Indigenous food harvesting as social–ecological monitoring: A case study with the Gitga'at First Nation

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Abstract
1. Indigenous peoples have been monitoring and managing the natural resources in their homelands and waters for millennia. Meanwhile, social–ecological systems thinkers are embracing the capacity of Indigenous knowledge systems, which are informed by land-based practices, to inform adaptive management.
2. Following the collaborative design of a community-based social–ecological monitoring system over two traditional seafood harvesting seasons, we conducted a conceptual framework analysis of meeting notes and interview transcripts with Gitga'at harvesters and knowledge holders to discern how Gitga'at people monitor their territory and what indicators they focus on.
3. An interconnected set of social–ecological concepts and indicators emerged, evidencing an intrinsic part of Gitga'at life: Gitga'at harvesters closely monitor their coastal social–ecological system through ongoing land- and sea-based practices.
4. The conceptual framework highlights the importance of maintaining and revitalizing Indigenous knowledge and harvesting practices to inform social–ecological monitoring and adaptive management at local and broader scales.
5. Amidst discussions of marine and coastal resource co-management in British Columbia, our results also suggest opportunities for scientific approaches to situating themselves within and support existing Indigenous frameworks and priorities.
6. This research also adds to the discussion on the development of appropriate regional and global indicators and frameworks to monitor the resilience of social–ecological systems.

Key words
biocultural indicators, community-based monitoring, conceptual framework, environmental monitoring, indigenous food systems, indigenous knowledge, land-based practices, participatory research, reciprocity, relational values

1 | INTRODUCTION

Indigenous peoples around the world have been monitoring and managing the natural resources in their homelands and waters for millennia (Lepofsky, 2009; Turner & Berkes, 2006). Scholarship within sustainability sciences and resilience thinking has come to recognize the capacity of place-based and Indigenous knowledge systems to enable adaptive management and resilience...
(Berkes, Colding, & Folke, 2000). Resilience can be defined as the capacity for a social–ecological system to respond and adapt to change while maintaining its core identity (Folke, 2006; Ostrom, 2009). In recent decades, partnerships between scientists and Indigenous peoples have also embraced opportunities to refer to both Indigenous and scientific knowledges to better understand and manage ecological systems (Eckert, Ban, Frid, & Mcgreer, 2017; Housty et al., 2014; Moller, Berkes, Lyver, & Kisilaloglu, 2004).

An increasing number of environmental monitoring programmes have also begun to solicit the knowledge of Indigenous peoples to better manage natural resources, conserve biodiversity and adapt to climate change (Thompson, Lantz, & Ban, 2020). These initiatives have involved varying degrees of partnerships, ranging from externally driven initiatives with local Indigenous data collectors employed to administer a specific methodology, to autonomous Indigenous place-based activities as methods of monitoring (Danielsen et al., 2009; Wilson, Mutter, Inkster, & Satterfield, 2018). These different levels of partnership are often reflected in the monitoring indicators that are used. Monitoring initiatives driven by external agencies tend to focus primarily on ecological indicators (e.g. Bellfield, Sabogal, Goodman, & Leggett, 2015), while those led by Indigenous peoples tend to include a more holistic suite of indicators including social, ecological, social–ecological and spiritual angles (e.g. Lyver et al., 2017; Parlee, Manseau, Dene, & Nation, 2005; Thompson et al., 2020).

Whether externally or locally driven, monitoring initiatives that involve Indigenous peoples and their knowledge are occurring in a time of unprecedented rates of social and ecological change, and imperial and colonial policies continue to politically, economically and socially marginalize Indigenous peoples throughout the world (e.g. Dhillon, 2015). Colonial pressures are often compounded by the effects of climate change, making Indigenous lifeways among the most threatened (Ford et al., 2016; Savo et al., 2016). Indeed, much work has been dedicated to exposing the multiple ecological changes experienced by Indigenous communities due to rapid climate change (Krupnik & Jolly, 2002; Shaffer, 2014; Turner & Clifton, 2009). In spite of these challenges, Indigenous peoples are actively reclaiming and asserting their languages, cultures and rights to manage their lands and waters (Corntassel, 2012; Simpson, 2017). Several communities have decided to partner with academic researchers to seek ways of documenting environmental changes to inform adaptation on their own terms (e.g. Bennett & Lantz, 2014; Gearheard, Aporta, Aipellee, & Keefe, 2011).

