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Looking Back to Move Forward: Lessons From Three Decades of Research and Management of Cetacean Tourism in New Zealand

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Cetacean tourism in Aotearoa New Zealand is now over 30 years old and has experienced substantial growth in visitor numbers and operations. The industry is remarkably diverse, targeting several dolphin and whale species, and encompassing varied habitats in coastal waters, fiords and submarine canyons. The knowledge and experience collected over these past 30 years has both advanced the global understanding of cetacean tourism, and influenced scientific practices for its study and management. Here we review the approaches taken in quantifying the impact of cetacean tourism in New Zealand, and critically assess the efficacy of the research and management strategies adopted. We place particular focus on the Bay of Islands, Hauraki Gulf, Kaikoura, Akaroa and Fiordland, areas that include the oldest, and longest studied industries nationally. We propose a set of best research practices, expose the most notable knowledge gaps and identify emerging research questions. Drawing on perspectives from the natural and social sciences, we outline the key determinants of failure and success in protecting cetacean populations from the detrimental impact of tourism. We suggest four golden rules for future management efforts: (1) acknowledge cetacean tourism as a sub-lethal anthropogenic stressor to be managed with precaution, (2) apply integrated and adaptive site- and species-specific approaches, (3) fully conceptualize tourism within its broader social and ecological contexts, and (4) establish authentic collaborations and engagement with the local community. Lastly, we forecast upcoming challenges and opportunities for research and management of this industry in the context of global climate change. Despite New Zealand's early establishment of precautionary legislation and advanced tourism research and management approaches, we detected flaws in current schemes, and emphasize the need for more adaptive and comprehensive strategies. Cetacean tourism remains an ongoing challenge in New Zealand and globally.

Keywords: whale watching, dolphin swim-with, wildlife tourism, tourism impact, cetacean conservation, impact research, tourism management

INTRODUCTION

An increasing demand to interact closely with whales, dolphins and porpoises has led to commercial activities targeting wild cetaceans (hereafter cetacean tourism) becoming a burgeoning industry globally (Hoyt, 2018). Prior to the Coronavirus (COVID-19) pandemic of 2020, the industry had significant potential for further growth (Cisneros-Montemayor et al., 2010), even though there were already clear signs that this form of tourism is often not managed sustainably (Higham et al., 2009). The dramatic post-COVID-19 hiatus in tourism provides a unique opportunity to reflect and build on past experience, and to prepare for future scenarios.

Cetacean tourism can benefit human communities and cetacean populations via improving livelihoods, providing opportunities for education and research, and fostering a climate for conservation initiatives (Hoyt, 2018). This, and the often uncertain effects of tourism on cetaceans, have led to considering the activity a lower priority threat compared to those resulting in direct mortality (e.g., bycatch, hunting) or alteration of habitat (Higham et al., 2016). Detrimental effects on the animals, however, are clear (Samuels et al., 2003; Machernis et al., 2018), and cetacean tourism is now recognized as a sub-lethal consumptive industry (Neves, 2010; Higham et al., 2016). As such, its management is best based on a precautionary principle (Bejder et al., 2006b) and on analytical frameworks incorporating the ecological and social aspects of the industry, and the multiple threats to cetaceans (Higham et al., 2009). Moreover, animal welfare (i.e., individual effects) is increasingly recommended as a necessary complement to conservation indicators (i.e., population-level effects) (Papastavrou et al., 2017; Nicol et al., 2020). To date, however, priorities and approaches to cetacean tourism research and management have varied significantly at both local and global scales.

New Zealand has a 30-year history of cetacean tourism research and management. Following the establishment of the first dedicated operation in Kaikoura in 1987 (Donoghue, 1996), the industry flourished in multiple locations, each characterized by a unique combination of ecological, social, research and management features (**Figure 1**). The New Zealand evidence- and partnership-based approach to environmental conservation (Ewen et al., 2013) translates in scientific studies often commissioned by the government (Constantine, 1999; Orams, 2004), and in research and management initiatives involving multiple stakeholders, including local *iwi* (Māori tribes; Simmons, 2014) and tour operators. In some cases, these studies have prompted site-specific management actions. Recent longitudinal studies, however, have exposed the inadequacy of past and present management regimes (Hartel et al., 2014; Bennington et al., 2020; Dwyer et al., 2020) and outlined the financial, procedural and institutional barriers to effective marine conservation (Bremer and Glavovic, 2013; Dodson, 2014). Effective management of cetacean tourism in New Zealand continues to be a challenge.

In this review we draw on our personal experiences of extended engagement in marine mammal and cetacean tourism research, advocacy and community outreach, and advisory roles to national and regional governments and organizations in New Zealand and internationally. Where possible, the perspectives of other interested parties (e.g., governmental agencies, tour operators) are included, based on available literature and personal communications.

Building on previous assessments of the industry (Donoghue, 1996; Constantine, 1999; Orams, 2004), we aim to (1) critically review approaches taken in New Zealand to studying and managing tourism pressures via analysis of five case studies, (2) put forward clear and specific recommendations for the future of research and management of cetacean tourism within a national and international context, and (3) highlight the main knowledge gaps, emerging questions, future challenges and opportunities for managing the industry in light of both welfare and conservation considerations. Overall, we aim to initiate a productive dialogue on the future of cetacean tourism industry in New Zealand.

CASE STUDIES OF CETACEAN TOURISM IN NEW ZEALAND

The Department of Conservation (DOC) is the government agency responsible for administering the Marine Mammals Protection Act (MMPA) New Zealand Government, 1978 and the Marine Mammals Protection Regulations (MMPR) (New Zealand Government, 1992). Under the MMPR, DOC issues permits for commercial operators conducting tours to view and/or swim with marine mammals, and regulates human behavior around the animals with site-specific conditions.

Over the past three decades, in response to the significant growth in international tourism (Upton, 2019), cetacean tourism has become an established industry in the country. The permit system provides a legal structure to regulate its proliferation, but has often been used to formalize already existing commercial activity (Allum, 2009), hence in a reactive, rather than proactive fashion. The number of permits issued by DOC to view and/or swim-with cetaceans increased from one in 1987 to 63 by 1997 (Constantine, 1999), and to 76 by 2020 (DOC, pers. comm.). The number of permits, however, is likely to underestimate the actual increase in tourism pressure over time, as operators can increase the number and duration of trips at their discretion. In addition, wild cetaceans have been increasingly exposed to interactions pursued by non-permitted operations and to opportunistic boat encounters. Data on trip number, frequency and duration, and cetacean daily and cumulative exposure to overall pressure, which would have allowed for a more representative description of tourism evolution, are unavailable or sporadic (e.g., Bejder et al., 1999; Green, 2005; Martinez et al., 2011).

As of today, most current permits allow only viewing cetaceans, while 27 permits grant the additional right to swim with dolphins. The level of enforcement is variable and, depending on the region, boat patrols and "mystery shoppers" are used to assess compliance. Site-specific voluntary codes of conduct often complement but may not contradict the MMPR.

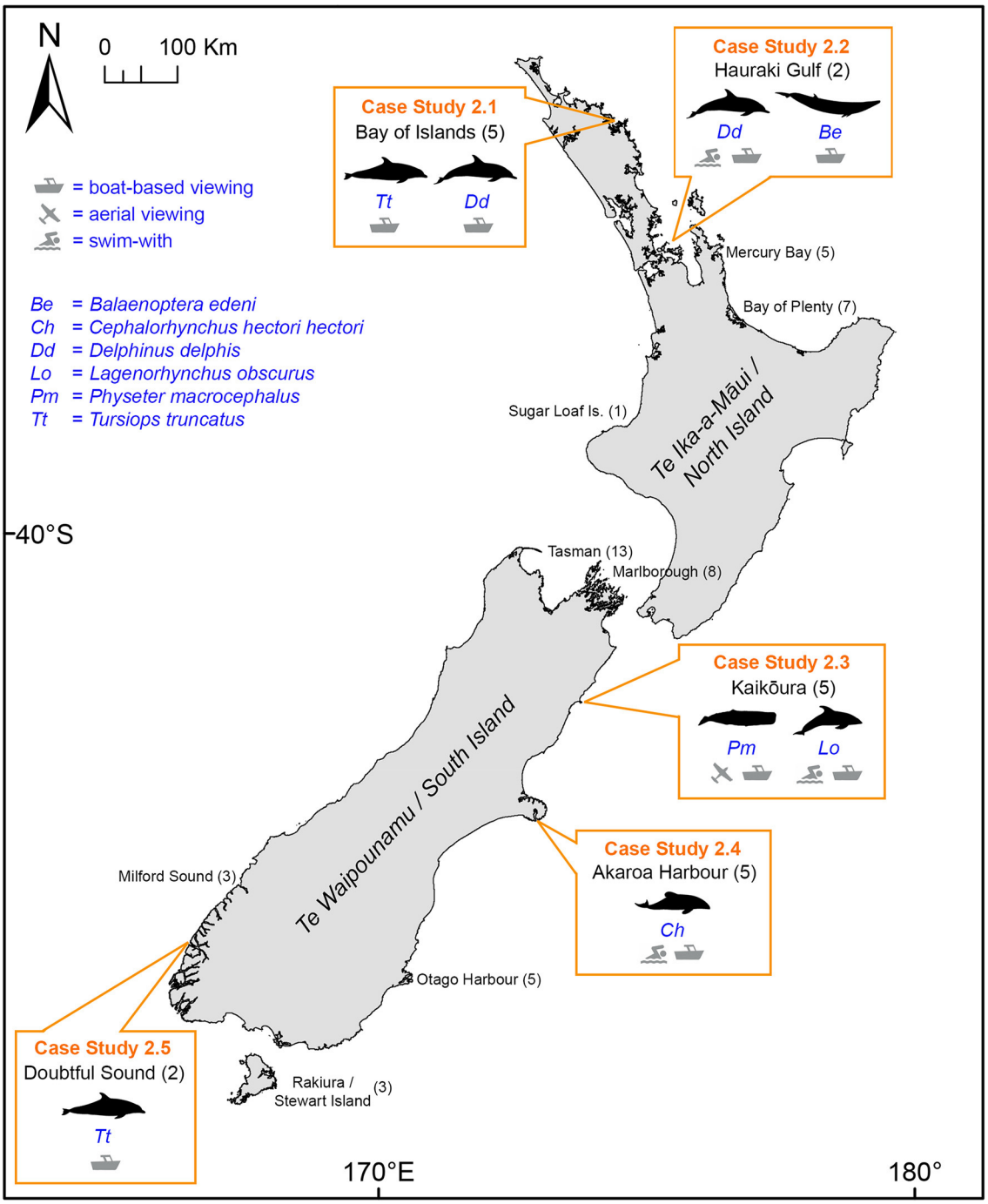

FIGURE 1 | Map of cetacean tourism destinations in New Zealand with permitted operations. For each destination, we report the number of permitted operators (in brackets). For the selected case studies presented in the following sections (boxes), we also indicate species targeted and characteristics of operations.

