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PERSPECTIVE

Protecting our coast for everyone's future: Indigenous and scientific knowledge support marine spatial protections proposed by Central Coast First Nations in Pacific Canada

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Abstract

1. We, the Haíłzaqv, Kitasoo Xai'xais, Nuxalk and Wuikinuxv First Nations, are the traditional stewards of our territories in the Central Coast of British Columbia, Canada. Our traditional laws obligate us to manage and protect our territories for current and future generations. Spatial management is inherent to our cultures through the Hereditary Chief governance system, in which specific people within a lineage inherit the rights and responsibilities for stewarding specific areas.
2. Since the 19th century, we have been experiencing cultural disruptions caused by settler colonialism, which are now worsened by the declines of marine species vital to our cultures. These declines reflect fishery impacts exacerbated by climate change.
3. Western fisheries management focuses on maximum sustained yields (MSY), ignoring body size declines that disrupt food webs and diminish population productivity for vertebrate and invertebrate taxa, thereby eroding resilience to climate change. The worldview encompassed by the MSY framework—*take the most that you can without compromising future exploitation while assuming no environmental change*—is the antithesis of ours—*take only what you need and leave lots for the ecosystem*. Furthermore, standard stock assessments do not account for uncertainties inherent to climate change effects on distributions and productivity, and many by-catch species are unassessed.
4. Consistent with our traditional knowledge, scientific evidence indicates that marine protected areas (MPAs), coupled with other measures to reduce fishing mortality, can restore exploited species, safeguard biodiversity and contribute to fisheries sustainability.
5. In the 2000s, we paired Indigenous knowledge and Western science to develop marine spatial plans. These plans are foundational in our contribution to the ongoing development of the Marine Protected Area Network for Canada's

Northern Shelf Bioregion (MPAN-NSB), for which we are co-governance partners with 14 other First Nations and the governments of Canada and British Columbia.
6. Our proposed spatial protections for the MPAN-NSB encompass areas important to many exploited taxa and to corals, sponges, eelgrass beds and other carbon stores. Their implementation would fill conservation gaps which have persisted under current fishery management.
7. Given our history of spatial management through the Hereditary Chief governance system, the MPAN-NSB is a culturally appropriate way forward for marine conservation in our territories.

KEYWORDS
fisheries, indigenous knowledge, indigenous-led conservation, marine protected areas, marine spatial management, values

1 | INTRODUCTION

1.1 | Positionality statement

Our work builds on Indigenous knowledge and Western science. When combined synergistically, these two knowledge systems can improve our understanding of past, present and future ecosystems (Kimmerer, 2002; Ban et al., 2018; Reid et al., 2021), and help guide the transformation—in values, policies and actions—that society must rapidly undertake to meaningfully reduce biodiversity loss and climate disruption (Artelle et al., 2018; Díaz et al., 2019). Our combined positionalities transcend and bridge both knowledge systems. The Indigenous members of our team—Mike Reid, Muxvpenstista (Lena Collins) and Hereditary Chiefs Smawn (Richard J. Hall) and Ernest Mason—are deeply connected to their traditional territories, where they live, engage in their cultures, harvest foods and medicines from the land and sea and work in fisheries management and marine spatial planning, often applying the tenets of Western science. Gord McGee and Alejandro Frid are settlers with academic training in resource management and ecology who apply their training while forging their own connections to the territories and communities of their co-authors. All authors work together under the umbrella of the Central Coast Indigenous Resource Alliance. To create this work, we met regularly over many months, pored over many drafts and incorporated feedback from other Indigenous and non-Indigenous colleagues.

Our messages are told in two voices. The Indigenous voice conveys culture and lived experience, often without citations because it represents what the Indigenous authors have experienced directly or been taught through oral traditions. The Scientific voice synthesizes published scientific findings, thereby using technical language and academic conventions. The two voices often intertwine, exemplifying how Indigenous Nations can embrace science while honouring and practicing their ancestral teachings and governance and, conversely, how those trained in Western science can practice their discipline with openness to a plurality of knowledge systems.

1.2 | Background and objectives

We, the Haíɫzaqv, Kitasoo Xai'xais, Nuxalk and Wuikinuxv Nations, are the title and rights holders of our unceded territories in the Central Coast of what is now known as British Columbia (BC), Canada (Figure 1). Our stories, songs, dances and family lineages codify knowledge and responsibilities that connect us to our territories. Prior to colonization, our populations were large and our fishing technologies sophisticated yet, over the centuries, our traditional laws and practices precluded us from depleting our local resources (Ban et al., 2020; Beveridge et al., 2020; Brown & Brown, 2009; Campbell & Butler, 2010). Today, we draw upon the knowledge and wisdom of our ancestors, Elders, stewardship committees and science partnerships to fulfil our obligation to manage and protect our territories for current and future generations. Fundamental to this task are our traditional laws, which build on the following principles:

Respect–All living beings deserve respect and need to be cared for. Take only what you need and heal any damages that occur to the lands and waters. Be patient and go slow; consider the long-term sustainability of your plans with careful forethought.

Balance and interconnectedness–All living beings are interconnected and changes to one species can cascade through the natural world, which affects intergenerational equity.

Intergenerational knowledge—We learn from the past and adapt our knowledge and decisions based on experience.

Reciprocity–The natural world provides us with everything that is necessary; we take care of the natural world first and it takes care of us.

These principles (Table 1) are consistent with what Western scientists now call ecosystem-based management (EBM) which, unlike conventional resource management, focuses on broad ecosystem dynamics and their linkages to people (Grumbine, 1994; Francis et al., 2007). We have been practicing EBM for thousands of years (Adams et al., 2021; Mathews & Turner, 2017).

Colonization brought external forces that altered our territories and, until recently, disrupted the application of our traditional laws.