The purpose of this paper is to showcase an example of autonomous Indigenous monitoring in northern British Columbia, Canada. Based on the conversations and interviews conducted as part of developing a monitoring programme based in Indigenous knowledge in collaboration with researchers from the University of Victoria (Thompson et al., 2019), we outline a conceptual framework—a set of interrelated concepts and their relationships (Jabarreeen, 2009)—which illustrates how Gitga’at people monitor their territory through continued use and occupancy. As with other Indigenous peoples (e.g. Lyver et al., 2017), a large portion of Gitga’at relationship with the land and sea is centred around food harvesting activities, including travelling, harvesting, preparation and preservation (Guerrier, Turner, Gomes, Garibaldi, & Downing, 2015; Garibaldi & Turner, 2004). Thus, the analysis and resulting framework described in this paper focus on food species that play an important role in the cultural identity of Gitga’at people. The framework describes the interconnected social and ecological elements and indicators that Gitga’at people use to monitor while participating in harvesting activities and is illustrated by changes observed by Gitga’at harvesters over the course of two harvest seasons.

Our case study adds to a growing body of literature describing Indigenous systems of caring for nature and people (e.g. Gould, Pai, Muraca, & Chan, 2019; Whyte, Brewer, & Johnson, 2016), and contributes to broader conversations about diverse ways of knowing in sustainability processes. For example, the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) recently articulated a conceptual framework emphasizing the concept of nature’s contributions to people (NCP), defined as ‘all the positive contributions, losses or detriments that people obtain from nature’, and recognizing the critical role of culture in mediating all relationships between people and nature (Diaz et al., 2018; Pascual et al., 2017). One of the motivations behind such a shift from the dominant ecosystem services concept was the intent of being more inclusive of diverse value systems and worldviews (Kadykalo et al., 2019). This shift has also included an emphasis on relational thinking among sustainability scholars which derived from increasingly nuanced discussions of the relationships between humans and nature (e.g. Chan, Gould, & Pascual, 2018; Fish, Church, & Winter, 2016). Intrinsic and instrumental values have been relevant in the understanding the material and intangible benefits of nature. However, the role of relational values (the ‘preferences, principles, and virtues associated with relationships, both interpersonal and as articulated by policies and social norms’; Chan et al., 2018), which are often shaped by cultural heritage, had been generally overlooked or mis-valued in ecosystem assessments (Satz et al., 2013). Following the presentation of our framework, we draw parallels to the NCP framework, focusing on the NCP concepts of ‘maintenance of options’ and our concept ‘cultural continuity’ and encourage relational thinkers to embrace reciprocal loops between the actions of people and the many benefits of nature. By demonstrating examples of the ways in which the Gitga’at practice of harvesting as monitoring encapsulates relationships and responsibilities with and between the human and non-human world, we hope to inform future dialogues around sustainability and resource management in land- and seas-Scapes subject to diverse value systems.

### 1.1 | Context

The Gitga’at are a Tsimshian (Ts’msyen) tribal group whose people have occupied and cared for their lands and waters on the Northwest coast of North America for several thousand years. The traditional
The idea of initiating a programme to document Gitga’at harvesters’ observations of change was spurred by the director of the Gitga’at Oceans and Lands Department (CP) in early 2016 when he and several harvesters witnessed abnormalities in Gitga’at territory including sea star wasting syndrome, increasing red tides and high levels of biotoxins in clams. The idea had also been previously suggested by ethnoecologists and climate scientists who had documented some of the longer-term changes experienced by Gitga’at people (Turner et al., 2013). To assist with designing a Gitga’at monitoring programme, a partnership was formed with researchers at the University of Victoria. To ensure Gitga’at knowledge was reflected in the design, Gitga’at co-researchers were an integral component, and the project was designed to be highly participatory (Thompson et al., 2019). The principles of this reciprocal relationship were built into a protocol agreement that was signed between researchers at the University of Victoria and the Gitga’at First Nation prior to the beginning of any research activities.

