last sighting records from the analysis, which also resulted in a low slope (transformed data slope = 0.16).

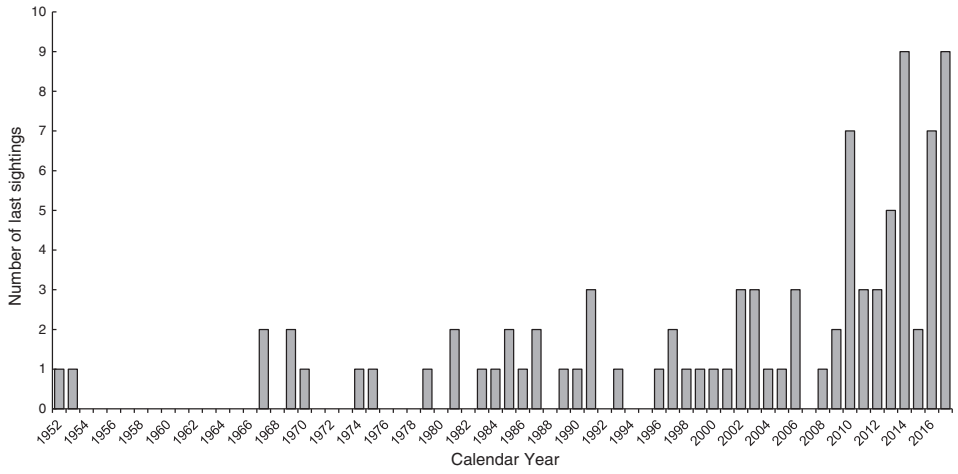

FIGURE 2 Last sighting data frequency distribution for otter in Hong Kong

3.2 | Threats to otter persistence

Sixteen (16.16%, $n = 99$) interviewees were aware of negative human-related actions taken against otters. Fourteen (of the 16 interviewees) described the hunting of otters, predominantly for personal consumption (i.e., food). Two interviewees referred to the protection of fishponds from otter predation; however, they did not elaborate on the specifics of this (Appendix S3). Much of the hunting reported had taken place in the past with interviewees commenting that it was now difficult to catch otters, because of low otter numbers or absence. Six other interviewees also described by-catch of otter accidentally captured in traps set for other animals (e.g., snakes, birds, shrimps). On three occasions the otter had drowned in the trap, on one occasion the otter was killed and consumed, and on the other occasions the otter was released or escaped.

3.3 | Local perceptions

Half (51.14%, $n = 88$) of the interviewees who had sighted otter stated that otters affect fish stock and/or rivers (Figure 3). The interviewees clarifications were relatively consistent (i.e., there were only three categories) and half were categorized as "negative" themed comments (51.11%, $n = 45$) which related to "impacts on humans" and were predominantly associated with otter predation on commercial fish stocks. The remainder of the clarifications were "warning sign" statements (22.22%, $n = 45$) and acknowledged that "while otter predated on fish stocks, the impact was insignificant due to low otter numbers/absence." Fewer interviewees stated that otter do not, or that they do not know if otters, affect fish stocks/rivers (37.50%, $n = 88$ and 11.37%, $n = 88$, respectively). Their clarifications were also relatively consistent (1–2 categories), but were dominated by "warning sign" statements, which were conditional in nature, indicating that a change to the current situation may result in a negative perception toward otter, such as "there are insignificant impacts because otter numbers are low," or "impacts are not as great as that of bird predators."