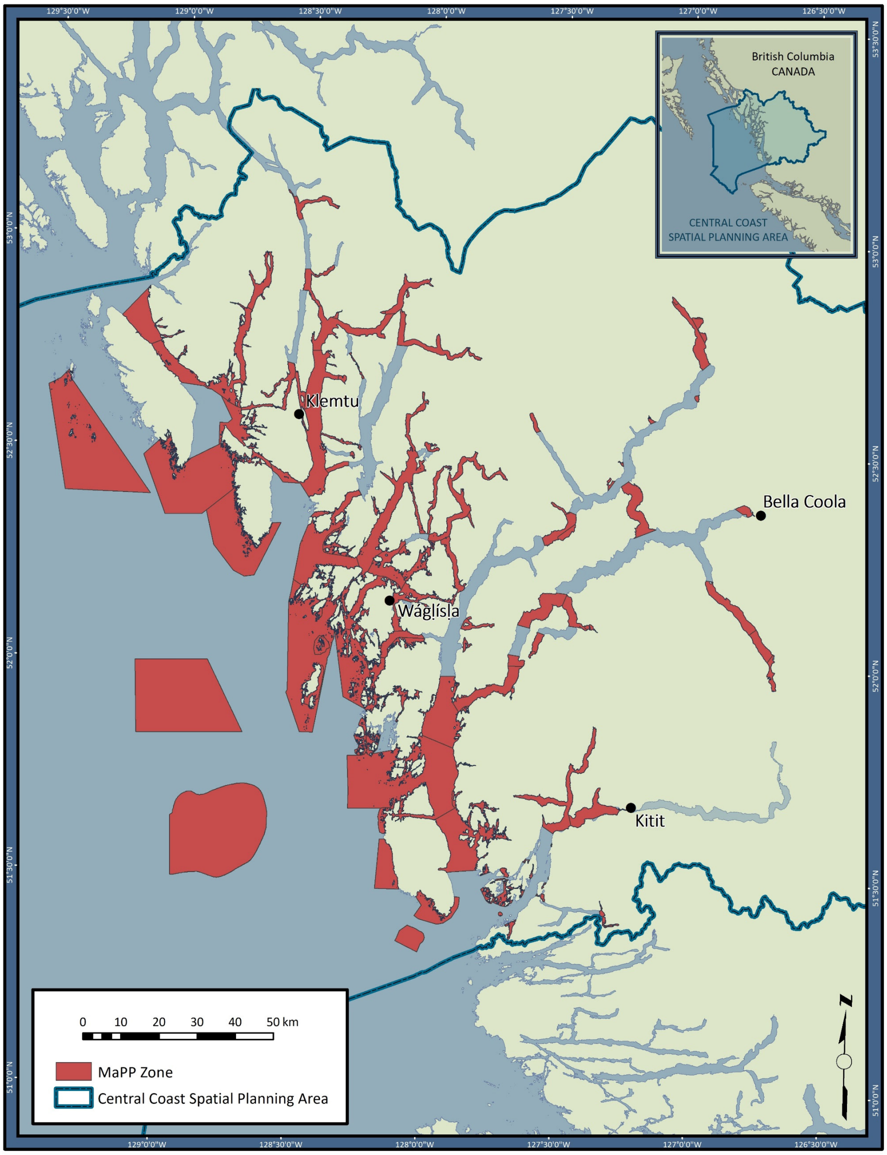

FIGURE 1 The Central Coast subregion of Canada's northern shelf bioregion, including communities (Klemtu, Kitasoo Xai'xais Nation; Wágḷísḷa, Haíɫzaqv Nation; Bella Coola, Nuxalk Nation; Kitit, Wuikinuxv Nation.) and spatial management zones detailed in MaPP (2015). The inset locates the central coast subregion within British Columbia, Canada

Over the last century, we have observed precipitous declines of marine species essential to our ecosystems, cultures and economies (Table 2; Appendix S1). These declines primarily reflect the mismanagement of commercial and recreational fisheries (Kitasoo/Xai'xais First Nation, 2022; Steel et al., 2021; Yamanaka & Logan, 2010), yet climate change and ocean acidification are exacerbating the problem (Haigh et al., 2015; Weatherdon et al., 2016; Whitney et al., 2020). The effects of industrial shipping—including noise pollution and oil spills—are also affecting our territories and ways of life (Erbe et al., 2014; Heiltsuk Tribal Council, 2017).

To address these problems, in the 2000s, each of our Nation's developed marine use plans which apply an EBM approach (CCFN, 2012). Our plans build on our traditional laws and Western science and aim to re-establish the natural balance through conservation and protection of ecosystems. In the process, we created the Central Coast Indigenous Resource Alliance, which enables our four Nations to collaborate in marine conservation, research and fisheries management. As we later elaborate, our marine use plans are foundational to our contribution in the ongoing development of a Marine Protected Area Network for Canada's Northern Shelf Bioregion (MPAN-NSB; Watson et al., 2021).

In 2014, the governments of 18 First Nations (including our four Nations), the Provincial Government of BC and the Government of Canada—primarily represented by Fisheries and Oceans Canada (DFO: the federal aquatic ecosystem and resource management agency)—became co-governance partners in developing the MPAN-NSB (Watson et al., 2021). The current scenario for the MPA network was built over 7 years of scientific advice (e.g. Gale et al., 2019; Martone et al., 2021), spatial analyses (e.g. Frid et al., 2021; Rubidge et al., 2018, 2020), Indigenous knowledge inputs and engagement between co-governance partners and stakeholders.

The development of the MPAN-NSB is grounded in the premise that protected and interconnected areas representing the regional diversity of species and habitats will help reverse ecological decline (Baskett & Barnett, 2015; Carr et al., 2017; Roberts

TABLE 1 Expanded description of principles fundamental to our traditional laws that are consistent with ecosystem-based management

Principle	Description
Respect	The need for respect in interacting with the natural world and other humans is described in numerous First Nation oral histories. It encompasses the maintenance and restoration of ecological integrity, stewardship of resources and places, being inclusive and participatory and applying the precautionary principle to ensure that decisions today are not detrimental to future generations
Balance and interconnectedness	Balance ensures the intergenerational equity (fairness to future generations) that has sustained First Nations cultures through time; it encompasses the modern concepts of sustainable use, integrated management and the fair distribution of costs and benefits. Interconnectedness recognizes that all components of an ecosystem, including humans, are interlinked
Intergenerational knowledge	Within Central Coast First Nations communities, 'listening to your Elders' speaks to intergenerational transfer of knowledge. Adaptive management is a modern term that expresses the similar concept that decisions should be based on learning from past experience. Intergenerational knowledge and successful adaptive management require good communication
Reciprocity	The act of giving thanks is practiced throughout Central Coast First Nations cultures. Reciprocity within and between clans, and reciprocity with the spirit world is necessary. The principle of reciprocity speaks to shared responsibility and community—two themes, which are cornerstones of First Nation's culture. Through this principle, we recognize that the natural world provides us with everything that is necessary; we take care of the natural world first and it takes care of us

et al., 2017), bolstering the well-being of our communities (Ban, Gurney, et al., 2019). Scientific evidence indicates that MPANs support ecological health and benefit fisheries by promoting: (i) greater population productivity of exploited species, (ii) the export of fish and invertebrates, as adults or larvae, from protected to fished areas and (iii) resilience to climate change and other environmental shifts (Baskett & Barnett, 2015; Micheli et al., 2012; Roberts et al., 2017). This evidence is consistent with our traditional knowledge on the benefits of spatial protections (Ban, Wilson, et al., 2019; Frid et al., 2016). Given that scientific and Indigenous approaches to marine conservation are compatible and complementary (Ban et al., 2018; Kimmerer, 2002; Reid et al., 2021), our contributions enhance the potential conservation effectiveness of the MPAN-NSB.

Evidence that marine protected areas (MPAs) rebuild exploited populations and benefit fisheries already is clear for the temperate coasts of countries that established and began monitoring MPAs decades ago (e.g. New Zealand, Qu et al., 2021; Willis et al., 2003; South Africa, Kerwath et al., 2013; USA–California, Caselle et al., 2015; Lenihan et al., 2021; USA–New England, Murawski et al., 2005; Australia's temperate region, Bosch et al., 2022). Canada, however, has lagged in the establishment, biological monitoring and compliance enforcement of MPAs (Jamieson & Levings, 2001), and—with few exceptions (e.g. Martell et al., 2000; Wallace, 1999)—lacks local evidence for MPA benefits. Still, there is no compelling biological argument suggesting that the types of spatial protections which have produced benefits elsewhere would not yield similar results in the MPAN-NSB.

The objectives of this paper are to (1) review how we used traditional knowledge and science to develop our marine use plans; (2) describe the impacts of species declines and ecosystem shifts on our cultures, and the contributions of fisheries and climate change to these problems; (3) discuss how current fisheries management fails to meet conservation objectives inherent to both our traditional laws and to EBM; and (4) use our traditional knowledge and the global conservation literature, with an emphasis on temperate study areas, to support our assertion that the MPAN-NSB can help rebuild biodiversity, benefit fisheries and help restore and maintain ecosystem functions that enhance resilience to climate change. The first objective establishes our positionality as traditional stewards and EBM practitioners. The second and third set the context for why marine spatial protections are needed. The fourth aims to establish a baseline of shared understanding among co-governance partners and stakeholders engaged in the development of the MPAN-NSB.

That shared understanding is critical because an MPAN that is developed and managed collaboratively by First Nations, Federal and Provincial governments will help rebuild and sustain habitats and species vital to our ecosystems and ways of life. In doing so, it will support our ability to rely upon and practice traditional marine management and contribute to a diverse economy for all Canadians. An MPAN that achieves these outcomes will reflect the principles of reconciliation committed to by Indigenous, provincial and federal governments.