2 | METHODS

We iteratively developed a conceptual framework of how Gitga’at people monitor through harvesting traditional foods with Gitga’at harvesters and knowledge holders, and we focused primarily on marine foods species. First, we conducted informal interviews (as described in Bernard, 2006) with 36 participants, including harvesters and Elders about whether a monitoring programme based in their knowledge and observations was of interest, and if so what the objectives of the programme should be. We held interviews in October and December of 2016 in the participants’ preferred location and notes were taken following these conversations to summarize the
ideas that had been discussed. We then organized community meet-
ings in the Gitga’at communities of Hartley Bay and Prince Rupert
in March 2017. Informal interviews and community meetings were
followed by workshops where harvesters were invited to help de-
sign tools to document their observations of change. These tools
included a harvesters’ logbook and a post-harvest season interview
guide that would be used to guide semi-structured interviews. For a
more detailed discussion of the steps taken to initiate, design, and
test the Gitga’at monitoring programme see Thompson et al. (2019).

We conducted semi-structured interviews with harvesters and
knowledge holders following the spring and fall/winter harvest
seasons of 2017–2018. Spring harvesting typically occurs in the
southern waters of Gitga’at territory and centres around Ky’el, a sea-
sonal village. At Ky’el, harvesters travel out during the day to fish
for halibut (txaw, Hippoglossus stenolepis) and spring salmon (yee,
Oncorhynchus tshawytscha), and to pick seaweed (la’ask, Pyropia
abbotiae) and other intertidal resources. Fall and winter harvesting
is mostly spread over the central and northern parts of the terri-

dory and is focused on bivalves such as Nuttals cockles (gaboox,
Clinocardium nuttallii) and butter clams (t’sa’ax, Saxidomus giganteus),
and seasonally available salmon species. Interviews included individ-
uals who, though they may not have participated in the harvest, have
lifetimes of experience preparing, preserving and cooking traditional
foods. Participants were selected based on our personal knowl-
dge of active harvesters and based on recommendations made by
participants. The interview guide, developed collaboratively with
Gitga’at harvesters, included questions to prompt participants to
speak about harvest intensity, whether their needs for traditional
foods were met, changes in the abundance and quality of traditional
foods, trading and sharing activities, as well as changes in weather
patterns, in the landscape and/or water (Thompson et al., 2019).
Interviews were digitally recorded and transcribed with permission
from participants.

We analysed informal interviews, community workshop and
meeting discussions, and the post-harvest interviews using a con-
ceptual framework analysis approach (Jabareen, 2009). This quali-
tative method involves categorizing and connecting concepts from
different sources of data to create a conceptual framework. The
method requires researchers to familiarize themselves with the data,
identify concepts and themes within them, then organizing them in
relation to one another to synthesize a framework. The framework
is then validated and revised as new inputs are added. In our case,
the data sources included notes and transcripts from informal in-

terviews, community meetings and workshops, and post-harvest
season interviews. We reviewed notes and transcripts to code over-
arching concepts and themes (e.g. access to resources, cultural con-


tinuity, habitat quality) and specific monitoring indicators that were
described by participants using NVivo software. We listed all mon-
itoring concepts, then connected these to specific indicators that
harvesters had spoken about. We then connected concepts based
on how participants described their feedbacks and visualized the
emerging pattern using Visual Understanding Environment software
(Tufts University, 2015). Our validation process included review and
revisions to the framework made by knowledgeable harvesters and
community leaders.

All interview and workshop participants gave their informed
written consent to participate in this study, and in accordance to
the University of Victoria’s Human Research Ethics Board (protocol
number 16-379), and the protocol agreement signed between the
University of Victoria and the Gitga’at First Nation. Only participants
who consented to have their responses attributed to them have been
named in this study. In accordance to the protocol agreement, all data
have been archived within the servers of the Gitga’at First Nation.

To illustrate the kind of information that can be provided from a
Gitga’at harvesters’ observations-based monitoring programme,
we analysed the content of interviews for observations of change
in the quantity and quality of traditional foods by coding these
themes, then organizing the data using Microsoft Excel. We fo-
cused this analysis on observations made by Gitga’at harvesters and
Elders during systematic post-harvest season interviews about the
species most commonly harvested (i.e. with the highest number of
interviewees having harvested that species in the two focal harvest
seasons). We used these data to calculate the proportion of partic-

tipants who had observed positive or negative trends in quality and
quantity of each food species, and whether they were meeting their
needs for that species. We then convened community meetings to
discuss this synthesis.