Commercial activities target predominantly the populations of six species: bottlenose (*Tursiops truncatus*), common (*Delphinus delphis*), dusky (*Lagenorhynchus obscurus*), and the endemic Hector's dolphin (*Cephalorhynchus hectori hectori*), as well as the sperm whale (*Physeter macrocephalus*), and the Bryde's whale (*Balaenoptera edeni brydei*). Substantial research on the effects of tourism on cetaceans has been undertaken at five locations, four of which are the focus of long-term monitoring programs: the Bay of Islands, the Hauraki Gulf, Kaikoura, Akaroa Harbour and Doubtful Sound (**Figure 1**). These are reviewed in detail in this section and in **Tables 1**–**4**. The literature on cetacean tourism at other destinations in New Zealand is summarized in **Table 5**.

TABLE 1 | Summary of the literature on bottlenose and common dolphin tourism in the Bay of Islands.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1994–95	Behavior of both common and bottlenose dolphins impacted by tourism. Socializing was the behavior most impacted for both species [1]. Documented seasonal shifts in habitat use with both species. Photo-identification studies identified non-resident bottlenose dolphin population [1]. No acoustic response in common dolphins exposed to a controlled series of pass-by and engine start-up. Uncertain evidence for bottlenose dolphins [2]. On-board education significantly improves customer experience [2].	Inclusion of swimmer placement to assess tourism impact. Ethogram describing the dolphins' behavioral responses. Systematic data collection on the operations and effects of the tour vessels on dolphin behaviors. Established methods for population monitoring.	Avoid "in path" swimmer placement [1,3]. Prohibit approaching bottlenose and common when foraging or resting, respectively [1]. Clear definition of "juvenile" [1]. Improve the level of on-board education [2].	Appointed a full-time Marine Mammal Ranger. Recommended swimmer placement to minimize impact. Engaged with tour operators outside of the Bay to ensure lowering potential cumulative impacts. Creation of a Dolphin Care Code and a code of ethics in Paihia.	[1] Constantine and Baker, 1997 [2] Helweg, 1995 [3] Constantine, 2001
1996–2001	Significant change in bottlenose dolphin resting behavior due to increased tourism pressure [1,4,5]. Dolphins sensitized to cumulative effects of swim attempts, with differences in age-class response to swimmers [3]. Identification of preferred resting areas [4]. Estimated 446 dolphins using the Bay. Core users identified. Identified individuals from the Bay in other locations [4,6].	Long-term study on behavioral response to tourism [4,5] Use of CATMOD to determine the interaction effects of dolphin group and vessel/operation variables [5] Habitat use models to identify core habitat and overlap with tour vessel use.	No further permits for dolphin-based tourism [3,4,5]. Creation of dedicated time periods when no vessels should approach dolphins [4,5]. Limitation of the amount of time tour vessels spend with dolphins and number of swim attempts per vessel [4,5].	Creation of "lunch break" to limit all vessel contact time, reduced permitted vessel encounter duration, limit to three swim attempts per permitted tour vessel per trip. Created two new permitted tour vessel exclusion areas based on resting areas. Proposed establishment of a moratorium on new permits. DOC handbook for dolphin tourism operators and outreach materials for the public.	[4] Constantine, 2002 [5] Constantine et al., 2004 [6] Berghan et al., 2008
2003–06	No genetic interchange between bottlenose populations around New Zealand indicates isolation of populations [7]. Annual decline in local abundance of bottlenose of 7.5% (1997–2006). Fewer dolphins used the Bay on a regular basis [8]. Long inter-calf intervals with high rates of calf mortality [9]. Strong association networks with some persisting for almost a decade [10,12].	Population genetics to understand regional connectivity. Genetic identification of individuals to understand population demographics. Long-term dataset for POPAN mark-recapture analysis and assessment of reproductive rates.	Focus on minimizing all anthropogenic impacts [8,9]. Enforcement of tour operators permit conditions [8,9]. Monitoring of demographic and social impacts to determine whether mitigation is effective [8,10]. Urgent conservation action [8,9].	Marine mammal ranger employed to enforce permit conditions, educate non-permitted tour operators and the public.	[7] Tezanos-Pinto, 2009 [8] Tezanos-Pinto et al., 2013 [9] Tezanos-Pinto et al., 2015 [10] Mourão, 2006
2007–12	Significant changes in fine-scale habitat use. The static tourism exclusion zones are rarely used by dolphins [11]. Near-complete abandonment of BOI area by dolphins, evidenced by continued decline in local population size (from 446 in 1994 [4] to 24 in 2012 [12,13]). Fragmented social structure [12].	Spatial ecology tools to reveal habitat shifts. Long-term photo-identification data to determine trends in demographic and social structure.	Replacement of static exclusion zones with dynamic protected areas [11]. Further measures to mitigate impacts [11,12].	Implementation of a 5-year moratorium on new permits. DOC Marine Mammal Handbook updated.	[11] Hartel et al., 2014 [12] Hamilton, 2013
2012–15	Continued high levels of calf mortality and reduction in habitat use. Continued changes in behavioral budgets in the presence of vessels. Poor compliance across all vessel types [13].	Behavioral state transitions.	Greater enforcement of MMPR for all vessels [13]. Adaptive protection measures supported with education.	2019: ban on swimming with dolphins in the Bay of Islands. Encounter time for permitted tour operators further reduced. Voluntary maximum approach distance to pods containing mother calf-pairs.	[13] Peters and Stockin, 2016

TABLE 2A | Summary of the literature on the sperm whale tourism at Kaikoura.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1990–92	Surface intervals and respiratory intervals shorter in presence of vessels, and some evidence for effects on echolocation behavior [1,2]. Outboard-driven tour vessels produce high levels of noise in the frequency range of echolocation buzzes [2].	Serial observations to control for behavioral differences among individuals [1,2]. Passive acoustics [2].	More sensitive boat handling by tourism vessels [1,2]. Use of directional hydrophones to track whales to reduce the need for fast approaches [2]. Continued monitoring to investigate long-term effects of disturbance [2].	Extensive use of hydrophones for tracking. Improved skipper behavior. Shift to waterjet propulsion for new, larger vessels.	[1] MacGibbon, 1991a,b [2] Gordon et al., 1992
1997–98	Diverse demography of visitors. Positive attitudes of local and Māori community toward tourism. Issues and tensions between tourism and locals' aspirations and needs. Significant economic impact of tourism.	Questionnaires, interview.	Develop a comprehensive community-based tourism strategy with strong links to a national tourism strategy. Policy directions: maintain local ownership of key facilities, retain local control in decision making, safeguard carefully tourism's visual impact, and adequately resource and manage key public sites.	None.	Simmons and Fairweather, 1998
1998–2005	Respiratory intervals and time to first echolocation click shorter, surface intervals longer, heading changes at the surface more frequent in the presence of vessels; responses more pronounced for "transient" whales.	Multi-year dataset; shore-based observations; accounting for impact of research vessel; distinction among individual whales. Multi-model inference statistical approach.	No increase to level of permitted activity. Long-term scheme for monitoring behavioral changes required, with cooperation of whale watching companies. Recommendations for improvements in educational material.	10-year moratorium on whale watching permits. In 2005, establishment of Te Korowai o Te Tai o Marokura (the Kaikoura coastal guardians), a volunteer, multi-stakeholder group, to provide leadership about the use and protection of Kaikoura's resources, including in relation to whale watching.	Richter et al., 2003, 2006
2009–11	Respiratory intervals longer in presence of vessels when measured from shore; variance of heading change at surface increased in presence of tour vessels; time to first click and duration of first silence longer in presence of vessels [3]. Decline in the abundance of sperm whales visiting Kaikoura [4].	Research vessel, shore-based observations and platforms of opportunity [3]. Mark-recapture modeling (Cormac-Jolly-Seber) [4].	Current regulations appropriately manage the interactions between tour vessels and whales; continued caution warranted concerning growth of industry [3].	10-year moratorium on whale watching permits.	[3] Markowitz et al., 2011 [4] Van der Linde, 2010
2016–20	Continued decline in abundance, driven by a decrease in numbers during summer [5]. Decline in abundance may be partly driven by oceanographic variability due to climate change [6].	Mark-recapture models (Robust design) [5].	Need to carry out longitudinal study to evaluate impact of tourism on population demography [5,6].	Review of tourism impacts and moratorium due in 2022.	[5] Somerford, 2018 [6] Guerra, 2019