2 | DEVELOPMENT OF OUR MARINE USE PLANS

Spatial management has always been inherent to our cultures through the Hereditary Chief governance system: a form of marine tenure in which specific people within a lineage inherit the rights and responsibilities for stewarding specific areas (Atlas et al., 2020; Ban, Wilson et al, 2019; Brown & Brown, 2009). Adapting that system into a modern context, in the early 2000s, each of our Nations developed their own marine use spatial plans. The work was carried out by community-based planning committees comprised of Hereditary Chiefs, Elders, elected councillors, commercial fishers and representatives from Nation-level agencies. Biologists, planners

TABLE 2 Summary of temporal trends of selected species that are culturally and/or ecologically significant. ECPs are species recommended as ecological conservation priority for the MPAN-NSB (Gale et al., 2019). These examples represent only a subset of biodiversity losses in our territories. For brevity, asterisks (*) indicate that literature citations already are provided in the main text (see 'species declines')

Species group	Common name	Scientific name	ECP	Ecological and cultural role	Trend in the central coast
Corals and sponges	Large-bodied sponges	Classes Hexactinellidae and Demospongiae	Yes	Habitat forming; food web base; water filtering; carbon sequestration*	Cumulative damage from bottom-contact fishing gear has been severe in some areas*
	Structural corals	Orders Antipatharia, Alcyonacea and Anthoathecata	Yes	Habitat forming; food web base; carbon sequestration*	Cumulative damage from bottom-contact fishing gear has been severe in some areas*
Crustaceans	Dungeness crab	*Cancer magister*	Yes	Traditional food; consumer*	Catches by Indigenous fishers declined by 77% in recent years (1997–2016) relative to earlier years (1926–1996)*
	Spot prawn	*Pandalus platyceros*	Yes	Traditional food; Forage species (Gale et al., 2019)	Ongoing local declines experienced by Indigenous fishers
Echinoderms	Giant sea cucumber	*Apostichopus californicus*	No	Traditional food	Ongoing local declines experienced by Indigenous fishers
Forage fish	Eulachon	*Thaleichthys pacificus*	Yes	Traditional food; forage species; nutrient transport; directly supports multiple predators*	Stocks that use Central Coast rivers (including Bella Coola and Wanuxv) declined severely since the late 1990s and remain depressed*
	Pacific herring	*Clupea pallasii*	Yes	Traditional food; nutrient transport, directly supports multiple predators*	The aggregate biomass declined from 1981 to historic lows in 2006–2012. Though signs of recovery have occurred since, biomass declined in 2020 and 2021 Appendix (S2)
Molluscs	Geoduck	*Panopea generosa*	Yes	Traditional food; habitat-forming species (Gale et al., 2019)	Since the 1980s, local declines experienced by Indigenous fishers have been ongoing
	Northern abalone	*Haliotis kamtschatkana*	Yes	Prey to diverse predators*	Due to commercial overfishing, coastwide fisheries have been closed since 1990. For the Central Coast, fishery independent survey documented an 83% decline in mean densities between 1978 and 2006, with most of the decline occurring prior to 1990*
Rockfishes	Quillback rockfish	*Sebastes maliger*	Yes	Traditional food; high trophic position*	Strong declining trend in biomass between the 1980s and early 2000s, which coincided with the rapid rise of commercial fisheries in the 1980s. The trend appears to have stabilized, with spawning biomass in 2011 being 37% of the 'unfished' biomass (median estimate) (DFO, 2012). Between 2006 and 2015, however, mean total length declined at an average rate of 4.57 mm/year (McGreer & Frid, 2017), which suggests ongoing effects of overexploitation on size-dependent fecundity and trophic position*

TABLE 2 (Continued)

Species group	Common name	Scientific name	ECP	Ecological and cultural role	Trend in the central coast
	Yelloweye rockfish	*Sebastes ruberrimus*	Yes	Traditional food; High trophic position*	Between 1980 and the 2010s, following the rapid rise of commercial fisheries biomass declined precipitously. The trend appears to have stabilized, with spawning biomass in 2018 being 35% of the 'unfished' biomass (median estimate of weighted operating model for North Outside Stock: Cox et al., 2020). Median body length in the catches of Indigenous fishers declined from 84 cm in the 1980 to 46 in the 2010s* Since at least 2003, average age has been declining by nearly 10 months each year while average length has been shrinking by ≈4 mm each year (McGreer & Frid, 2017), which suggests ongoing effects of overexploitation on size-dependent fecundity and trophic position*
Pacific salmon	Chinook	*Oncorhynchus tshawytscha*	Yes	Traditional food; Forage species, nutrient transport, directly supports multiple upper level predators*	Relatively stable numbers between 1980 and 2019 (Appendix S1). However, the high proportion of hatchery spawners in the Atnarko and Wannock River likely are masking declines for wild stocks, and the relatively poor returns of wild spawners warrant concern for long-term productivity (Appendix S1)
	Chum	*Oncorhynchus keta*	Yes	Traditional food; forage species, nutrient transport, directly supports multiple upper level*	On average, 58% decline between a historical baseline (1960–1990) and recent years (2015–2020; Appendix S1)
	Coho	*Oncorhynchus kisutch*	Yes	Traditional food; forage species, nutrient transport, directly supports multiple upper level predators*	Downward trend to the 1990s and again since 2015, particularly during 2018–2020 (Appendix S1)
	Pink	*Oncorhynchus gorbuscha*	Yes	Traditional food; forage species, nutrient transport, directly supports multiple upper level predators*	On average, 78% decline between a historical baseline (1960–1990) and recent years (2015–2020) (Appendix S1)
	Sockeye	*Oncorhynchus nerka*	Yes	Traditional food; forage species, nutrient transport, directly supports multiple upper level predators*	On average, 91% decline between a historical baseline (1960–1990) and recent years (2015–2020) (Appendix S1)
Seaweeds	Bull kelp and giant kelp	*Nereocystis leutkeana* and *Macrocystis* sp.	Yes	Substrate for traditional spawn on kelp herring fisheries; habitat forming and nutrient transport (Gale et al., 2019)	Regional and global declines are ongoing due to synergistic effects of ocean warming, loss of predators that consume grazers, and (in some areas) over-harvesting (Hamilton et al., 2022; Krumhansl et al., 2016)
	Black seaweed	*Pyropia abbottiae*	No	Traditional food;	During a recent marine heatwave traditional harvesters experienced a severe decline, with a low point reached in 2016. More recently, the marine heatwave has subsided, and traditional harvests have stabilized, albeit less productively due to reduced abundance

(Continues)

and GIS analysts supported the work. Indigenous knowledge and scientific data were combined to delineate ecologically important areas. These areas included juvenile-rearing habitats, larval sources and dispersal corridors for species that were depleted and/or of cultural significance, as well as areas of outstanding biodiversity.

In 2012, our four Nation-level plans were integrated into the *Central Coast First Nations Integrated Marine Use Plan*: 'a harmonized reflection of the goals, objectives and strategies of the Heiltsuk [Haíłzaqv], Kitasoo Xai'xais, Nuxalk and Wuikinuxv Nations (CCFN, 2012)'. Conservation dominates these goals and objectives. Consistent with the scientific literature (Roberts et al., 2017), the integrated marine use plan states that 'A larger genetic pool, and healthier species populations and ecosystems will better enable species to respond to a changing climate. We plan to increase the resiliency of species and ecosystems through spatial planning, reduced harvesting, and mitigation of other human impacts (CCFN, 2012)'.

Starting in 2011, our marine use plans became the basis for our input into the Marine Planning Partnership (MaPP): a spatial planning process our governments co-led with the governments of 14 other First Nations and of British Columbia (Diggon et al., 2020). The process included stakeholder engagement and in 2015 produced the *Central Coast Marine Plan* (MAPP, 2015), which delineated a network of spatial management zones (Figure 1). MaPP, however, could not legislate MPAs that exclude or limit fisheries; under federal law only DFO, not an MaPP partner, has that authority (Diggon et al., 2020).