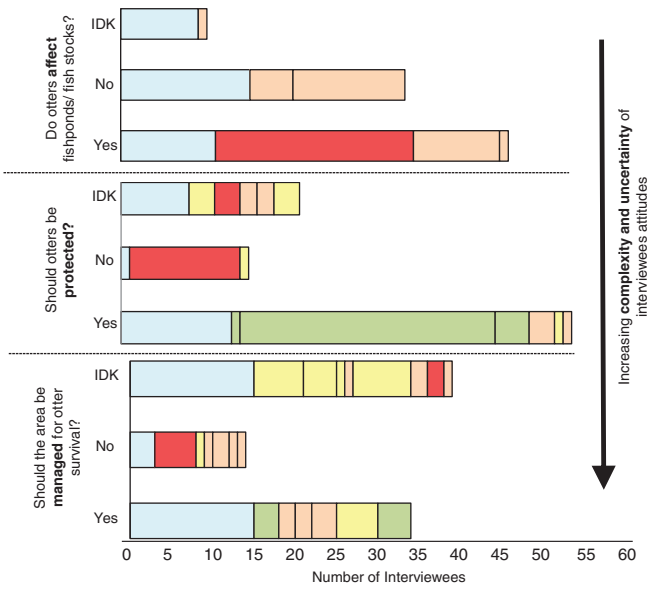

FIGURE 3 Interviewees attitudes toward the effects of otter, and the need for otter protection, and management. Bars represent the number of interviewees who responded: "IDK" (I don't know), "No," or "Yes" to each question. Where clarification to the answer was provided, interviewee's statements were coded and similar statements collated under categories. Each bar is divided according to the categories identified (Appendix S5). Complexity of attitudes refers to the number of categories (i.e., greater number of categories = greater complexity of attitudes) and uncertainty refers to the number of "IDK" responses (i.e., greater uncertainty = greater number of "IDK" responses). Colors represent the theme of the clarifications provided: green—"positive" statements, red—"negative" statements, yellow—"neutral" statements, orange—"warning sign" statements, blue—"no clarification provided"

More than half (59.55%, $n = 89$) of the interviewees stated that otters should be protected in Hong Kong, but their clarifications were diverse, with six categories identified (excluding "no clarification provided") (Figure 3). The majority were "positive" comments (66.04%, $n = 53$) relating to "biodiversity value," "legal protection," and that "otter do not impact humans." A small number of clarifications (7.55%, $n = 53$) were categorized as "warning signs" as they referred to the "potential for impact on humans" (Appendix S5). Fewer interviewees stated that otter should not be protected (16.85%, $n = 89$), with 86.67% ($n = 15$) of them referring to the "impacts on humans" resulting from otter predation on fish stocks. However, a larger proportion of interviewees (23.59%, $n = 89$) were unsure about otter protection and their clarifications were more complex (including five categories, categorized under a mix of "neutral" (28.57%, $n = 21$), "warning sign" (19.05%, $n = 21$), and "negative" (14.29%, $n = 21$) themes). "Negative" comments were again related to "adverse impacts on humans," while "warning sign" comments referred to the "potential for impacts, or no impacts on humans due to low otter numbers" (Appendix S5). The interviewees' attitude toward otter protection was significantly related to their perception of whether otter affected their fishponds/stocks ($p < .001$, Fisher's exact test). This was strongest amongst interviewees that believed that otters affect fishponds/stocks and also should not be protected (93.33%, $n = 15$) (Appendix S3).

Greater uncertainty was associated with the question about otter management, with a large proportion of the interviewees stating that they did not know if management should be implemented for long-term otter survival (44.83%, $n = 87$) (Figure 3). Their clarifications regarding their uncertainty were relatively complex (with eight categories); however, they were dominated by "neutral" comments (Appendix S5; 46.15%, $n = 39$). The remainder of the clarifications were "negative" or "warning signs" (Appendix S5; 15.39%, $n = 39$). There was also increased complexity in the responses received from interviewees that answered either "Yes" or "No" to management for otter, with each answer having six categories (excluding "no clarification provided"). Although 39.08% ($n = 87$) of interviewees agreed with otter management, 20.59% ($n = 34$) caveated their answer stating, "it's someone else's responsibility," "as long as there is compensation," or "there are no impacts on humans." A large proportion (71%, $n = 14$) of interviewees that answered "No" to management for otter clarified their answer with "negative" or "warning sign" statements (Appendix S5). There was no relationship observed between an interviewee's attitude toward the implementation of management and their perception of whether otters affect fishponds/stocks ($p = .29$, Fisher's exact test) (Appendix S3).

4 | DISCUSSION

The difficulty in studying rare and elusive species often results in limited ecological data on which to base conservation and management actions (Thompson, 2004). Such is the case of the Eurasian otter which saw a significant decline in numbers and now has a restricted distribution in Hong Kong. The commercial fish farmers who had lived/worked in the study area for 20+ years represented the interviewees with the greatest positive otter records. LEK includes a person's general knowledge of nature, which has typically been acquired as experiential knowledge, based on their observations and experiences from their local environment (Yli-Pelkonen & Kohl, 2005). Otter in Hong Kong predominantly forages at night-time but it can also be seen during the day (Shek, 2006). As the fish farmers spent time amongst the ponds during the day-time, it is reasonable that there were some sightings during the day. However, there was increased positive otter records associated with interviewees that also spent time amongst the ponds at night-time (62.5%). Altogether this study demonstrates an intimate relationship between this rare species and the fish farmers who live and work in the aquatic habitats that they share. Not only did LEK provide key distribution and population data for otters in Hong Kong, but the fish farmer attitudes evident from the surveys point a way forward for how the species may be managed in the increasingly under-pressure and urbanized landscape that now dominates the PRD.