TABLE 2B | Summary of the literature on the dusky dolphin tourism at Kaikoura.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1993–98	Surface activity [1,2], movements [1–3], and group cohesion [1] change in presence of vessels. The number of groups has increased and their distribution is further south since the establishment of tourism [3]. Diverse demography of visitors. Positive attitudes of local and Māori community toward tourism. Issues and tensions between tourism and locals' aspirations and needs. Significant economic impact of tourism [4].	Shore-based theodolite tracking, surface activity levels [1–3]. Questionnaires, observation [4].	Reduce trips between 11 a.m. and 2 p.m.; voluntary or regulated "time off"; no increase in activity, enhance education and enforcement, stricter regulations for private vessels [1]. Comprehensive community-based tourism strategy linked to a national strategy [4].	Adoption of a voluntary summertime midday rest period (11:30–13:30, 1.Dec to 31.March). 10-year moratorium on dolphin watching permits (1999–2009). Guide and skipper course.	[1] Barr and Slooten, 1999 [2] Yin, 1999 [3] Brown, 2000 [4] Simmons and Fairweather, 1998
1998–2008	Resting and socializing decrease in the presence of tourism activities [5,7]. Number of swim drops correlated with behavioral responses [5]. Effects on heading, dispersion, and leaping rate of large groups [7]. Decrease in visits during the rest period (visit/h) [6]. No change in size and location of core area compared to pre-tourism [8]. Importance of education in visitor satisfaction [9].	Shore-based theodolite tracking, boat-based behavioral observation [5–8]. Questionnaires and interviews [9].	Reduce or maintain current level of activity, midday rest period mandatory in October-March, or constant observations, education and encouragement for compliance [6]. Limit the number of swim attempts [5]. Enhance education efforts on tours [5,9].	5-year moratorium on motorized boat-based permits (2009–2014). Mandatory rest period in Nov-Feb, voluntary in March. New limits on swim drops (max. 5/trip) and no. swimmers per boat to reduce no. of vessels In 2005, establishment of Te Korowai o Te Tai o Marokura (the Kaikoura coastal guardians), a volunteer, multi-stakeholder group, to provide leadership about the use and protection of Kaikoura's resources, including in relation to dolphin watching.	[5] Markowitz et al., 2009 [6] Duprey et al., 2008 [7] Markowitz, 2012 [8] Dahood, 2009 [9] Lück, 2003
2008–10	Resting and socializing, and swim speed decrease in the presence of vessels, milling and surface activity increased; number of vessels predict magnitude of changes; change in reorientation rate associated with aircraft [10–13]. The population is relatively resilient to tourism pressure [10].	Theodolite tracking, focal follows. Log-linear analyses of behavioral state transitions; analysis of movements Before-During-After interactions.	Social sciences to update old studies on perceptions, attitudes and desires in local communities and visitors [10,13]. Clarify define regulations; enhance enforcement; define Limits of Acceptable Change; 5-year monitoring and re-evaluation cycle; establish an industry-funded research program integrated within the management scheme [10,13].		[10] Lundquist and Markowitz, 2009 [11] Lundquist et al., 2012 [12] Lundquist et al., 2013 [13] Lundquist, 2014
2011	Tourists on swim-with-dolphin tours displayed high satisfaction rates [14].	Questionnaires	Enhance education and visitors' empowerment		[14] Lück and Porter, 2019

TABLE 3 | Summary of the literature on Hector's dolphin tourism at Akaroa Harbour.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1999–2004	Akaroa dolphin tourism is valued at NZ$1.47 million; swim/tour vessels make up 13.4% of total traffic, but 47.1% of dolphin-boat interactions. Behavioral changes related to vessel presence [1]. Anecdotal evidence of habituation. Doubling of vessel traffic during 1990s [2]. Boat traffic as lethal threat [2].	Theodolite tracking of dolphins and vessels [1,2]. Operator survey questionnaires.	Don't increase tourism activity in Akaroa Harbour. Minimum tour education requirement. Education of recreational boat users. Annual operator workshops.	Informal moratorium on issue of new permits Voluntary code of conduct. Levy on permitted operators to fund research. Review of research [3].	[1] Nichols et al., 2001 [2] Stone and Yoshinaga, 2000; [3] Green, 2005
2005–13	Behavioral changes in response to boats (shift from traveling/diving to milling/socializing) [5–7]. Increased magnitude of effect with additional vessel. Dolphin response to swim encounters varied with swimmer placement, dolphin behavior, and swimmer behavior [7]. Vessels within 300 m of dolphins for 35.2% of observations; 70.4% of dolphin-boat encounters involved commercial vessels [7]. Using sound to attract dolphins associated with sustained and closer encounters [8]. First attempt at standardizing data recording by tour operators in Akaroa Harbour, weaknesses of the 2006–08 operator data collection system using data sheet [9].	Theodolite tracking of dolphins in presence and absence of vessels. Group focal follows. Markov-chain methods on transition probabilities, behavioral budget [7].	Reduce cumulative tourism exposure and/or the number of permits [7]. Establish a moratorium on Hector's dolphin tourism in NZ. Time-area closure systems within the Akaroa Marine Reserve [6]. Ban using sound to attract dolphins [8]. Education of recreational boat users. Annual operator workshops.	Detailed technical report [4]. 2007: Maximum swimming time per trip reduced from 60 to 45 min. 2008: 5-year moratorium on new permits.	[4] Allum, 2009; [5] Martinez, 2010 [6] Martinez et al., 2010 [7] Martinez et al., 2011 [8] Martinez et al., 2012 [9] Martinez and Stockin, 2011
2013–19	Economic impact of tourism in Akaroa estimated at NZ$6–8 million; wider value NZ$22.2–24.9 million in the Canterbury economy, and NZ$27.9–31.3 million nationally [10].			Since 2015: Annual SMART Operator course offered [11]. 2016: 10-year moratorium on new permits. Voluntary reduction in permitted trips from 37 to 34. Tracking systems installed on tour vessels 2019; improved boat ramp signage [12].	[10] Yeoman et al., 2018 [11] Healey, pers. comm. [12] MacTavish, pers. comm.
2020 and ongoing	Analysis of changes in tourism pressures and dolphin habitat use in 1995–2020.	Analysis of existing dataset [1,5] on dolphin distribution related to tourism operations. GPS-based tracking of tour vessels. Automated hillside camera system to quantify vessel traffic, passive acoustic T-POD and SoundTrap monitoring of dolphins an acoustic environment.			University of Otago, in progress

TABLE 4 | Summary of the literature on bottlenose dolphin tourism at Doubtful Sound.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1999–2004	First studies on the short-term effects of tour vessels on dolphins, showing disruption of behavioral budgets [1]. Increased dive intervals with different avoidance strategies in males and females [2]. Increase in some aerial displays and erratic movements [4]. Spatial quantification of critical habitat (areas of high use, including for resting and socializing) [3].	Systematic population surveys and monitoring since 1990, with Photo-ID as core method Development of Markov-Chain methods to quantify impact on behavioral budget [1]. Modeling and controlling for influence of research vessel in assessment of behavioral change due to tour boats [2].	Establish a multi-level marine mammal sanctuary and limit boat traffic where dolphins rest and socialize [3]. Change of tour operator behavior to reduce impact and extent of dolphin interactions.		[1] Lusseau, 2003b [2] Lusseau, 2003a [3] Lusseau and Higham, 2004 [4] Lusseau, 2006
2005–09	Dolphin watching deemed unsustainable [5]. Declines in abundance and calf survival [6,7]. Analysis according to IUCN criteria results in Fiordland bottlenose dolphins being declared critically endangered [8].	Assessment of population trends and conservation status [6–8].	Reiteration of previous recommendations.	2007: public meetings, involvement of external experts. Discussion and consultation document released by DOC outlining options for managing impact of tourism on dolphins [9]. 2008: voluntary Code of Management (CoM) established by committee including DOC, tour operators and researchers [10].	[5] Lusseau et al., 2006 [6,7] Currey et al., 2007, 2009a [8] Currey et al., 2009b [9] Williams, 2007 [10] Department of Conservation, 2008
2010–16	Increase in dolphin excursions beyond the fiord (decreased occupancy) [11]. Changes in group cohesion and acoustic behavior in response to vessels and noise [12]. Groups with calves particularly sensitive to vessels and noise [12]. Significant decline in frequency and length of dolphin-boat interactions since implementation of CoM [13]. Slight recovery in calf survival and population abundance [14,15]. Breaches of Dolphin Protection Zones, but compliance improving over time [16].	Combined visual and acoustic data collection [12]. Staged approach to quantify and account for impact of research vessel [12].	Cap the number of tour vessels and trips operating in the area. Reduce vessel speed and shift in vessel design (e.g., water-jet propulsion) to reduce noise [12,13]. Consider turning voluntary CoM into formal legislation [13].	Effectiveness of the CoM to be reviewed after 10 years of its implementation (due 2018).	[11] Henderson et al., 2013 [12] Guerra et al., 2014 [13] Guerra and Dawson, 2016 [14] Brough and Johnston, 2015 [15] Johnston and Bennington, 2018 [16] DOC compliance monitoring reports
2017–19	Core dolphin habitat highly consistent over more than 10 years (2005–2018), but low overlap with Dolphin Protection Zones (<15%) [17]. Continued support for the CoM by stakeholders [18].	Kernel Density Estimation for quantifying core habitat [17].	Multiple options for changes in Dolphin Protection Zones to increase overlap with core habitat [17]. Extend compliance to wider boating community, review extent and location of Dolphin Protection Zones, and considerations to limit vessel activity [18].	Continuation of CoM and compliance monitoring by DOC.	[17] Bennington et al., 2020 [18] McLeod, 2018
2020 and ongoing				Re-evaluation of CoM [19].	[19] Richard Kinsey (Fiordland DOC office), pers. comm.

TABLE 5 | Summary of the research on cetacean tourism at other New Zealand destinations.