The formal process for developing the MPAN-NSB began in 2014, this time with DFO and other federal agencies at the table (Watson et al., 2021). Through that process, our spatial management zones from MaPP (Figure 1) were adapted into the current scenario for the Central Coast Subregion of the MPAN-NSB. That scenario is expected to become available for stakeholder engagement in the latter part of 2022 (prior engagement occurred during each year of 2016–2021).

3 | IMPACTS OF SPECIES DECLINES ON HAÍŁZAQV, KITASOO XAI'XAIS, NUXALK AND WUIKINUXV PEOPLES

Since the 19th century, we have been experiencing social, cultural and economic disruptions caused by settler colonialism. These disruptions have caused cumulative impacts to our Nations which, as we later describe, are now worsened by species declines (Table 2).

Our Nations' first objective has always been to steward the natural world; everything else flows from that responsibility. Not being able to carry out this duty causes tremendous cultural loss, despair, stress, anger and uncertainty in our communities. Like other Indigenous Peoples, we experience species declines as a form of colonial oppression (Eckert et al., 2018; Whyte, 2018).

Food has always connected our peoples through trade networks and ceremonies. In contrast to Eurocentric views in which individual status grows with accumulated wealth, in our cultures, Hereditary Chiefs and Matriarchs increase their status by redistributing their own wealth—including foods harvested from the land and sea—to others during Potlatch ceremonies. Through this gift giving, Potlatches fulfil many social, governance and economic functions, and formally express gratitude and respect towards the plants and animals that gave themselves to people (Ban et al., 2020; Ban, Wilson et al., 2019; Brown & Brown, 2009). Furthermore, when individuals travel from another village to attend a Potlatch, they gift foods and medicines from their own territory to the hosting Chief; the gifts from other areas are highly valued as part of the richness and diversity of resources that uplift the Chieftainship. As for other Indigenous Peoples, our food needs cannot be quantified solely as basic dietary requirements (Donatuto et al., 2016).

Although economic and food security losses from species declines can potentially be quantified, the cultural losses often are 'invisible' to Western paradigms. Cultural losses include health and economic impacts—such as increased reliance on low-quality store-bought foods due to lost fishing opportunities—but the greatest costs are loss of self-determination, identity or sense of order in the world (Turner et al., 2008). Our communities know these losses through the declines of cultural keystone species (Table 2). Our proposed zones for the MPAN-NSB strive to support recovery of these species and their ecosystems.

Our food security also encompasses food sovereignty, authority and access. The COVID-19 pandemic has at times reduced our access to store-bought foods because of breakdowns in supply chains, increasing our reliance on local marine foods. Food insecurity in Indigenous communities across Canada has led to increased rates of disease (Reading, 2015). Although the impacts of reduced food sovereignty and security have yet to be estimated for our communities, the economic, social and cultural costs have been significant. An MPAN-NSB that supports continued access to the foods that have sustained us for millennia will also benefit our physical, mental and cultural health.

We are also concerned about loss of future economic opportunities. As detailed in a later section, well-managed MPAs can enhance fisheries through the spillover of larvae and adults (Barceló et al., 2021). Central Coast Nations and other Canadians would benefit from the MPAN-NSB's contribution to a diverse economy that includes commercial fisheries, wilderness tourism and other ventures.

4 | EXAMPLES OF SPECIES DECLINES

This section describes the declines of selected species (or species groups) that meet multiple conservation criteria and therefore are recognized as ecological conservation priorities for the MPAN-NSB (Gale et al., 2019). These species also are foundational to our stories, legal systems, social structures and economies; without any of them, our ecosystems and ways of life would be diminished. Because all of these species are important to us, we present them in alphabetical (i.e. neutral) order. Table 2 summarizes these and other examples of declining species.

4.1 | Dungeness crab

Dungeness crab *(Cancer magister)* are important predators of molluscs and scavengers (Gale et al., 2019) and a key traditional food. Catches by our food fishers declined by 77% in recent years (1997–2016) relative to earlier years (1926–1996) (Ban et al., 2017). Ecological modelling indicated that successful food harvesting trips (which fishers defined as catching 15 crabs with a two-trap set) were unlikely to occur at eight of nine sites surveyed during 2014–2015. Food fishers associated the timing of the decline with increased exploitation by commercial and recreational sectors (Ban et al., 2017).

At least three studies, two in BC (Burns et al., 2020; Frid et al., 2016) and one in Alaska (Taggart et al., 2004), indicate that spatial protections promote rapid rebuilding of Dungeness crab sizes and abundances.

4.2 | Eulachon

Eulachon (*Thaleichthys pacificus*) transport nutrients from offshore areas to nearshore and riparian ecosystems and are important prey for many predators (Gale et al., 2019; Marston & Willson, 2002). Eulachon are extremely nutritional and were historically called the 'salvation fish', as they arrived early in spring, when our communities were low on nutrient-dense foods. Beyond their nutritional value, eulachon hold ceremonial, legal and social roles within our cultures, and are essential to trade relations (Beveridge et al., 2020; Moody, 2008).

During the late 1990s, our fishers experienced the precipitous decline of eulachon spawners in the Bella Coola and Wanuxv Rivers, where runs have yet to rebound (Moody, 2008). The collapse coincided with the expansion of shrimp trawl fisheries, for which eulachon is a significant by-catch species; yet environmental changes may also have contributed to the decline (Moody, 2008). In 2011, eulachon were assessed as Endangered on the Central Coast (COSEWIC, 2011). For over 20 years, our communities have not had access to eulachon in harvestable numbers, which has disrupted familial relations, intergenerational teachings and seasonal harvesting rhythms (Beveridge et al., 2020; Moody, 2008).

Recent research found that LED lights attached to shrimp-trawling gear reduced eulachon by-catch by 91% (Hannah et al., 2015). To their credit, shrimp trawlers approached DFO with the desire to use LED lights and the practice is now mandatory (DFO, 2021). While we welcome this improvement, by-catch reduction is not 100% effective, and our eulachon populations remain depressed. Our proposed zones for the MPAN-NSB include shrimp trawl exclusions to protect eulachon. MPAs also can contribute to eulachon restoration by protecting estuaries.

4.3 | Kelp and other seaweeds

Kelps (order Laminariales) are foundation species that create physical structures used by diverse life-forms. They provide habitat for myriad organisms that live on them, including smaller seaweeds, crabs, snails and other invertebrates. They also create a forest-like habitat used by many species of juvenile fish, including rockfish (Hamilton et al., 2022).

Some kelps are inseparable from our cultures. During spawning season, Pacific herring (*Clupea pallasii*) aggregate around kelp, and the fertilized eggs attach to the kelp fronds, which provides the foundation for our spawn-on-kelp fisheries (Gauvreau et al., 2017; Kitasoo/Xai'xais First Nation, 2022). We also eat smaller seaweeds of the genus *Pyropia* (formerly *Porphyra*); we have such a high regard for *Pyropia* that each coastal Indigenous language has its own name for this seaweed (Turner, 2003).

Kelps, *Pyropia* and other seaweeds are among the proverbial canaries in the coal mine for ocean warming because warming of less than one degree Celsius can decrease their growth and productivity (Kobluk et al., 2021; Krumhansl et al., 2017). During the marine heatwave (Cheung & Frölicher, 2020) that peaked in our waters in 2015–2016, *Pyropia* productivity crashed. Harvesters estimated an 80%–90% decline relative to typical years, with great impact to our communities.

During the same marine heatwave, harvesters noticed a *Membranipora* outbreak on kelps. *Membranipora* are an encrusting bryozoan and native to our coast. Cooler waters usually keep them in check, and harvesters recognized the outbreak as a symptom of the marine heatwave. These observations catalysed research by our Nations and academic partners (Denley et al., 2022).