3 | RESULTS

All active harvesters and Elders who took part in informal interviews
demonstrated a strong interest in a potential monitoring programme
based in Gitga’at harvesters’ observations and knowledge. Four key
and interrelated objectives emerged from conversations regarding
how harvesters wanted to see their knowledge and observations
used to track changes occurring in Gitga’at Territory. These objec-
tives were to:

1. Inform stewardship decisions and adaptation measures;

2. Encourage youth to learn about their traditional foods and how
the territory is changing;

3. Strengthen the case for Gitga’at rights to manage resources in
their territory and

4. Inform health and wellness programming.

We conducted post-harvest season semi-structured interviews
with 42 individuals after the spring and fall/winter harvest seasons
between June 2017 and March 2018. In all, 23 individuals were in-
terviewed after the spring harvest season and 29 were interviewed
following the fall/winter harvest season, with 10 interviewees par-
icipating in both seasons. Participants’ age ranged from 24 to 92 years,
with an average of 56, and 67% being between 40 and 79 years old.
71% of participants were men and 29% were women. Active harvest-
ers who were interviewed had anywhere between 1 and 68 years
of harvest experience with any given species, with an average of
29 years of experience, and 67% of harvesters had at least 20 years of experience harvesting focal species (Table 1). Not all participants answered all questions; thus, sample sizes vary for each question.

3.1 | Conceptual framework of Gitga’at monitoring by harvesting

Our conceptual framework analysis of participants’ observations of change revealed 10 elements that are monitored through Gitga’at harvesting activities: food species abundance; food species quality; habitat quality; harvest intensity; cultural continuity; sharing and trading institutions; external factors; and abnormal species and landscape features. Participants described using several indicators to assess change within each of these elements (Table 2). These elements are ecological, social and social–ecological in nature, and many participants described feedbacks between different elements, which are represented by the arrows in Figure 2. Indicators used to monitor each element and feedbacks between elements, as described by participants, are further detailed in the next sections. We emphasize that the framework presented here, including its concepts and indicators, is not comprehensive as we only interviewed a subset of Gitga’at people, with a focus on harvesters, and that it is a simplified representation of a complex and nuanced system of human–nature relationships.

3.2 | Abundance

Harvesters described changes in the abundance of food species by noting changes in the quantity harvested relative to the effort invested. For example, cockles are deemed to be decreasing in abundance (Figure 4) since harvesters must dig for longer periods of time relative to the past before finding cockles at their preferred beaches. As one harvester, who preferred to remain anonymous, put it, ’It used to be that with one rake 4 or 5 cockles would come out. Now one rake and it’s just dirt, sand and a rock. You gotta go hunt and find them’ (Anonymous 1, 9 April 2018). The abundance of food species can also be estimated and monitored based on the abundance of other species that may have an ecological or phenological relationships with the focal species, and there is an understanding that ‘nothing acts on its own’. For example, some knowledge holders recall their elders stating that years with plentiful salmonberries coinciding with plentiful sockeye salmon. Many participants also said that, since they know what some food species’ spatial distribution is normally like during different seasons, they are able to evaluate whether food species abundance has changed. For example,}

### Table 1

Table showing common seasonal food species, number of participants, and years of harvest experience. 'NA' indicates where the years of harvest experience were not disclosed by the participant.