NORTH ISLAND					
Location	**Mercury Bay, Coromandel**				
Species	**Common dolphins**				
Year	**Research findings**	**Research methods**	**Management recommendations**	**Management actions**	**References**
1998–2001	Dolphin response change from attraction, to neutral, to avoidance over the course of the encounter; small groups avoid vessels sooner and more frequently than larger groups; interactions more likely to be sustained when involving larger dolphin group and fewer swimmers. No evidence of disturbance on non-resident dolphins, but risk of cumulative effects of tourism exposure at different locations in their distribution.	Boat-based photo-identification, group size, behavioral state and activity budget.	Limit distance and length of approaches. Introduce a site-specific code of conduct.		Neumann, 2001; Neumann and Orams, 2005, 2006
SOUTH ISLAND					
Location	**Porpoise Bay, Catlins**				
Species	**Hector's dolphins**				
Year	**Research findings**	**Research methods**	**Management recommendations**	**Management actions**	**References**
1995–97	No displacement from core use area, dolphin-boat orientation changes from "toward boat" at onset of encounter to away as encounter duration extends; tighter groups with vessels in the bay. No evidence of disturbance but concerns about chronic, cumulative effects.	Theodolite tracking of dolphins, boats and swimmer positions to assess dolphin-boat orientation and pod dispersion.	Do not exceed current disturbance levels. MMPR to include important features of individuals and populations (age, sex, species, habitat use).	Interpretation panels, posters and leaflets for the public with DOC specific guidelines Southland District Council 's Coastal Plan DOC summer warden Voluntary code of conduct	Bejder, 1997; Bejder et al., 1999
2001–03	Compared to 1995–97: no evidence of displacement, similar habitat use, 3-fold increase in exposure, decrease in boat attraction, longer swims, looser groups when vessels in the bay, decreased diving and increased milling and socializing behavior.	As above (Bejder, 1997; Bejder et al., 1999)	Establish a Marine Mammal Sanctuary in the Bay. Establish time closures in the dolphin core use area. Restrict tourism to one permitted operator for 40 min/day; restrict kayaking area and prohibit on-site renting.	Lone permit revoked for non-compliance	Martinez et al., 2002; Green, 2005
Location	**Lyttelton Harbour and Timaru Harbour**				
Species	**Hector's dolphins**				
Year	**Research findings**	**Research methods**	**Management recommendations**	**Management actions**	**References**
2000–05	Vessel presence affect group swimming speed and grouping behavior. Group behavior toward vessels changed over a period of 7 years from neutral, to vessel-positive, to avoidance. Low-level tourist vessel activity considered to not be placing undue stress on the population.	Theodolite tracking of dolphin positions and behavior.	Further research on impacts of vessels on dolphins.	None	Travis, 2008

(Continued)

TABLE 5 | Continued

Location	**Queen Charlotte Sound, Marlborough**				
Species	**Hector's, bottlenose, dusky dolphins**				
Year	**Research findings**	**Research methods**	**Management recommendations**	**Management actions**	**References**
1995–2014	Baseline data on dolphin occurrence and distribution. Swim-with industry is relatively new (since 2004) and mainly targets bottlenose dolphins with active pursuit of interactions. Dolphins show neutral reactions to swim attempts	Vessel logbooks and observations from platforms of opportunity. GAMs and GLMs to investigate dolphin occurrence, distribution and habitat use in relation to environmental variables. Behavioral observation of responses to swimmers.	Protection of periods and regions of high density and predicted density. Coherent management of tourism, marine farming, and vessel traffic effects.		Cross, 2019
Location	**Milford Sound, Fiordland**				
Species	**Bottlenose dolphin**				
Year	**Research findings**	**Research methods**	**Management recommendations**	**Management actions**	**References**
1999–2002	Resting and socializing behavior are sensitive to boat interactions, dolphins need at least 68 min between two interactions [2]. Dolphins more frequently absent from Milford Sound during months of intense vessel traffic [3]. Marks of physical injuries caused by boat strikes, calf killed by a tour boat in 2002 [1].	Boat-based visual survey, operator boat traffic data, oceanographic parameters to build discrete time Markov chain of dolphin presence/absence [3]; Markov Chain and log-linear analyses of behavioral state transitions [2].	Reduce vessel traffic and boat-dolphin interactions with protected areas [3].	2006 Marine Mammal Viewing Code of Practice (voluntary)	[1] Lusseau et al., 2002 [2] Lusseau, 2004 [3] Lusseau, 2005

The Bay of Islands, Northland

The Bay of Islands (BOI) is a sheltered habitat containing over 144 islands, and numerous inlets, bays and estuaries. Bottlenose dolphins inhabit the BOI year-round, with 1–3 groups of 15–20 individuals usually present at any time (Constantine et al., 2004; Peters and Stockin, 2016). These dolphins are not exclusively resident in the BOI, but range along the northeast coast of the North Island (Constantine, 2002; Berghan et al., 2008; Tezanos-Pinto et al., 2013), and display seasonal inshore and offshore movements (Constantine and Baker, 1997; Hartel et al., 2014; Peters and Stockin, 2016). Common dolphins are also regularly present in the outer BOI (Constantine and Baker, 1997).

Cetacean tourism started in 1991 with a single vessel offering viewing and swim-with tours with common and bottlenose dolphins (Constantine and Baker, 1997; Constantine, 1999). Two additional companies began tours in 1993–1994. In 1995, bottlenose dolphins became the primary focus of tourism operations, as they were easier to locate and often found closer inshore. Concerns raised by the original tour operator and local Māori over the impact of the industry prompted research on population demographics and tourism impacts on bottlenose dolphins in 1993. The research demonstrated clear behavioral effects on the local dolphin population and recommendations were made to limit expansion of the industry (Constantine and Baker, 1997), which, by then, had already grown rapidly and was operating more tours with larger vessels (**Table 1**). Over the 2000s, despite a moratorium on permits since 1998, heightened pressure from permitted operators was compounded by increasing numbers of private boat users and non-permitted operators seeking out interactions with dolphins. In response, DOC implemented further permit restrictions on the number and duration of trips, swim attempts and swimmers, created static exclusion zones, promoted better education, and continued to hire marine mammal rangers to try and resolve the issues (**Table 1**). These measures were insufficient to mitigate impacts on the dolphin population. The dolphins became rapidly sensitized to swimmers (Constantine, 2001) and behavioral states were altered by vessel presence, with dolphin tour vessels having the greatest impact (Constantine and Baker, 1997; Constantine, 2001; Constantine et al., 2004; Peters and Stockin, 2016). Rapid declines in local abundance (Tezanos-Pinto et al., 2013), changes in fine-scale habitat use (Hartel et al., 2014) and decay in social structure (Constantine, 2002; Hamilton, 2013) continued to indicate a highly impacted population (Hamilton, 2013). In 2019, swimming with the dolphins was banned and interaction times were further reduced. Currently, four permitted companies operate one to two trips per day each. However, existing measures (such as trip duration limits and static protected areas; Hartel et al., 2014) are likely ineffective and are often ignored (Peters and Stockin, 2016). A renewal of the moratorium on permits, the institution of adaptive time-area closure systems, stronger and enforceable limitations for all users and operations, and appropriate consultation processes were strongly recommended (Peters and Stockin, 2016) but, as with previous recommendations, have not yet been comprehensively addressed by management.

The BOI offers an example of inadequate management and rapid, dramatic negative consequences of tourism. Stricter mitigation measures to decrease pressures on the dolphins following identification of impacts from the then low levels of tourism in the early 2000s (Constantine and Baker, 1997) could have prevented the rapid decline of the local population (**Table 1**). Despite robust research advice and cultural significance, the welfare of this population has been largely neglected by management authorities.

The Hauraki Gulf, Auckland

The shores of the Hauraki Gulf (hereafter the Gulf) host New Zealand's largest metropolitan area, with shipping, fishing and aquaculture activities based throughout the Waitematā Harbour. Compared to other parts of New Zealand, cetacean tourism in the Gulf remains relatively small scale and stable, with only two permits currently in existence, of which one is actively used. Tourism focuses specifically on common dolphins and Bryde's whales, although regular encounter by the tour boats have offered insights to other species (Berghan et al., 2008; Hupman et al., 2015).

The common dolphin is the species most frequently encountered by operators (O'Callaghan and Baker, 2002; Stockin et al., 2008a; Colbert, 2019). During encounters with vessels, dolphin groups have been shown to reduce feeding and resting behavior (Stockin et al., 2008b), increase vocalization rate (Petrella et al., 2012), change group cohesion (when calves were present; Schaffar-Delaney, 2004), and alter feeding strategies (Burgess, 2006; de la Brosse, 2010). Annual abundance estimates range from 2,478 (95% CI = 1,598–3,615; Hamilton et al., 2018) to 8,632 (95% CI = 7,738–9,630; Hupman et al., 2018), thus vessel effects are likely diluted across a large population. However, photo-identification efforts along the wider northeastern North Island coastline (Neumann et al., 2002; Meissner, 2015; Hupman, 2016) show that individual dolphins may be subject to cumulative tourism impacts across several locations (Meissner et al., 2015).

A small number of Bryde's whales are present in the Gulf year round. Over the period 2004–2013, seasonal abundance estimates ranged from 38 to 74 individuals, with a super population of 100–183 whales using the Gulf overall (Tezanos-Pinto et al., 2017). The whales forage most actively in daylight (Izadi et al., 2018) and sometimes in association with common dolphins and Australasian gannets (*Morus serrator*) (Stockin et al., 2008a; Wiseman et al., 2011), both of which act to increase the whales' detectability by tour operators. Although globally abundant, the Bryde's whale is considered Nationally Critical in New Zealand (Baker et al., 2019) and yet, to date, there has been no investigation of tourism impacts on the species in the Gulf.

Even though bottlenose dolphins are commonly seen in the Gulf, the impacts of tourism registered in the longer-established industry in the Bay of Islands have led to the species being excluded from swim-with permits, and more recently viewing permits in this area.