Other threats to kelp include commercial harvests and outbreaks of urchins, which are herbivores that overgraze kelp (Hamilton et al., 2022). MPAs that exclude commercial harvests could increase the resilience of kelp and other seaweeds to a warmer ocean (Hamilton et al., 2022).

4.4 | Northern abalone

Northern abalone (*Haliotis kamtschatkana*) are important prey for many predators (Gale et al., 2019) and a key traditional food. Due to commercial overfishing, coastwide fisheries have been closed since 1990. For the Central Coast, mean densities declined by 83% between 1978 and 2006, and most of the decline occurred before 1990 (COSEWIC, 2009). Models applying traditional knowledge and scientific data estimate that large size classes declined at an annual rate of 3.7% between the 1940s and the 2010s (Lee et al., 2019). Although northern abalone are scarcer today than in the mid-1900s, their current abundance exceeds that of the early 1800s, before exploitation by the commercial fur trade nearly extirpated sea otters, which are major predators of macroinvertebrates. The recent geographic and demographic expansion of sea otters is contributing to current low abundances of abalone (Lee et al., 2019).

Abalone are low-mobility broadcast spawners susceptible to Allee effects at low population densities (Stierhoff et al., 2012). MPAs have been effective for restoring and conserving densities and body sizes of northern abalone in BC (Wallace, 1999) and of other abalone species elsewhere (Micheli et al., 2012; Rogers-Bennett et al., 2002).

4.5 | Rockfish

Of approximately 36 rockfish species in BC, 21 are ecological conservation priorities, which reflects the ecological importance of the genus *Sebastes* (Gale et al., 2019). Two of these species, quillback and yelloweye rockfish (*S. maliger* and *S. ruberrimus*), are among our key traditional foods. Importantly, quillback and yelloweye rockfish are predators that occupy a high trophic position (Olson et al., 2020) and therefore may potentially influence species diversity (Heithaus et al., 2008) on rocky reefs. Marked declines in the biomass of quillback and yelloweye rockfish began in the early 1980s, as commercial fisheries expanded (Cox et al., 2020; DFO, 2012). Although biomass declines appear to have tapered off in recent years (Cox et al., 2020; DFO, 2012), the median body length of yelloweye rockfish in the catches of Indigenous fishers declined from 84 cm in the 1980s to 46 cm in the 2010s (Eckert et al., 2017) and the body sizes of both species were trending downward, rapidly, between the 2000s and the mid 2010s (McGreer & Frid, 2017). Because larger individuals are more fecund (Dick et al., 2017) and occupy higher trophic positions (Olson et al., 2020), body size declines signal reductions in population productivity (Marshall et al., 2021) and disruptions to marine food webs (Cheng et al., 2019).

Some rockfishes have very small home ranges and strong fidelity to complex reefs, including quillback and yelloweye rockfish, and therefore may strongly benefit from even small MPAs (Hannah & Rankin, 2011). Long-term research in California indicates that spatial protections can help rebuild the densities and body sizes of rockfish and of lingcod (*Ophiodon elongatus*: a co-occurring, highly mobile, fished species) (Caselle et al., 2015; Keller et al., 2019; Starr et al., 2015; Thompson et al., 2017). Also, research within the NSB points to differences between protected and fished areas in the trophic structure of rockfishes and lingcod (Olson et al., 2019). MPA benefits for rockfish, however, may require many years to accrue and the required time may vary between species and locations (McGreer et al., 2020; Starr et al., 2015).

Our science programmes have mapped biological hotspots where rockfish abundances and species diversity are outstanding. These hotspots are candidates for the highest protection levels afforded by the MPAN-NSB (Frid et al., 2021).

4.6 | Pacific herring

Similar to eulachon, Pacific herring transport nutrients from offshore areas to their nearshore spawning areas, where they provide a seasonal pulse of nutrients to diverse predators (Gale et al., 2019; Surma et al., 2018). Our traditional harvest of this species has been managed sustainably for thousands of years (Gauvreau et al., 2017; Kitasoo/Xai'xais First Nation, 2022; McKechnie et al., 2014). Herring in our territories, however, have undergone recent periods of severe decline caused by fisheries and exacerbated by shifts in natural mortality (Appendix S2).

Poor environmental conditions may cause low recruitment or high natural mortality, thereby reducing the biomass of herring stocks. Without fisheries, biomass may recover relatively quickly as environmental conditions improve. Under fishery exploitation, however, biomass declines that might have been mild and short-term turn more severe and last longer (Essington et al., 2015). Herring also are very vulnerable to marine heatwaves and climate change (Cheung & Frölicher, 2020; Weatherdon et al., 2016). Therefore, we are very concerned about the lack of spatial management for herring fisheries. We have always recognized that herring form distinct substocks, each associated with specific spawning areas and scientific analyses are consistent with our traditional knowledge (Okamoto, Hessing-Lewis, et al., 2020; Petrou et al., 2021). Accordingly, we have always managed our herring fisheries at the scale of spawning areas (10s of km^2). DFO, however, aggregates substocks at regional scales (1000s of km^2) to make management decisions, which is risky because a few strong substocks may dominate the regional trend and obscure declines for substocks at risk of collapse (Okamoto, Hessing-Lewis, et al., 2020).

Consistent with our traditional practices (Gauvreau et al., 2017; Kitasoo/Xai'xais First Nation, 2022), fishery models highlight two spatial tools for protecting substocks while still allowing roe fisheries when sufficient biomass is available. One is to spatially allocate roe fisheries so that they remove proportionally more biomass from more abundant substocks (Okamoto, Hessing-Lewis, et al., 2020). The other approach, which fits well with the MPAN-NSB, is to use MPAs at critical spawning areas while adjusting quotas in fished areas for the protected biomass (Okamoto, Poe, et al., 2020). These approaches are complementary. MPA management measures can also reduce disturbance by motorized vessels during spawning season, which our traditional knowledge recognizes as detrimental to herring productivity.

4.7 | Pacific salmon

Pacific salmon (*Oncorhynchus* spp.) play important ecological roles in offshore, nearshore and riparian ecosystems (Walsh et al., 2020), and have been one of our primary foods for over 7500 years (Campbell & Butler, 2010). Runs of sockeye (*O. nerka*), pinks (*O. gorbuscha*), chum (*O. keta*) and coho (*O. kisutch*) that once filled the inlets, bays and estuaries have diminished severely, with devastating effects for our ecosystems, cultures and food security. When comparing salmon abundance (escapement plus catch: Appendix S1) between recent years (2015–2020) and a historical baseline (1960–1990), these declines amount, on average, to 91% for sockeye, 78% for pink (odd and even year combined) and 58% for chum (Appendix S1).

Our communities *can no longer access* salmon as a reliable and abundant food source. Smaller river systems that once held upwards of 15,000 salmon now have a few hundred or less; these declines are largely unreported by DFO, which lacks proper monitoring resources (Price et al., 2008). Our traditional fisheries target specific salmon runs, and therefore occur in freshwater or near estuaries (i.e.

terminal fisheries); with guidance from Hereditary Chiefs, our stewardship offices and fishery programmes close these fisheries during years of low escapement (Atlas et al., 2020). Mixed stock and interception fisheries that occur at sea, however, remain a threat.

Large-scale fisheries are only one of several factors contributing to salmon declines. Ocean warming and competition with hatchery fish have lowered the productivity of wild stocks (Connors et al., 2020), and industrial impacts on freshwater and estuarine habitats reduce juvenile survival and overall productivity (Wells et al., 2020). Because adult salmon encounter diverse stressors (e.g. fisheries, marine heatwaves) over vast ocean areas (Wells et al., 2020), MPAs are most likely to help mitigate salmon declines by protecting estuarine habitat critical to juveniles (Sharpe et al., 2019).