Fisheries staff in other regions have in the past been reliable in accurately identifying otter presence in fishponds (Kloskowski, 2005). Here, interviewees reported sightings of otter extending from the 1950s to present, providing the first comprehensive account of historical and recent otter distribution in Hong Kong (Figure 1). Based on the otter sightings, the wetlands contiguous with Mai Po represent the present core area for this population, which is also supported by the limited sightings documented by Shek (2006). With the high number of otter sightings in this area open questions remain at a finer spatial resolution, for example, sites with only current records could be either a range expansion or missing historical data. The Mai Po area comprises the greatest concentration of fishponds in Hong Kong, which is likely to be an important factor associated with the higher otter sightings. Jahrl (1986) and Kortan, Adamek, and Polakova (2007) also found the largest and strongest otter populations in the Czech Republic and Austria within the main fishpond areas. This human-dominated environment is likely to represent the last stronghold for the Hong Kong population, demonstrating the importance of this area to the otter's survival.

The gap in the recent sightings (2010–2018) between the Mai Po core area and the most southern sightings at Castle

Peak (Figure 1) may reflect low otter numbers but could also be a signal of extirpation and a contraction in range. No otter sightings were reported from the eastern New Territories at Starling Inlet. While the interview findings do not prove otter absence from this area, it is worth noting that most of the interviewees had lived/worked in the area for 15+ years but none were aware that otter were present/native to Hong Kong let alone had heard of otters in the local area. Field survey from a separate study (unpublished data) also only found otter presence in the main fish pond area (a) and otter absence in the fish pond area to the south (b) (the area in the east (c) and at Castle Peak in the south of (b) were not surveyed). The findings of the interview study generally demonstrate that LEK can provide much needed information (e.g., species distribution, population status, and threats) which is fundamental to species conservation (Drew, 2005; Gilchrist et al., 2005). As the otter population is still very low, management may be required to overcome factors limiting otter population recovery, and/or avoid/minimize threats to long-term otter survival. When developing such management actions, the human dimensions of otter conservation requires consideration given the otter's reliance on human-dominated wetland habitats and the subsequent influence of local people on the success of any proposed management strategy.

Most of the interviewees who could recognize a pattern in the otter population over time (70%), believed that otter numbers had significantly declined; with many commenting that they had not seen otter for many years, sometimes since their childhood, and some believed otters to be extirpated in Hong Kong. This observed decline is supported by the natural history literature which describes a decline in otter numbers from the 1960s onwards (Marshall & Phillips, 1965; Marshall, 1967; Hill & Phillipps, 1981). Further, the last sighting history slope was relatively flat (Figure 2). Compared to the slopes of other species (see Turvey et al., 2015) it was in the lower range, which corresponded to species confirmed in separate field surveys (see Vongkhamheng, Johnson, & Sunquist, 2013) as having low abundance. However, the low number of last sighting histories in any given year (range = 1–10) (Figure 2) is comparable with the very rare species from the Turvey et al. (2015) study. The observed historical decline, flattened slope, and very low numbers of last sightings reported by interviewees, indicates that otter continues to have a rare status in Hong Kong.

Habitat loss and hunting during the last century contributed to the decline of the otter population. Over-exploitation particularly illegal poaching for fur and traditional Chinese medicine in the 1950s–1970s, threatened otter survival in many parts of China (Zhang, Yoxon, & Yoxon, 2014). The hunting of otters for personal consumption was quite openly reported by the interviewees. However, it appears that hunting pressure is reduced at present due to the difficulty in catching otters which was attributed to low otter numbers or absence. Interviewees also commented that otter had been accidentally captured in traps set for other animals. In more than half of these reports the otter had died. Although wild animals in Hong Kong are protected from hunting under the Wild Animals Protection Ordinance (Cap 170) illegal trapping is on-going (GovHK, 2017). While targeted trapping of otters does not appear to be a current threat, trapping otters as by-catch is. By-catch has been reported to contribute toward otter mortality in other areas (see review by Quintela, Da Silva, Assis, & Antunes, 2012), which is of concern given the small population size indicated in the study. In addition, given the information acquired about hunting, there is a potential for targeted hunting to resume if otter numbers were to increase in the future. These findings highlight the importance of human dimensions when considering recovery actions for rare species. Any future conservation program should consider the social drivers affecting otter numbers, and subsequently promote public education and involvement in otter management as appropriate, to facilitate positive attitudes and stewardship toward otter protection and conservation.