| Harvest season | Food species | Number of harvesters interviewed | Harvest experience |
|----------------|--------------|---------------------------------|-------------------|
|                | Sm'algyax name | English name                | Minimum (years) | Maximum (years) |
| Spring 2017    | Ła'ask Red laver seaweed | Pyropia abbottiae | 16 | 2 - 68 |
|                | Yee Chinook salmon | Oncorhynchus tshawytscha | 13 | 17 - 50 |
|                | Txaw Pacific halibut | Hippoglossus stenolepis | 11 | 2 - 47 |
|                | ‘Yaans Black katty chitons | Katharina tunicata | 7 | 16 - 30 |
|                | Dsk’wi’its Red sea urchins | Mesocentrotus franciscanus | 7 | 4 - 33 |
|                | Üüla Harbour seal | Phoca vitulina | 7 | 5 - 48 |
|                | Ts’mhooon Yelloweye rockfish | Sebastes ruberrimus | 3 | 30 - 45 |
|                | Gyenti Giant red sea cucumber | Parastichopus californicus | 3 | 1 - 45 |
|                | Ts’ak Gumboot Chiton | Cryptochiton stelleri | 3 | 3 - 50 |
|                | Hagwun California mussel | Mytilus californianus | 2 | 20 - 48 |
| Fall/winter 2017 | Gą boxo Nuttal's cockle | Clinocardium nuttallii | 12 | 6 - 52 |
|                | Ts’a’ax Butter clam | Saxidomus giganteus | 8 | 25 - 52 |
|                | Üux Coho salmon | Onchorynchus Ksutch | 8 | 25 - 41 |
|                | K’almoos Dungeness crab | Cancer magister | 7 | 18 - 50 |
|                | Üüla Harbour seal | Phoca vitulina | 5 | 4 - 42 |
|                | Yee (Winter) Spring Salmon | Oncorhynchus tshawytscha | 5 | NA - 68 |
|                | Wüdzii Moose | Alces alces | 5 | 7 - 27 |
|                | Wan Black tail deer | Odocoileus hemionus columbianus | 4 | NA - NA |
|                | Amgyilk Surf Scoter | Melanitta spp. | 2 | 14 - 44 |
when speaking about their observations of changing seaweed abundance and spatial growth patterns on rocks (Figure 2), one seaweed harvester explained:

It’s different now. It used to be the whole beach would be the same condition. Like if you had to trim the ends [of seaweed], you’d be doing that the whole way through. But now you find a rock [where the seaweed is] completely rotten, the next one you can salvage a bit, and the next one is absolutely perfect. And so last year I picked like that and I was salvaging some and they were pretty good, and I had to work like hell for half a sac or something, then I found one little place that filled a sac and a half, and I’m done…. Yeah. The thicker patches seemed to be going rotten, but you’d find small patches that were perfect. (Anonymous 2, 21 July 2017)

3.3 | Quality

Participants indicated that the quality of food species is monitored via several traditional indicators at different phases of the harvesting process. For example, when harvesting seaweed, the length, texture and colour of fronds are used to judge quality. In addition, the ease of harvest of seaweed is used to judge quality; the harder the seaweed is to pull off the rocks, the higher its quality. Quality is judged during the drying phase based on its colour and texture. The taste of fresh and dried seaweed is also used to judge its quality. For most food species, harvesters are quick to note any abnormalities or signs of illness. Mona Danes, now an Elder herself, relayed: 'I was working with the Elders for over 20 years, and to hear their stories... Everybody knew good clams good cockles and stuff like that. There was no one around to tell them it wasn’t good. They went...'

| Concepts monitored by Gitga’at people through harvesting activities | Indicators |
|---|---|
| Abundance of food species | Catch per unit effort (CPUE) \ Spatial distribution of species \ Associated species \ Cyclical patterns of abundance |
| Quality of food species | Texture \ Size \ Smell \ Colour \ Taste \ Ease of harvest \ Signs of illness |
| Habitat quality | Water clarity \ Smell \ Species diversity and abundance \ Sediment texture \ General feeling \ Presence of supernatural beings |
| Food harvest intensity | Prevalence of traditional management practices \ Spatial harvest intensity \ Amount harvested |
| Sharing and trading institutions | Number of people giving and receiving foods \ Age of people giving and receiving foods \ Geographical spread of shared or traded foods |
| Accessibility | Physical barriers to harvesting \ Physical barriers to travelling \ Cost of fuel \ Availability of time |
| Weather | Wind strength \ Wind direction \ Relative number of sunny days \ Relative number of rain or snow days \ Air temperature \ Water temperature |
| Cultural continuity | Knowledge of territory \ Use of Sm’algyax \ Knowledge of harvest protocols \ Number of young people on the land \ Prevalence of ceremony |
| Abnormal species and landscape features | • Invasive species \ • Strange animal behaviour \ • Unusual phenology \ • Landslides |

FIGURE 2 Conceptual framework representing Gitga’at peoples’ description of monitoring through traditional food harvesting. Each box represents a social, ecological or social–ecological concept monitored by Gitga’at harvesters. Arrows represent Gitga’at knowledge of the interrelationships among these different concepts. Specific indicators used to monitor each concept are listed in Table 2.
by red tide that was it. That was all we ever heard' (M. Danes, 5 March 2018).