4.8 | Structural corals and large-bodied sponges

Structural corals are coral taxa that are erect and branching (including the orders Antipatharia, Alcyonacea and Anthoathecata) and large-bodied sponges are sponge taxa that are erect and vase- or mound-shaped (including the classes Hexactinellidae and Demospongiae). Both species groups are foundation species that provide habitat to rockfishes and other organisms (Archer et al., 2020; Buhl-Mortensen & Mortensen, 2005; Du Preez et al., 2020; Dunham et al., 2018; Rooper et al., 2019; Stone et al., 2015). Their ecological roles also include water filtration, carbon sequestration and basal support for food webs (Archer et al., 2020; Bo et al., 2018; Dunham et al., 2018; Soetaert et al., 2016).

Corals and sponges are very vulnerable to physical damage from bottom-contact fisheries (Dunham et al., 2018; e.g. Du Preez et al., 2020; Sheehan et al., 2021). BC's trawl fishery reported ≈322 tons of corals and sponges caught as by-catch between 1996 and 2004 (Ardron et al., 2007). Unaccounted by this figure are the impacts of other gear types (groundlines; traps) and damaged organisms that remain on the seafloor (e.g. Du Preez et al., 2020; Du Preez & Tunnicliffe, 2011).

Our science programmes have mapped biological hotspots for corals and sponges where proposed MPAs would exclude bottom-contact fisheries (Frid et al., 2021). Both species groups would immediately benefit from these spatial protections (Ardron et al., 2007; Stone et al., 2015).

5 | CLIMATE CHANGE AND OCEAN ACIDIFICATION

Greenhouse gas emissions caused by human activities and resource consumption are the top driver of climate change and ocean acidification (IPCC, 2021). The impact of marine heatwaves on seaweeds is only one example of local manifestations of this problem. Others include the recent melting of glaciers, more frequent droughts and extreme rainfall (Whitney et al., 2020), which can alter the temperature, flow and sediment load of rivers, reducing survival and productivity of salmon and eulachon spawners. During recent droughts (e.g. 2018–19), we observed small rivers drying, which forced spawners into estuaries where egg survival is poor due to high salinity.

More generally, since the 1970s, the oceans have been steadily warming (IPCC, 2021), contributing to the decline and redistribution of marine species (Cheung, 2018; Cheung et al., 2021). Marine heatwaves—extreme warming events that last for months to ≈2 years before subsiding to an average trend—have become more frequent since the 1980s and are projected to become even more frequent as global warming continues (Frölicher et al., 2018). Marine heatwaves decrease nutrient availability at the surface and can cause abrupt declines and redistributions of marine organisms (Frölicher & Laufkötter, 2018).

The Northeast Pacific Ocean has experienced two marine heatwaves in the last 10 years, and climate models predict at least four more by 2100 (Cheung & Frölicher, 2020). In addition to affecting our kelp and *Pyropia* harvests, past marine waves exacerbated the steady decline of sockeye salmon that has been occurring throughout the Northeast Pacific (Cheung & Frölicher, 2020). Similar impacts of climate change apply to many other species in our territories (Weatherdon et al., 2016).

The oceans absorb about a third of greenhouse gases that human activities emit into the atmosphere, causing acidification (IPCC, 2021). Ocean acidification affects the larval and adult stages of many species in our territories, impacting their survival (Haigh et al., 2015).

Ocean warming and acidification act synergistically with the pressures of fisheries, highlighting the need to manage fisheries more conservatively (Cheung et al., 2012; Link et al., 2021). As we later elaborate, MPAs can enhance resilience to these stressors (Baskett & Barnett, 2015; Roberts et al., 2017).

6 | LIMITS OF CURRENT FISHERIES MANAGEMENT POLICY TO SUSTAINING ECOSYSTEMS

Beginning in the 1980s, the general trend for Canadian fish stocks became one of decline (Hutchings et al., 2012). Responding to that crisis, in 2009, DFO implemented the *Sustainable Fisheries Framework* (SFF) (DFO, 2009b) and its supporting document, *A Fishery Decision-Making Framework Incorporating the Precautionary Approach* (DFO, 2009a), thereby establishing fishery management policies intended to be precautionary and ecosystem-based. Further improvements came in 2019, when changes to the *Fisheries Act* (Parliament of Canada, 2019) mandated robust stock assessments to inform management decisions.

Despite these notable improvements, the SFF's stated intentions for ecosystem-based management are rarely realized. In the most common application of the SFF, the goal of maximum sustained yield

(MSY) is paramount. DFO managers strive to maintain stocks in the 'healthy zone'—above 80% of biomass at MSY (B_{msy})—where larger catch limits are allowed. Managers implement lower catch limits if a stock enters the 'cautious zone' (40%–80% of B_{msy}) and apply the greatest catch restrictions if a stock enters the 'critical zone' (below 40% of B_{msy}). These default reference points, though not required by the policy, are widely used.

The SFF, therefore, has been operationalized to maintain species-specific fishery yields, not the restoration and conservation of ecosystems. For most species, B_{msy} is approximately 30%[1] of the 'unfished' biomass: the estimated abundance in the absence of large-scale fisheries. Under the SFF, there is no intention to rebuild stocks above the low bar of 80% of B_{msy} (≈24% of the 'unfished' biomass for many species) and towards historical levels that are more consistent with ecosystem-based management. In other words, the default biomass thresholds of the SFF normalize impoverished ecosystems (Frid & Atlas, 2020).

Yelloweye rockfish are a case in point. The stock that encompasses the Central Coast is estimated to have declined by 65% relative to the unfished biomass yet remains in the SFF's 'healthy zone' (weighted operating model for North Outside Stock: Cox et al., 2020). To enter the critical zone—the threshold for substantial reductions in allowable catches—yelloweye rockfish *would have to decline by 89%* (Cox et al., 2020). Given the ecological and cultural importance of yelloweye rockfish (Eckert et al., 2018; Olson et al., 2020), the SFF's permissible depletion of this species is inconsistent with the ecosystem approach that the policy claims to embrace. These issues extend beyond rockfish and apply to many fished species (Frid & Atlas, 2020).

For Central Coast salmon, the paucity of population monitoring has contributed to a data deficient management regime in which DFO has failed to establish limit reference points or rebuilding targets (Price et al., 2017). This limits DFO's ability to declare a conservation concern and adjust fisheries management.

The spatial scale of current management also is a problem for many species. Most stocks are managed as single entities over large regional scales, which misaligns with the local scales at which Indigenous fishers experience declines (Ban et al., 2017; Okamoto, Hessing-Lewis, et al., 2020).

The SFF also lacks reference points for other indicators of stock status, such as body size, which determines individual fecundity and population productivity (Marshall et al., 2021), and the trophic dynamics that influence ecosystems (Olson et al., 2020; Strong & Frank, 2010). The worldview encompassed by the MSY framework—*take the most that you can without compromising future exploitation while assuming no environmental change*—is the antithesis of the worldview of our Nations—*take only what you need and leave lots for the ecosystem*.

The MSY framework is not unique to Canada and has been applied internationally for at least 40 years. Nonetheless, since at least 1977, it has been 'frequently viewed by fisheries and other scientists as an outdated notion, which has been bypassed by a better understanding of ecological and human systems (Pauly & Froese, 2020)'. Given the MSY emphasis of the SFF, we want to ensure that the MPAN-NSB rebuilds and conserves depleted species to the levels required for resilient ecosystems. That is, we seek to restore and maintain the biodiversity that we depend on rather than suffer continued ecological degradation under a single-species management paradigm focused on the commodification of marine life.