The Gulf case study provides an example of a cetacean tourism industry embedded in a context of multiple stressors (aquaculture, fishing, commercial shipping, contaminants), and targeting two species with different life history, behavior and

ecology. Despite establishment of the Hauraki Gulf Marine Park in 2000 (the only one of its kind in New Zealand), most of the conservation issues affecting the area remain unmitigated (Hauraki Gulf Forum, 2020). The suitability of dynamic marine protected areas, in combination with minimizing encounters at certain times of the day, and avoidance of feeding and nursery dolphin groups should be investigated for the future management of anthropogenic impacts in this region (Dwyer et al., 2020).

Kaikoura, Canterbury

Kaikoura is the longest established cetacean tourism destination in New Zealand, and tourism is the main driver of the local economy (Orams, 2002; Curtin, 2003). Activities are focused around the Kaikoura submarine canyon, a foraging habitat for dusky dolphins and sperm whales (Childerhouse et al., 1995; Benoit-Bird et al., 2004). Since 1991, there have been three boat-based operations, one focusing on viewing of sperm whales and two on viewing and swimming with dusky dolphins, in addition to three air-based operations. This case study focuses on the research and management of sperm whale tourism (**Table 2A**). The history of tourism and research targeting dusky dolphins is summarized in **Table 2B**.

Kaikoura is one of the few places in the world where sperm whales can be seen close to shore year-round. The individuals encountered regularly at Kaikoura are exclusively males (Childerhouse et al., 1995, Jaquet et al., 2000). Some are resident in Kaikoura for many months at a time, and return regularly; others transit through the area (Childerhouse et al., 1995; Somerford, 2018). The effects of tourism on the local population have been investigated in a series of studies commissioned by DOC at ∼10-year intervals starting in 1990. Several effects due to the presence of vessels and aircraft have been detected (**Table 2A**). These have not always been consistent among studies, but have generally included changes in both surface behavior and echolocation. Although responses have been interpreted as of minor consequence overall, variation among individual whales (especially between "residents" and "transients") and between seasons could act to swamp the real effects of tourism activities (Richter et al., 2006; Markowitz et al., 2011). Precautionary management was therefore recommended, and an increase in the number of boat trips and permits strongly discouraged (Richter et al., 2006; Markowitz et al., 2011).

DOC responded to these calls by issuing 10-year moratoria on permits in 2002 and 2012. The monopoly of one company conducting all vessel-based whale watching tours has caused disquiet among others seeking permits (Simmons and Fairweather, 1998; Orams, 2002; Curtin, 2003; Simmons, 2014), but has likely reduced impacts on the whales. Additionally, this company introduced significant changes to its vessels (switching from 6 m outboard-powered rigid-hulled inflatables to 20 m diesel jet-engine catamarans) and its operations (often using directional hydrophones to track whales). These measures reduced underwater noise and the need for high-speed approaches, hence acted to mitigate disturbance to the whales.

Despite these management decisions, longitudinal studies show a significant decline in the number of sperm whales visiting Kaikoura over the past 30 years, especially during summer (Somerford, 2018). It is now essential to understand whether the detected behavioral responses to tourism may have had direct long-term consequences, or whether they add to the suite of other factors affecting this population (e.g., climate change; Guerra, 2019). In particular, there is growing concern about cumulative impacts of chronic, repeated interactions when very few individuals (<3) are present in the area, as happens commonly in early summer (Guerra, 2019), because this could lead to complex physiological, behavioral and/or ecological long-term consequences (Bejder et al., 2009).

Kaikoura could be cited as a reasonable model for management of tourism on sperm whales. The impacts of tourism on sperm whales have been regularly monitored, there is only one boat-based, long-term operator and the regulations are largely followed (Curtin, 2003). Relationships among tourism operators, researchers, local communities and managers are generally positive, and have helped develop cetacean tourism in an orderly fashion. Continued longitudinal study is necessary to monitor the conservation status of this population, to unveil the effects of chronic exposure on resident individuals, and to understand whether the detected behavioral changes resulting from tourism translate to biologically meaningful effects.

Akaroa Harbour, Banks Peninsula

The Hector's dolphin is endemic to New Zealand. The species is Endangered (Reeves et al., 2013), and the population at Banks Peninsula has experienced significant depletion since 1970 (up to 80%; Slooten, 2007) mainly due to bycatch in gillnets and trawls (Dawson, 1991). The Banks Peninsula Marine Mammal Sanctuary (established in 1988), and further protection measures in 2008 led to an increase in adult survival rate (Gormley et al., 2012), but were insufficient to support population recovery (Slooten, 2013).

Akaroa Harbour is the primary focus of tourism on Hector's dolphins, and is a hotspot of dolphin abundance at Banks Peninsula (Brough et al., 2020). Dolphins are present year-round. Their distribution is concentrated close to shore in the summer months (Dawson et al., 2013) coinciding with calving (Slooten and Dawson, 1994) and the seasonal peak in tourism. Beginning with a daily natural history tour in 1985, dolphin tourism grew into a NZ$1.46 million industry by 1999 (Nichols et al., 2001). In addition, recreational vessel traffic more than doubled over the same time period (Stone and Yoshinaga, 2000).

Research on the potential impact of tourism in Akaroa Harbour began in 1999 (**Table 3**). Studies provided evidence of changes in behavioral state and directionality of travel (Nichols et al., 2001), cautioned about calf vulnerability to boat-strike (Stone and Yoshinaga, 2000), and indicated that dolphin response to swim encounters varied with swimmer placement and behavior, dolphin behavior, and possibly the dolphins' previous exposure to tourism (Martinez et al., 2011) (**Table 3**). Researchers lauded operators' compliance with some permit conditions (e.g., swim encounter duration), but cautioned that growth in operations, and the tendency to "hand-over" dolphin groups from one tour boat to the next, could cause the same dolphins to be repeatedly targeted over the course of the day (Nichols et al., 2001; Martinez et al., 2011). Martinez

et al. (2011) emphasized that in-water interactions, even when initiated and apparently well-tolerated by dolphins, could have long-term detrimental effects on the dolphin population. Further development of the industry was therefore discouraged. In 2008, after granting two new permits to already existing non-permitted operations (Allum, 2009) (from four to six permits), and allowing permitted operators to increase their number of trips (from 25 to 37 trips/day), DOC issued a 5-year moratorium on new permits, which was later followed by a 10-year moratorium in 2016. Currently, five permitted and multiple non-permitted operators are active in Akaroa Harbour.

Adherence by commercial operators to the MMPR and permit conditions (Martinez et al., 2011), combined with moratoria and voluntary initiatives, has reduced the potential effects of tourism on the local Hector's dolphin population. However, an increased number of visitors and a recent surge in cruise ship tourism have resulted in a longer "peak season," leading to an overall increase in tourism pressures. In addition, recreational boat traffic, predominant in the harbor, is frequently in breach of the MMPR (Martinez et al., 2011).

A 2019 economic assessment revealed the importance of the industry both locally (NZ$6–8 million in direct annual operator income) and regionally, and tied its fate to that of the dolphin population (Yeoman et al., 2018). In 2018, DOC commissioned a new study to investigate changes in dolphin distribution at varying levels of tourism. Such longitudinal studies of behavior, habitat use, and demography provide the best hope of quantifying the consequences of anthropogenic pressures, especially in the context of multiple threats (e.g., permitted tourism, non-permitted and recreational operations, bycatch, cruise ship traffic, and aquaculture), as well as forecast the future of the industry.

Doubtful Sound, Fiordland

Doubtful Sound is one of the most popular nature tourism destinations in New Zealand. The fiord is home to a small (65–71 individuals), isolated, largely closed and resident population of bottlenose dolphins (Currey et al., 2009a; Bennington et al., 2020) currently listed as Critically Endangered by the IUCN (Currey et al., 2013). Researchers have monitored the population in collaboration with DOC almost continuously since 1990 (**Table 4**), when the first boat-based scenic cruise operation was established. Interactions with the dolphins are an iconic feature of scenic cruises, and have been a cause of concern since the early 2000s (Lusseau, 2003a,b; Guerra et al., 2014). As of 2020, two permitted companies operate in Doubtful Sound year-round, offering multiple daily and overnight trips.

Studies conducted between 2000 and 2009 showed a range of behavioral responses to tour vessels, determined the location of critical resting and socializing habitats (Lusseau and Higham, 2004) and detected a worrisome downward trend in calf survival and abundance (Currey et al., 2007, 2008) (**Table 4**). Concerns were voiced that tourism levels were unsustainable for this dolphin population (Lusseau et al., 2006), and DOC released a Threat Management Discussion Paper (Williams, 2007) offering several options for managing tourism operations. In 2008, DOC, in conjunction with tour operators and scientists, developed a voluntary Code of Management (CoM) to leave dolphin encounters to chance, restrict vessel traffic in "Dolphin Protection Zones," and reduce the extent of dolphin-vessel interactions. These "Dolphin Protection Zones" partially and loosely overlapped with the critical habitats identified by Lusseau and Higham (2004). Nevertheless, the implementation of the CoM led to declines in the frequency and duration of dolphin-vessel interactions, suggesting that tourism pressure on the population had eased (Guerra and Dawson, 2016). It also coincided with a reversal of the downward trends in calf survival and abundance recorded in the 1990s and 2000s (Currey et al., 2007, 2008), which had possibly been caused by tourism, demographic stochasticity and/or other impacts (e.g., construction and operation of a power plant) (Henderson et al., 2014; Brough and Johnston, 2015; Brough et al., 2016).

The generalist focus of scenic cruises, the voluntary nature of the CoM, and the close cooperation between DOC, scientists and tour operators in the development of management measures, all seem to have contributed to generally high compliance by tour operators (Guerra and Dawson, 2016). However, continued behavioral reactions to vessels and noise, and vulnerability of groups with calves (Guerra et al., 2014), low compliance among members of the recreational and non-permitted boating community, and the limited extent of the static Dolphin Protection Zones undermine the effectiveness of the plan in protecting this population. The CoM was reviewed in 2018 (McLeod, 2018) prompting a re-evaluation of spatial protection measures, formalization of the CoM, and further limitations on vessel activity.