A large proportion of interviewees (59.55%) believed otter should be protected with many (66.04%) providing "positive" comments including concern about "low otter numbers," "local otter extinction," and the "absence of impacts to fishermen" (e.g., "Otherwise they will become extinct and kids can't see them"—male recreational fisherman, 81 years old). Other studies have also found similar high support for wildlife conservation by local people (Mir, Noor, Habib, & Veeraswami, 2015). However, "warning sign" comments were also provided which indicated that protection of otters was conditional (e.g., "If the otter number is not high, it is ok to protect them; but if there are too many, I do not agree to protect them"—male commercial fish farmer, 63 years old).

Wildlife management that supports co-existence of humans and wildlife is fundamental for species conservation in urban areas. However, challenges arise where there is extensive urban development and human population growth, coupled with rare species population recovery (Jochum, Kliskey, Hundertmark, & Alessa, 2014). Many interviewees (93.33%) that did not support otter protection were the same people who believe that otter affected their fish stocks. And even those that disagreed that otters affect fish stocks (37.50%), clarified their answer with a "warning sign" response, indicating their attitude was related to the real or perceived commercial effect of otters on local people. Other countries subject to similar historical otter population decline, have experienced human-otter conflict when the population recovered (e.g., Kranz, 2000; Pearce, Serfass,

Ashcraft, & Stevens, 2017). Such issues often become complex and well established having endured over time (Dickman, 2010), thereby creating challenges to finding solutions. Therefore, while there is a general perception that otters predate on aquaculture fish from ponds, the otter's low numbers, perceived biodiversity value, and the perceived higher predation impact of wetland birds, accounts for the observed positive attitudes toward otter. However, these findings also indicate the potential for a shift toward "negative" attitudes and possibly behavior, if otter numbers increase. It therefore provides an early-warning of the potential for human-otter conflict in the future.

The fishpond area is already under threat from urban encroachment and competition with the Mainland China fish market (Cheung, 2004). In addition, an ageing local community and uncertain recruitment of next-generation fish farmers, makes the area vulnerable to land use changes. This background of social factors is likely contributing toward the complexity of attitudes observed, particularly in relation to the prospect of implementing management for otter conservation. The diversity of clarifications provided ranged from "a lack of interest in management"; to the perception that "management would be too difficult"; to disagreement with management due to the "impacts of otter on humans," or because "compensation of wildlife-related impacts on humans is not adequate"; to agreement with management "due to the rare status of otters," or "only if otters don't affect humans," or "if someone else takes responsibility." The complexity of attitudes indicates the potential difficulty in developing a conservation strategy acceptable to the range of local stakeholders. In addition, the increased proportion of "I don't know" responses also indicated a strong level of uncertainty regarding the implementation of management actions for otter conservation. Failing to understand the different attitudes of stakeholders can have significant implications for the success or failure of management actions (Dickman, 2010). People base their perceptions