Importantly, conventional management in Canada and abroad often fails to meet even the low bar of maintaining stocks at or above 80% of B_{MSY} (Costello et al., 2016). For Canada in 2021, only 30% of fished stocks exceeded that threshold, 33% were below it and the status of the remaining 37% was uncertain (Archibald & Rangeley, 2021). Furthermore, many species caught as by-catch, including 11 of 26 (42%) recorded by one of our science programmes (Frid et al., 2021), lack a stock assessment. Importantly, standard stock assessments do not account for climate-induced shifts in species distributions and biological productivity, thereby ignoring key uncertainties about how fisheries may impact stocks (Karp et al., 2019). The MPAN-NSB would provide insurance against such uncertainties and for unassessed species. It would also be consistent with our Hereditary Chief governance system, in which individuals responsible for specific areas implement spatial closures to restore and conserve exploited species (Ban, Wilson, et al., 2019; Frid et al., 2016).

7 | GLOBAL EVIDENCE OF MPA BENEFITS

A salient criticism of MPAs is that 'If the threat to an area is overfishing, reducing fishing pressure through management is the answer (Hilborn, 2018)'. As elaborated above, however, such fishery reductions often aim to keep individual stocks from dipping below 80% of B_{MSY}. In contrast, the objectives of MPANs include the restoration and conservation of biological diversity which, as described below, promotes resilience to climate change (Kroeker et al., 2019; Roberts et al., 2017) and enhances blue carbon stores for climate change mitigation (Krabbe et al., 2022).

Global evidence indicates that MPAs that are well-designed and enforced for fisher compliance do rebuild populations of exploited species (Edgar et al., 2014) (Appendix S3). A well-known syntheses of 124 fully protected MPAs from 29 different countries found that fish, invertebrates and seaweeds combined had, on average, 4.5 times more biomass, 66% greater density, 28% larger sizes and 21% higher species diversity inside MPAs than in fished areas (Lester et al., 2009). That synthesis was published 13 years ago. Since then, evidence of MPA benefits has accrued further. While some of that evidence is presented below, we do not attempt its comprehensive review and instead refer readers to published syntheses (Ban, Gurney, et al., 2019; Baskett & Barnett, 2015; Carr et al., 2017; Grorud-Colvert et al., 2021; Roberts et al., 2017). Importantly, the conservation benefits of partially protected MPAs, though not as extensive as those of fully protected MPAs, are significant (Sciberras et al., 2015) (Appendix S4).

7.1 | Fishery benefits of MPAs

Marine protected areas can potentially displace fishing effort and increase exploitation rates outside MPAs (Hilborn, 2018; Hilborn et al., 2004). Solutions to this problem include reducing quotas proportionally to the biomass unavailable to fisheries under MPA restrictions (Hilborn et al., 2004; Okamoto, Poe, et al., 2020) and/or fleet reductions, which may require support for fishers undergoing a transition (Sen, 2010). Yet increased fishery productivity facilitated by MPAs can potentially offset negative impacts of fleet displacement (Halpern et al., 2004; Hopf et al., 2016; Kerwath et al., 2013) and, as illustrated by the California experience, MPAs do not necessarily lead to reduced fishery revenues (Appendix S5).

The expected benefits of MPAs to fisheries build on three key concepts: (1) Bigger fish are disproportionately more fecund than smaller fish (Barneche et al., 2018; Dick et al., 2017); (2) fisheries remove the largest individuals, but MPAs restore higher densities of larger and more fecund individuals (Marshall et al., 2019, 2021; Willis et al., 2003), and overall greater abundances (Lester et al., 2009), which (3) leads to the spillover, or export, of larvae and adults from protected into fished areas (Barceló et al., 2021; Di Lorenzo et al., 2020). Similar concepts apply to commercially harvested invertebrates, which also grow larger and more fecund inside MPAs (Micheli et al., 2012; Pelc et al., 2009).

Data support these concepts. Given fisher compliance and enough time (Edgar et al., 2014; White et al., 2020), fish become more abundant, and larger (and therefore more fecund) inside MPAs (Bosch et al., 2022; Keller et al., 2019; Lester et al., 2009; Willis et al., 2003), and their increased larval production (Thompson et al., 2017) boosts recruitment into fished areas (Le Port et al., 2017). The evidence for larval subsidies from MPAs to fished areas includes genetic studies from temperate MPAs (Appendix S6).

Larval spillover benefits fisheries through the following mechanisms (Barceló et al., 2021). Larvae from outside MPAs move into both fished areas and MPAs. Larval exports from MPAs, therefore, increase fishery yield only if they exceed the amount of larvae that fished areas already receive from non-MPA sources, which requires a process called 'filling-in': The replenishment of older and larger fish classes that had been made scarce by fisheries but that can now recover under spatial protection. The time required to fill-in depends on the life history of the species—longer lived species, which grow more slowly and mature at older ages, take longer to fill-in than shorter lived species—and on aspects of how the fishery is managed, including age at first capture (Barceló et al., 2021).

The time required for MPAs to benefit fisheries can be long for some NSB species: ≈22 years for lingcod (max. life span 25 years), 36 years for yellowtail rockfish (*S. flavidus*, max. life span 64 years) and 62 years for China rockfish (*S. nebulosus*, max. life span 79 years) (Barceló et al., 2021). Stewardship decisions by our Nations, however, are made on behalf of multiple generations of our descendants. The MPAN-NSB is an investment into the long-term health of the biosphere that sustains us; the wait is worthwhile.

If this long-term view is taken, the potential financial benefits of larval spillover are substantial. For example, larval dispersal from a New Zealand MPA (11% of recruits of Australasian snapper over a 400-km^2 area; Le Port et al., 2017) is estimated to generate $1.49 million NZD/year (≈$1.29 million CAD/year) in additional commercial landings and $3.21 million NZD/year (≈$2.78 million CAD/year) from additional economic activity generated by recreational fishers (Qu et al., 2021).

Importantly, benefits to fisheries from adult spillover—adult movements from MPAs into fished areas—require only a few years to contribute to increased fishery yields (Di Lorenzo et al., 2020). For instance, 10 years after five fishery closures were established in New England, the average revenue per trawled hour was double within 4 km of closure boundaries than farther away (Murawski et al., 2005). Only 10 years after a 40-km^2 MPA was established in South Africa, commercial catch rates of Roman seabream *Chrysoblephus laticeps* were nearly double outside the MPA while catches remained stable elsewhere along the coast (Kerwath et al., 2013); because Roman seabream require 5 years to recruit into the fishery, increased catches adjacent to the MPA likely reflect adult spillover within the first 5 years and both adult and larval spillover afterwards (Barceló et al., 2021; Kerwath et al., 2013). Similar benefits of adult spillover are expected under a wide range of MPA locations and conditions (Di Lorenzo et al., 2020). In the case of lingcod, an ecological conservation priority for the MPAN-NSB (Gale et al., 2019), movement data from individuals tagged in an Alaskan MPA suggest substantial benefits to fisheries from adult spillover (Starr et al., 2011).

In summary, adult spillover benefits occur quickly but over smaller areas, typically a few hundred metres to a few kilometres from MPA boundaries (Di Lorenzo et al., 2020), while larval spillover benefits manifest more slowly but can accrue over 1000s of squared kilometres (Barceló et al., 2021; Le Port et al., 2017). Both types of benefits are consistent with our Nation's traditional use of spatial management for the continuous replenishment of exploited species (e.g. Ban et al., 2020; Ban, Wilson, et al., 2019). However, if fishery displacement increases exploitation rates outside MPAs, biomass is unlikely to increase at the population level (summed biomass across MPAs boundaries) (Ovando et al., 2021). Quota reductions or other management measures outside MPAs may be required to pre-empt this problem (Hilborn et al., 2004; Okamoto, Poe, et al., 2020).