Doubtful Sound is similar to other case studies in that it experienced an initial phase of management inaction, a failure to fully and promptly integrate science-based management recommendations (e.g., multi-level marine mammal sanctuary; Lusseau and Higham, 2004), and ongoing compliance issues. However, voluntary management measures appear to have contributed to reducing exposure of dolphins to vessels, and overall, the fiord represents an example of relatively successful evidence-based management. The small size, isolation, and history of low calf survival and rapid fluctuations in abundance (Currey et al., 2007, 2009b; Brough and Johnston, 2015) emphasize that continuing monitoring and research, combined with decisive and effective management action, will continue to be critical for the Doubtful Sound dolphin population.

EFFECTIVE RESEARCH STRATEGIES

To ensure a genuinely sustainable industry that safeguards the well-being of cetacean individuals and populations requires rigorous scientific evidence to quantify impacts, develop management options, and evaluate their effectiveness (Bejder and Samuels, 2003). Based on 30 years of research on tourism impacts in New Zealand, and in the light of recent assessments of global research on cetacean tourism (IWC Sub-Committee on Whale Watching, 2019), we outline five key points to consider in the development of research strategies.

Comprehensive Research on Short- and Long-Term Responses

Documenting short-term behavioral responses is the most common approach to evaluating tourism impacts on cetaceans (**Tables 1**–**4**, **6**). Although they should not be taken as sufficient indicators of detrimental impacts (Corkeron, 2004; Bejder et al., 2006a, 2009), they represent an important first step to identifying tourism effects on animal welfare, forecasting likely biological consequences on populations (Christiansen and Lusseau, 2015; New et al., 2015, 2020; Booth et al., 2020), and designing and monitoring management intervention. A robust approach to research requires baseline knowledge of population biology and ecology, and employs multiple tools, such as the quantification of behavior changes (e.g., Lusseau, 2003a; Meissner et al., 2015), acoustic responses (e.g., Richter et al., 2006, Guerra et al., 2014), patterns of habitat use (e.g., Lusseau and Higham, 2004; Hartel et al., 2014), and health variables (e.g., Rowe and Dawson, 2009; Dwyer et al., 2014). These indicators of change would also be useful to investigate individual well-being through the Welfare Assessment Tool for Wild Cetaceans (WATWC), a framework being developed with the support of the International Whaling Commission (Nicol et al., 2020). The tool is used to characterize consequences of potential welfare hazards to nutrition, environment, health, behavior, and affective state of exposed animals, and to compute a score indicating the severity of harm to the individuals or populations assessed (Nicol et al., 2020). Until the WATWC and welfare frameworks for wildlife are established, key metrics for the computation of welfare risk are the intensity and duration of impacts over the life-span of individuals, and the number of individuals affected (De Vere et al., 2018; Nicol et al., 2020).

Inevitably, however, short-term responses do not provide information on latent effects, those that appear elsewhere or at a lagged time, or on individuals that may already be avoiding the area due to disturbance. Moreover, short-term behavioral responses must be interpreted with caution, as they display significant variation between and within populations, groups and individuals (e.g., due to sex, Lusseau, 2003b; presence of calves, Guerra et al., 2014; previous exposure to disturbances, Constantine, 2001; Bejder et al., 2009; among others).

There is thus a vital need to identify the long-term consequences of tourism disturbance on cetacean populations (e.g., abundance, reproduction and survival rates). Identifying how non-lethal impacts result in population-level consequences has proven a challenge (Lusseau and Bejder, 2007; New et al., 2014; King et al., 2015), but remains an important objective to understand the mechanisms that lead to detrimental effects (e.g., stress, displacement from quality habitat, compromised foraging and resting). Long-term datasets offer precious opportunities to analyze demographic and distribution trends in the context of tourism development and management (e.g., Tezanos-Pinto et al., 2013; Somerford, 2018; Bennington et al., 2020) and shed light on the long-term consequences of tourism disturbance on cetacean populations.

Control Data

One crucial feature of effective research on both short- and long-term responses is the availability of control data (Bejder et al., 1999; Bejder and Samuels, 2003). These data should be gathered at appropriate temporal (before/during/after) and/or spatial scales (control/impact sites) (Bejder and Samuels, 2003), and using research methods unlikely to influence cetacean behavior (e.g., land-based, unmanned aerial vehicles, remote cameras, passive acoustic methods; Lundquist et al., 2013). In the absence of true control data, modeling to factor out the impacts of research activities and platforms is advised (Nowacek et al., 2001; Lusseau, 2003a; Richter et al., 2006; Guerra et al., 2014; Christiansen et al., 2020). Moreover, long-term data covering periods of step-wise changes in tourism (e.g., Constantine et al., 2004; Bejder et al., 2006b), and data from populations exposed to different levels of tourism (e.g., Lusseau, 2004; Fumagalli et al., 2018), have much more explanatory power than short-term data from one site. Lastly, information from benchmark studies at other locations can significantly enhance investigation and management of tourism effects, especially in data-deficient situations. In New Zealand, the research and management experience at the Bay of Islands and Doubtful Sounds influenced permit conditions in Waikato, Marlborough and Bay of Plenty, among others, where the bottlenose dolphin is now excluded from viewing and swim-with activities.

At many locations, where so far it has been difficult to observe cetaceans in the absence of vessels and/or swimmers, the COVID-19 pandemic may be creating unprecedented opportunities to collect control data.

Tourism Within the Context of Additional Pressures

Tourism often co-occurs alongside other potential stressors, such as bycatch, climate change, pollution, shipping, or habitat modification. Even when its impact is considered to be mild, cetacean tourism has the potential to aggravate the combined pressures on wild individuals and populations. Research should therefore aim to assess and manage potential cumulative impacts in unison (Maxwell et al., 2013; New et al., 2014), rather than in isolation. As evidenced by the case studies presented here, complementing tourism research with broader investigations of population exposure and responses to other threats helps gain a comprehensive picture of population conservation status, interpret and contextualize tourism effects. In addition, it can help identify management opportunities, capitalize on existing strategies, and eliminate redundant legislation to optimize governance. Finally, considering tourism within the context of multiple pressures generates the knowledge needed to negotiate management trade-offs between concurring industries affecting the same populations.

Evidence-Based Management Recommendations

Studies with a clear focus and specific research questions can deliver targeted recommendations, which in New Zealand have been particularly useful for the establishment of permit

TABLE 6 | Recommended actions to increase management efficacy of cetacean tourism at national and local destination level in New Zealand.

	Precaution	Adaptation	Holistic Approaches	Multi-Stakeholder Collaboration
National level	• Develop a National Plan for cetacean tourism • Clarify **ambiguous terms** (e.g., define "*juvenile,*" "*sufficient* education") in permit conditions • Address lack of **enforcement** of the permit system (e.g., "on the spot" ticketing for violations) • Enable precaution with **adequate policy tools** (e.g., shift burden of proof) • Devise a sustainable **financial system** to support the necessary long-term science (e.g., tourism levies)	• Enhance legal tools to promptly **reverse and adjust measures** based on the regular assessment and monitoring of management efficacy, compliance and cetacean responses • Add regulations for **revoking** permits and penalties for non-compliance • Early, frequently and regularly **revise management of tourism,** particularly of industries targeting distinct, small, declining populations • Improve and set standards for delivery of effective **educational, conservation-oriented information** on tours	• Regularly assess priorities and update the Marine Mammal Action Plan considering the integrated impacts of **global** and **national** stressors, the scientific information on individual welfare and population-level effects, and public interest and attitude toward cetacean tourism • Use of emerging techniques including **health and welfare assessments** to be incorporated into tourism impact assessments • Facilitate the formation of dedicated **interdisciplinary research** consortia, both nationally and locally	• Strengthen frameworks for **consultation** with recreational and non-permitted operators, tourism agencies and other stakeholders • Enhance **participation in and support of research** (sharing knowledge, data collection) • Establish collaborations with existing agencies and groups (e.g., boating education and certification agencies) to promote **knowledge and compliance to regulations** among the broader boating community • Ensure consistency of conservation and management messages in **marketing** and **delivery** of tourism activities
At each destination	• Extend enforceable obligations to **non-permitted** and **recreational** operations • Assess the suitability of site-specific **time-area closures** to tourism	• Establish the **legal basis** for adaptive management at local and regional level • Shift to **least obtrusive practices** in tourism (e.g., land-based, watching only) and research (e.g., land-based, platforms of opportunity) • Distinguish impacts from different segments of boating public, to articulate **specific management measures for the relevant boat users**	• Support **long-term studies** on behavior, distribution and population biology in partnership with local stakeholders • Identify **control sites or times** for the collection of control data • Assess the suitability of the **WATWC framework**, validate and improve the tool • Launch research efforts to characterize **stakeholders** (operators, researchers, government, visitors, local community) which ought to be integrated in management frameworks • Analyze and conceptualize tourism within relevant local, regional and national threats, and their **cumulative effects**	• Enhance **education and communication** of national and site-specific regulations and conditions
Bay of Islands	• Renew moratorium	• Modify the current static area-closure system • Reduce the number of vessels on the water • Revise regulations regarding the number of trips allowed daily and the practice of "handing over" groups	• Coordinate research and management regionally to protect dolphins exposed to multiple threats	• Enhance education of permitted, non-permitted and recreational users
Hauraki Gulf	• Prevent tourism increase		• Coordinate research and management regionally to protect dolphins exposed to multiple threats • Begin research on the impacts of tourism on Bryde's whales	• Capitalize on the ongoing engagement with the voluntary shipping Transit Protocol to promote science-based and social process in management
Kaikoura	• Renew moratorium • Reduce interactions with individual whales during summer, when whale abundance is particularly low	• Clarify and revise regulations for air-based operations • Consider ceasing dolphin-swimming activities and restrict tours to dolphin-watching	• Combine research on short-term whale responses with studies of long-term population dynamics • Investigate long-term changes in spatial distribution and abundance of dolphins relative to the changing extent of tour operations	• Enhance communication and awareness of risk of decline in whale abundance during summer, and of need to minimize impact from tourism
Akaroa Harbour	• Renew moratorium • Establish regulations for cruise ship traffic and monitor the resulting effects	• Revise regulations regarding the number of trips allowed and the practice of "handing over" groups	• Continue monitoring of the population, at local and regional level, the threats it is exposed to, and their effects on welfare and conservation • Update research on short-term responses to tourism operations, and on long-term population dynamics	• Enhance education of non-permitted and recreational users