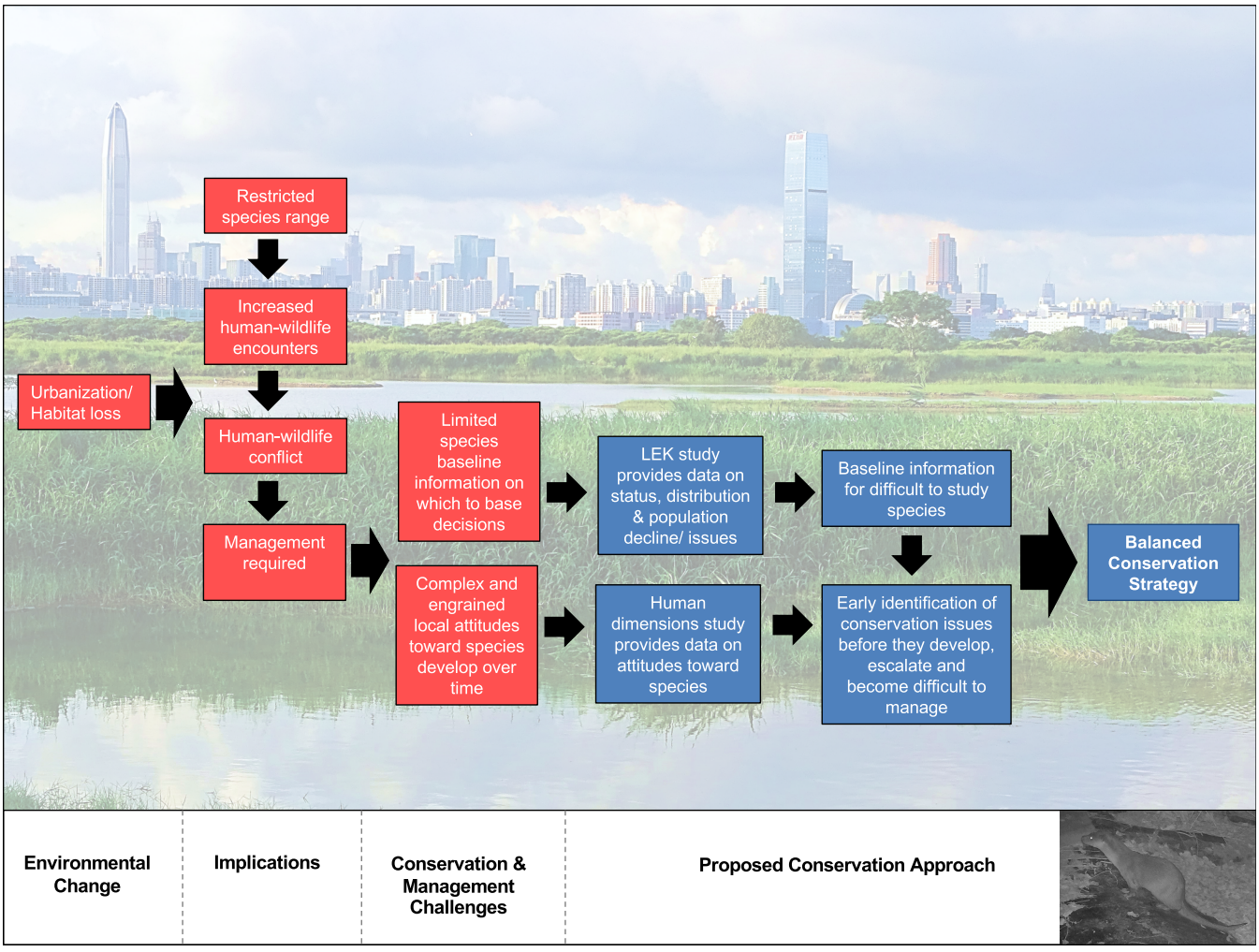

FIGURE 4 The importance of local ecological knowledge and human dimensions of conservation in balancing the complex challenges of managing land for both local livelihoods and environmental stewardship

and attitudes toward wildlife on facts and personal experiences (e.g., wildlife damage) as well as a range of social factors such as wider societal experiences, cultural norms, expectations and beliefs (Dickman, 2010). As it is the social factors that can play an important role in human-wildlife conflict, our findings highlight the need for in-depth understanding of local social factors before developing any future strategy for otter conservation. Further, once the social factors are understood, it will be imperative that the development and implementation of any management actions involve local people from the outset, as without commitment from local people conservation is probably impossible (Clark & Wallace, 2002).

Conserving rare species in a changing world is complex due to research difficulties, environmental pressures exerted by expanding human populations, increased human-wildlife encounters, and perceived or real human-wildlife conflicts. The case of the otters in Hong Kong demonstrates the value of LEK in providing fundamental baseline information on which to consider the status, threats, and potential management of rare and difficult-to-study species. However, the influence that the same local people can have on the success of conservation activities was also highlighted. As complete, long-term conflict resolution is difficult to achieve once conflict is established (Dickman, 2010) this study demonstrates the value of the early identification of potential conservation issues, before conflict has had a chance to develop, escalate, and become engrained. LEK and human dimensions provides a timely opportunity to carefully plan a balanced strategy anticipating issues and responding with strategic actions (Figure 4). This is of added importance for species with a restricted distribution and reliance on a human-dominated environment for not only the provision of, but also persistence, of important habitat. Finding a balance between local livelihoods and otter management is imperative to the long-term survival of this species in Hong Kong and requires targeted scientific studies to increase knowledge of the species ecology particularly relevant to potential conflicts identified (e.g., actual otter diet [Serfass, Bohrman, Stevens, & Bruskotter, 2014]), detailed social science studies to understand local social factors to facilitate the avoidance/minimization of potential conflict, provision of public education where required, and involvement of local people in the early development of management actions through inclusive engagement and communication.

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CONFLICT OF INTEREST

The authors declare no potential conflicts of interest.

AUTHOR CONTRIBUTIONS

Study design: S.E.M., T.C.B, B.C.H.H.; data collection: T.C.W. and S.E.M.; data compilation: T.C.W.; data analysis and writing the manuscript: S.E.M.; critical review: T.C.B. and B.C.H.H.

DATA ACCESSIBILITY

Due to possible sensitivity of human subjects' data, interview files are only accessible to the authors. However, a summary of interviewee questionnaire responses is provided in the Appendix S3.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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