8 | BENEFITS TO ECOSYSTEM RESTORATION AND RESILIENCE TO CLIMATE CHANGE

Complex food webs that include their top predators support ecosystem functions, including energy flows and resilience to climate change (Madin et al., 2016; Micheli & Halpern, 2005; Roberts et al., 2017; Strong & Frank, 2010). Longline, trawl and other fisheries, however, indiscriminately remove a large diversity of species, simplifying food webs by diminishing communities of functional groups, including large predatory fishes (Christensen et al., 2014;

Micheli & Halpern, 2005; Strong & Frank, 2010). MPAs can help mitigate this problem (Cheng et al., 2019; Micheli & Halpern, 2005). A recent meta-analysis (Cheng et al., 2019), which used data from 29 studies and 32 species distributed across 30 MPAs and 85° of latitude, found that—after controlling for MPA characteristics (size, age, full vs. partial protection), habitat, temperature and other factors—the intensity of predator effects was 49 times greater at MPAs with the greatest predator recovery than at fished areas where predators had declined (Cheng et al., 2019). Furthermore, by restoring and maintaining complex food webs, MPAs support functional redundancies that buffer against impacts of ocean warming (Eisaguirre et al., 2020; Roberts et al., 2017; Appendix S7).

Additionally, the restoration of large body sizes within MPAs increases resilience to climate change via two mechanisms. First, larger size classes of predators affect the distribution and abundance of a wider range of mesoconsumers (Madin et al., 2016). The restoration and conservation of large predators within MPAs, therefore, may buffer against range expansions by warm-tolerant mesoconsumers and their potential disruption to trophic cascades (Ling et al., 2009; Appendix S7). Second, the restoration of large body sizes within MPAs equates with increased per capita fecundity, which may buffer against population collapse and promote faster recovery from extreme events related to climate change (Micheli et al., 2012; Appendix S7).

The notion that MPAs confer resilience to climate change also applies to sessile organisms with critical ecosystem roles, such as large-bodied sponges and structural corals (Sheehan et al., 2021). Extreme storm events, which can physically damage these species groups through sedimentation and other processes, are expected to become more frequent with global warming (IPCC, 2021). Within MPAs that exclude bottom-contact fisheries, sponges and corals have lower baseline levels of physical damage and recover from extreme weather events faster inside than outside MPAs (Sheehan et al., 2021).

To be clear, MPAs enhance resilience to climate change and associated extreme events but are no panacea for these stressors (Friesen et al., 2021; Ovando et al., 2021; Tittensor et al., 2022). Nonetheless, network connectivity between individual MPAs pre-empts some concerns about MPA effectiveness in the face of climate-driven species redistributions (Carr et al., 2017). More generally, climate change impacts are likely to be much worse if additional stressors, including fisheries (Cheung et al., 2012, 2021), are unmitigated in the absence of MPAs that restore and protect larger and more fecund individuals (Micheli et al., 2012) and food webs (Cheng et al., 2019; Eisaguirre et al., 2020; Ling et al., 2009; Madin et al., 2016; Roberts et al., 2017). Critically, MPAs also contribute to climate change mitigation via protection of natural carbon stores (Appendix S8).

9 | CONCLUSION

Our traditional stewardship and enhancement practices enabled the sustainability of our cultures and societies. Over the past two centuries, however, the Western industrial economy has disturbed ancient linkages between our communities and our environment. Yet we continue to depend on surrounding ecosystems and remain obligated, by traditional law, to engage in their restoration and conservation. Our marine use plans are a modern manifestation of that obligation.

Our Nations and other Indigenous cultures throughout the world have long recognized that protecting parts of the ocean from exploitation mitigates human impacts on biodiversity and contributes to fishery sustainability (Ban et al., 2020; Johannes, 1978; Jones et al., 2010). Our proposed spatial protection zones for the MPAN-NSB are consistent with modern principles of marine conservation and essential to ecological, economic and cultural resilience. Their implementation would contribute to long-term ecosystem persistence, support intergenerational knowledge transfer, traditional education, food security, local fishery economies, and actualize many aspects of reconciliation with Indigenous Peoples.

As currently operationalized, conventional fisheries management focuses on maximizing yields for individual commercial species, thereby normalizing an ecologically depauperate world (Frid & Atlas, 2020). The dominant paradigm considers stocks to be healthy if their biomass clears the reference point of 80% of B_{msy}, which is only ≈24% of the 'unfished' biomass for many species. These criteria ignore declines in predator size structures and abundances that disrupt food webs (Madin et al., 2016; Olson et al., 2020; Strong & Frank, 2010), and body size declines that diminish per-capita egg production (Marshall et al., 2021), which erodes resilience to climate change and other perturbations (Micheli et al., 2012; Roberts et al., 2017). Furthermore, uncertainties inherent to how climate change affects species distributions and productivity have yet to be standardized into stock assessments (Karp et al., 2019), and many species caught as by-catch are unassessed (Archibald & Rangeley, 2021).

In contrast to the MSY framework that has dominated conventional fishery management, our traditional stewardship principles focus on the primacy of species interactions to the integrity of ecosystems (Table 1). The difference spans beyond mere objectives and encompasses different values and ontologies (Artelle et al., 2018; Whyte, 2018). While MSY and related frameworks of conventional fishery management reflect Eurocentric views of human domination, our Nations and other Indigenous Peoples see humans as only one species among myriad interconnected life-forms (Brown & Brown, 2009; Jones et al., 2010; Kimmerer, 2014, 2015). In this paradigm, humans not only lack a position of privilege; we are mere pupils of all other species, and it is to our peril to fail to learn from those wiser beings (Kimmerer, 2014, 2015; Kitasoo/Xai'xais First Nation, 2022). By embodying our traditional principles, our proposed spatial protections would fill gaps in biodiversity conservation and precautionary fishery management which have persisted under current management approaches.

Critically, MPAs can increase resilience to climate change by restoring and protecting food webs and size structures, and by safeguarding natural carbon stores, including eelgrass beds, corals, sponges and sediments (Roberts et al., 2017). Accordingly, our proposed spatial protections for the MPAN-NSB encompass areas important to large predatory fishes, corals, sponges (Frid et al., 2021), eelgrass beds and other carbon stores. They will strengthen the global network of MPAs required to ameliorate impacts from climate change (Tittensor et al., 2022).

Understandably, commercial fishers are concerned about revenue losses through MPA implementations, and fishers affected by fleet or quota reductions may require support to undergo a transition (Sen, 2010). Yet experience in other temperate regions indicates that larval and adult spillover generated by MPAs can enhance commercial catches (Barceló et al., 2021; Di Lorenzo et al., 2020). Given declines in the catches of many Canadian fisheries (Hutchings et al., 2012) and the depressed abundance of many species in our territories (Table 2), long-term benefits of MPA implementation are likely to outweigh the short-term costs.

Ultimately, a well-designed and enforced MPAN-NSB is consistent with the principles of our traditional laws (Table 1)—including responsibility to take only what one needs and respect and gratitude for all living things—and can provide widespread conservation benefits for both Indigenous and non-Indigenous Peoples. Given our long history of spatial management through the Hereditary Chief governance system, the MPAN-NSB is a culturally appropriate way forward for marine conservation in our territories. We will continue to work towards recognition and implementation of our proposed spatial protections.

AUTHOR CONTRIBUTIONS

M.R., M.L.C., S.R.J.H. and E.M. provided their Indigenous knowledge and lead its application throughout the manuscript; G.M. conceived the technical sections on marine spatial planning; A.F. conceived technical sections on MPAs, fisheries and climate change, and integrated all manuscript sections. All authors reviewed and edited the manuscript.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data supporting Appendix S1 are archived at https://zenodo.org/record/6149927. The remainder of data are published and in the public realm.

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ENDNOTE

[1] Variation around this general value is influenced by life-history parameters and other stock characteristics.

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SUPPORTING INFORMATION

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

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