(Continued)

TABLE 6 | Continued

	Precaution	Adaptation	Holistic approach	Multi-Stakeholder collaboration
	• Include tourism in the updated Threat Management Plan for the species			
Doubtful Sound	• Renew moratorium	• Review the extent and location of Dolphin Protection Zones • Upgrade voluntary guidelines into formal legislative framework applicable to all vessels and users	• Update research on short-term responses to operations and long-term population dynamics • Design a regional research program incorporating fiords and populations experiencing high, medium and no tourism disturbance	• Enhance communication with the broader boating community to improve compliance with guidelines

conditions and moratoria. Pre-tourism studies should be undertaken, if possible, to assess the impacts of the proposed industry, define initial regulations and establish a baseline for future monitoring (Martinez, 2003; Higham et al., 2009). At the onset of the industry, as well as regularly throughout its development, a main priority is the identification of situations in which cetacean tourism is incompatible with the welfare and conservation of the targeted individuals and populations. For example, there is a moratorium on tourism activities focused on the Critically Endangered and endemic Māui dolphin (*Cephalorhynchus hectori maui*), and it is currently illegal to approach bottlenose dolphins (*Tursiops truncatus*) and southern right whales (*Eubalaena australis*) in several regions. The identification of sensitive habitats is another essential first step in the design of tourism exclusion zones to effectively limit or prevent interactions in critical situations (Constantine et al., 2004; Lusseau and Higham, 2004; Lundquist, 2014).

In many locations, a key impediment to developing effective management strategies is the lack of information on the impacts of different segments of the boating community. For example, it is easy to focus on commercial operators, when they may not be the major source of impact. It is therefore important to quantify the frequency and effects of interactions with different vessel types, including recreational and non-permitted, in addition to permitted tour operators. The assessment of impacts where there are no permitted operations (e.g., Porpoise Bay, New Zealand) can be particularly useful. By understanding what specific activities lead to identifiable negative impacts, regulations can be targeted to specific activities. This will also help to devise measures that apply to the general public in places where the tourism industry does not have a role in managing impacts on cetaceans.

The social sciences and humanities, so far underrepresented in cetacean tourism research, can not only describe the social, economic and political aspects of the industry, explain and predict its evolution, and provide evidence-based recommendations for its advancement, but also facilitate and promote conditions that enable effective partnerships between stakeholders (Orams, 1996; Beausoleil et al., 2018; Whitty, 2018). Such partnerships can help design and implement management measures (Duffus and Dearden, 1990; Higham et al., 2009), and find best strategies to develop more unobtrusive and educational, and yet commercially viable, practices.

New Avenues for Research

The literature on cetacean tourism is substantive. Efforts should now focus on making full use of the existing datasets, and on addressing emerging gaps, new questions and evolving research approaches, rather than continuing to replicate descriptive findings which are now well-understood. The question is no longer *if* tourism can cause detriment, but *how* can we best predict, prepare for, and minimize it.

Beside advancement in the natural sciences, additional opportunities involve the social sciences and humanities (see section Evidence-Based Management Recommendations above), traditional ecological knowledge (*Mātauranga Māori* in New Zealand), animal welfare science (Papastavrou et al.,

2017; Beausoleil et al., 2018; Nicol et al., 2020), and new analytical/modeling techniques and technological innovations (Pirotta et al., 2014; Nowacek et al., 2016; Booth et al., 2020; New et al., 2020). In particular, we encourage colleagues with adequate resources and datasets to (1) advance research on early warning signs and strategies to detect thresholds or tipping points in population dynamics (Scheffer, 2010); (2) develop quantitative metrics for animal welfare that, alongside population-level metrics, can guide evidence-based decision making (Papastavrou et al., 2017), validate and enhance emerging frameworks (e.g., WATWC, Nicol et al., 2020), and contribute working toward a common understanding of welfare (see Beausoleil et al., 2018); (3) advance tools and technologies to minimize or eliminate the use of invasive methods in tourism research, which can cause additional disturbances or mask tourism impacts; (4) design more robust protocols for collection and analysis of policy-relevant data from platforms of opportunity and through citizen science (Lusseau and Slooten, 2002; Cheney et al., 2013; Embling et al., 2015; Hupman et al., 2015); and (5) advance research on the human dimension of the tourism industry, in particular the socio-economic drivers of management response and pathways to overcome obstacles to management success in order to achieve more effective protection.

DETERMINANTS OF MANAGEMENT EFFICACY

One key lesson to extract from the New Zealand experience is that it is critical to heed early signs of impacts of cetacean tourism. Early management intervention is more likely to be effective and more easily implemented. Once there are clear indications that cetacean populations are declining, it may be too late to reduce tourism (and other) impacts to sustainable levels. An essential prerequisite of management efficacy is a policy framework that enables decision makers to receive and act upon rigorous scientific information early and decisively (Mangel et al., 1996; Higham and Bejder, 2008). Policies should clearly express what levels of risk and change are tolerated, where possible defining clear, measurable and adaptive management criteria and thresholds (e.g., stopping rules). In practice, management of tourism in New Zealand has ranged from examples based on robust, science-based and actionable policies, to those more influenced by economic and political pressures. We identify four key features of successful interventions: precaution, adaptation, holistic approaches, and multi-stakeholder collaboration.

Precaution

A precautionary approach establishes a framework of protective measures to prevent an activity from inflicting serious or irreversible impact, even if the evidence of such harm is lacking or uncertain (Cooney, 2004). The need for precaution arises from the acknowledgment that cetacean tourism is a non-lethal anthropogenic stressor and a form of consumptive exploitation (Neves, 2010; Higham et al., 2016) whose impacts on a particular population are often unknown, uncertain or ignored.

Precaution calls for tourism on vulnerable, small, isolated, threatened, or resident populations, or in priority habitats, to be minimized or avoided (Constantine and Bejder, 2008; Ross et al., 2011; Johnston, 2014). This is best achieved by confining operations to populations able to sustain tourism pressure (International Whaling Commission, 2006) and by prohibiting tourism in certain areas or times (i.e., temporal and/or spatial closures) (Tyne et al., 2014). One time- and area-based management strategy could involve assigning different spaces to permitted tour operators, non-permitted operators and the public, while ensuring "no-access" zones or times where cetaceans are fully protected (Lusseau and Higham, 2004; Fumagalli et al., 2018).

Maintaining a precautionary approach may require managers to be resolute in the face of demands from industry and the public, and this is why precaution is more effective when formulated as a legal obligation within policy frameworks, planning, and management tools (e.g., the MMPR in New Zealand). It is also important that the burden of proof rests with the proponents of the activity (Bejder et al., 2006b; Constantine and Bejder, 2008) and that regulations are clear, unequivocal, and effectively enforced (Constantine and Baker, 1997; Childerhouse and Baxter, 2010; Lundquist, 2014; Peters and Stockin, 2016). Under some circumstances, voluntary guidelines can provide an effective first step in management (Schaffar et al., 2010) or complement official regulations to further reduce tourism pressure (Guerra and Dawson, 2016).

A clear statement on what level of impact can be tolerated is a necessary step toward more precautionary and effective management strategies. These may include the use of quantitative tools (e.g., risk thresholds) to monitor impact and assess management success (e.g., Limits of Acceptable Change; Duffus and Dearden, 1990; Higham et al., 2009). Setting measurable risk thresholds, however, first requires addressing some critical questions, such as what agencies set the thresholds, how are these set, how thresholds are monitored, and what should be done at sites where there are insufficient data to set thresholds. We suggest that thresholds should require regular validation and adjustment based on emerging information, apply a precautionary approach, and be set only if there is robust evidence of their safety. Where terminology is vague (e.g., "harassment"), unambiguous definitions are required, and should be linked to specific indicators.

Adaptation

It is important that management approaches can adapt to changing conditions and new information to improve protection (Higham et al., 2009, 2014; Hartel et al., 2014). They should allow for careful monitoring of impacts and assessment of management interventions. Furthermore, regulations should be easily modified on the basis of the best available evidence. For instance, welfare concerns could initially prompt gradual reductions in tourism, which would likely be less drastic and costly than those required once a population has already declined or been displaced (Papastavrou et al., 2017). If population-level effects are detected, however, targeted actions should be swiftly implemented.

Tour operations that are more generalist and do not exclusively rely on cetacean tourism (e.g., scenic and wildlife viewing tours) offer more scope for adaptation to changes in management, and should therefore be more resilient. In turn, this may help facilitate compliance with new regulations.

Holistic Approaches

Ideally, science for policy is comprehensive and multi-disciplinary. Defining management strategies requires information on the target species, the tourism operations, and how both have changed over time at the site (Duffus and Dearden, 1990; Higham et al., 2009). Aspects to take into account include (1) the health and ecology of the cetacean population, (2) cetacean exposure to tourism and other threats, (3) the characteristics of tourism activities, (4) policy and governance, and (5) social, economic and political aspects of the community where the tourism activities occur (Higham et al., 2009).

In this context, it is important to realize that impacts of tourism on cetaceans are partly due to a mismatch in the timeframe of social, economic and political processes (e.g., short-term profits, election cycles) and biological factors (sustainability of cetacean populations over a 50–100 year timeframe). Furthermore, data on (1) and (2) above may already indicate what is required for impacts on the target species to be sustainable but, when other layers are added, there is an argument made for compromise. The politics of compromise can be insidious, and undermine actions needed urgently. It is crucial that biological viability remains a core, non-negotiable goal; impacts on the target species should not be trumped by social need. A solid understanding of the social dimension (including tourism dynamics, policies, societal values and stakeholders' attitudes) should help identify the most effective course of management action. There is a risk, however, that a quest for holism may result in complexity and delay, so achievement of this ideal may need to be balanced with the need for urgency.

Information outputs need to be communicated effectively to managers, tour operators, and policy makers to facilitate translation into management action. This requires genuine engagement and continued collaboration, ideally with long-term relationships and working groups integrating four key stakeholders: the management agencies, the biologists, the tourism operators, and the social scientists (Higham et al., 2009). This approach should help to (1) streamline the development of management measures in response to research findings, (2) ensure that the lessons learnt from previous failings and successes extend beyond scientific reflection, and (3) incorporate valuable insights gained by managers, policy makers and tour operators into research considerations.

Multi-Stakeholder Collaboration

The management of cetacean tourism is chiefly about managing human behavior (Forestell and Kaufman, 1993). Understanding and involving the local human component is therefore essential for an effective transition to activities that are lower impact and truly sustainable. It is important for management agencies to collaborate with tour operators, community representatives, and researchers in the development of guidelines and regulations (Higham et al., 2009). Participatory, democratic and transparent forms of governance can contribute to management efficacy (Cooney, 2004) but a balanced oversight is needed to ensure that management remains timely, evidence-based and focused on shared objectives.

Permitted commercial tour operators represent arguably the most important, yet underestimated agency of positive change in the management of cetacean tourism. Studies of visitor experiences when engaging with rare and endangered species in New Zealand have highlighted the potential for commercial operators to contribute positively to conservation outcomes (Higham and Carr, 2003). Although not all operators conduct their businesses sustainably, there are visionary businesses which contribute directly to research programs, and offer leadership in community stewardship and conservation advocacy. The recently established "SMART Operator" program (Sustainable Marine Mammal Actions in Recreation and Tourism Participation), a voluntary collaboration between commercial boat operators and DOC, is providing interested operators with training and certification to operate more responsibly around marine mammals. While researchers need to remain independent of the industry, these operators can become strong allies in seeking positive change.

It is noteworthy that the Tourism Futures Taskforce (TFT) has recently been appointed by the Minister of Tourism to provide advice on rebuilding a sustainable, climate-safe New Zealand tourism industry following the COVID-19 pandemic (Tourism Futures Taskforce, 2020). The TFT seeks a post-COVID focus for tourism that shifts from mass tourism to values-based tourism, is aligned with the aspirations of local communities and measured in terms of net benefits in relation to the Living Standards Framework (LSF) and the four capitals (social, economic, environmental and cultural) (*Te Tai Ohanga* The Treasury, 2019). This move will require tourism operators to fundamentally shift from a depletive, volume-based approach, to a new "regenerative" sustainable tourism paradigm in nature-based tourism.

It is recognized that business models determine how cetacean tourism is practiced (Neves, 2010). In *te ao Māori* (the Māori worldview) the well-being of people cannot be separated from the well-being of the environment (Upton, 2019). *Kaitiakitanga* (guardianship of natural resources) is a concept embedded in the national legislation (Simmons, 2014), whereby cetaceans form part of the identity of a community. Indigenous business models (e.g., Whale Watch Kaikoura) founded on the principles of *kaitiakitanga*, *manaakitanga* (hospitality), and *tino rangatiratanga* (self-determination), seek to achieve long-term ecological integrity, the protection of *taonga* (treasures), cultural renaissance, community well-being and inter-generational wealth creation. These outcomes align with the principles of management efficacy and improved sustainability, and the role of such business models in reshaping cetacean tourism will need to be fully embraced in the emerging tourism paradigm (Upton, 2019; Tourism Futures Taskforce, 2020).

Research and conservation projects that build local expertise, resources and capacity are more likely to be resilient and to

continue independently from the principal investigators (Parsons et al., 2017). Moving away from "parachute research" (i.e., foreign scientists conducting research until their funding runs out and then leaving the site; Parsons et al., 2017) is a step toward ensuring conservation in areas where booming cetacean tourism lacks local research and management expertise, as it is often the case in developing countries and emerging destinations.

Working collaboratively, tourism operators, researchers and local communities can shift the essence of the visitor experience from fleeting entertainment, to deep and enduring engagement (Higham et al., 2014; Johnson and McInnis, 2014). Permit regulations currently compel tour operators to provide education and interpretation onboard their tours, however requirements are vague and effectiveness poorly documented. Evidence-based education, advocacy of conservation, awareness of animal welfare needs, and promotion of less obtrusive human-wildlife engagement could ultimately lead to higher compliance with existing regulations (Hoyt, 2012; Orams et al., 2014; Filby et al., 2015; Finkler et al., 2019; Lück and Porter, 2019). Involvement of tour participants in citizen science may also help promote public action (McKinley et al., 2017).

FUTURE CHALLENGES AND OPPORTUNITIES

The successful integration of precaution, adaptation, and community involvement into a more holistic approach to cetacean tourism is an important challenge. While some examples of addressing this challenge have been introduced in previous sections, specific recommendations for further implementation are presented in **Table 6**. At a national level, we encourage improvements in legislation, policies and practice. Among the priority actions listed, we suggest a revision of the current permit scheme and protected areas, a development of a National Plan for cetacean tourism, an update of the 2005–2010 Marine Mammal Action Plan, as well as the issue of more site-specific regulations applying to all users, including non-permitted operators and the public. Long-term multi-disciplinary research programs, research-informed advancement in education and engagement of the public, and ongoing collaboration between research and management are needed at each New Zealand destination. Finally, we report the latest recommendations issued by researchers in the five case studies (**Table 6**).

We emphasize that a prompt intervention to address current management weaknesses is particularly important as increasing anthropogenic threats, and in particular climate change, exacerbate pressures on marine ecosystems and will inexorably have societal repercussions (Hughes, 2000; Hoegh-Guldberg and Bruno, 2010). Health and welfare of cetaceans are already in decline (Gulland and Hall, 2007) and expected to worsen (Simmonds, 2017; Nunny and Simmonds, 2020) due to effects on their habitat and biology (Learmonth et al., 2006; Kaschner et al., 2011, 2019; Schumann et al., 2013). Inevitably, cetacean tourism operations will also be affected (Lambert et al., 2010). We must now use the tools available to identify species and populations most vulnerable to climate change (e.g., Dawson et al., 2011; Silber et al., 2017; Simmonds, 2017; Becker et al., 2019), and act to increase their resilience by mitigating effects of non-climatic threats (including tourism). As environmental conditions continue to change, multi-stakeholder systems need to ensure continued support to cetacean tourism research, conservation and management.

CONCLUSIONS

New Zealand has several destinations with mature cetacean tourism industries, a research community with a long history of engagement in marine conservation, a well-educated population, a strong economy, and a society with a strong connection to natural heritage. These characteristics place the country in a privileged position of advantage to manage tourism impacts well and responsibly. Nonetheless, the history of cetacean tourism is complex. On one hand, New Zealand has a reasonable regulatory base (MMPA and MMPR, site-specific permit conditions), established partnerships for evidence-based management, and long-term studies and monitoring. As evidenced by a few case studies, cetacean tourism can be managed in ways that are economically successful while reducing disturbance to populations (e.g., Doubtful Sound, Kaikoura, Hauraki Gulf). On the other hand, it has largely failed to timely intervene on populations experiencing local declines (e.g., Bay of Islands), there is no national plan for managing cetacean tourism, and no strategy to manage the multiple, co-occurring anthropogenic threats to cetaceans. In most cases, evidence-based recommendations have been ignored or partially implemented. In others, scientific data to guide tourism management is still completely missing.

This review indicates that the availability of robust scientific information, and recommendations to be precautionary are not sufficient preconditions for sustainable management to take effect. Conflicting interests, socio-economic pressures, ambiguity, political power struggles, ineffective scientific guidance, lack of societal vision and momentum, or all of the above, can weaken or stymie management actions. The proximal and ultimate causes of management inefficiency are complex and often difficult to tease apart. It is paramount that proactive collaborations are established between the interested parties, including scientists, managers and tour operators.

A necessary step forward, in New Zealand and elsewhere, is to declare in clear, unambiguous terms what levels of risk to marine mammal individuals and populations we are willing to tolerate. Once this moral, scientific, and societal decision is reached, scientists will be in a much better position to devise appropriate research in support of actionable policies. The research community has also the great responsibility to advocate for, and to help catalyze the transition to more resilient management systems, engaged communities, and research programs causing the least detriment to wild cetaceans, while providing timely and robust information for policy. The majority

of current New Zealand permits and moratoria expire in 2022–2026: there is a window of opportunity for comprehensive action on the next generation of permitted operations and the post-COVID scenario. Looking forward, we recommend that stakeholders engage without delay in formulating a clear policy and vision for this industry, and in developing an integrated, holistic and adaptive research and management system to tackle the future of cetacean tourism and conservation in New Zealand.

AUTHOR CONTRIBUTIONS

SD encouraged and initiated the study. MF and MG led the design of the study and the writing of the manuscript with contributions and support from all authors. The preparation of the case studies received significant support from TB and RC (Bay of Islands), TB and KS (Hauraki Gulf), WC and ES (Akaroa Harbour), WR (Kaikoura), SD and JH (Doubtful Sound). WC contributed the artwork. All authors critically reviewed the final manuscript.

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