3.4 | Habitat quality

The quality and abundance of food species are dependent on habitat quality, which is traditionally monitored based on a number of indicators. In the case of clam or cockle beaches, the smell of the beach and texture of the sediment are considered. The diversity of other species is also indicative of the health and productivity of a shellfish beach. For example, the spread of tube worms (Sabellidae spp.) is increasing at some cockle beaches, which diminishes cockle habitat and makes it difficult for harvesters to dig there. Many harvesters also spoke of a feeling of unease harvesting in certain places that are inhabited by supernatural beings, or from places that have been subjected to pollution in the past (i.e. the sinking of the M.V. Queen of the North, a BC Ferries ship that sunk in Gitga’at territory in 2006, releasing a combined estimated total of 20,000 L of diesel fuel and other hydrocarbons that contaminated several preferred clam harvesting sites; Harper, Bright, & Sanborn, 2007).

3.5 | Harvest intensity

Harvesters indicated that food species abundance and habitat quality are both influenced by harvest intensity at any given harvest site. Harvesters are aware of how many others have been using the same sites. Many interviewees expressed concerns that younger generations are no longer practicing sustainable harvesting techniques. These techniques include not harvesting juvenile mollusks to allow them time to reproduce and replenish harvest sites, and rotating areas of harvest to avoid depleting certain areas. One participant, who has been digging cockles for over 30 years, remembered a time when cockles were larger and more abundant (Figure 4) and said, ‘That’s when there weren’t much young people going out there. Mostly all elders...’ (Anonymous 3, 27 February 2018). Tony Eaton, who has been digging cockles for over 50 years echoed this sentiment when he said ‘We all say to ourselves that some young people harvest some of the ones that are too small... So that’s why they’re not giving them enough time to get bigger’ (T. Eaton, 27 February 2018).

Harvesters are also aware of shifting harvest intensities at different locations. For example, most harvesters have not been able to harvest butter clams from their preferred clam beach due to biotoxin (saxitoxin) levels being higher than recommended by the Canadian Food Inspection Agency and persisting through the entire harvesting season. Instead, they must harvest from other, less popular, beaches. Many harvesters have noticed that increasing pressures at these beaches are diminishing the harvest returns (Figure 3). George Fisher, who has harvested at these beaches the past several years, noted that ‘We all hit that beach every tide pretty much... Everybody did good there that year. But within the past couple years, yeah it’s been lower’ (G. Fisher, 5 April 2018). Marshall Reece, who has been harvesting clams for nearly five decades, remembers that ‘They used to bring us out and we’d get 11 sacs of clams a night. You know those 11lbs sacs? 11 in a night! That was crazy. Now you work hard to get 2 or 3 buckets. For 11 sacs, that’s 22 buckets in one night’ (M. Reece, 4 April 2018).

However, participants also expressed an understanding that a certain intensity of usage must be maintained to encourage productivity of several species for future harvest seasons. Echoing a sentiment expressed by several other Elders, Allan Robinson said, ‘If you don’t use it, you lose it’ (A. Robinson, 5 March 2018). He and others illustrated this with cockle and clam beaches that have not been dug in several generations, which now only yield small amounts of shellfish and are beginning to be overgrown with tubeworms. As Donald Reece said, ‘They used to harvest so much of that stuff and they said that it kept the beds healthy ‘cause they were harvesting all the time. And if you don’t harvest it will turn toxic. If we don’t start harvesting out at [our main harvest site] it’ll be so toxic, we won’t ever be able to touch it’ (D. Reece, 5 April 2018). The same concept is thought to apply to seaweed, which ‘...grows like a tree, it grows better when it’s pruned’ (A. Clifton, 19 July 2017).

3.6 | Cultural continuity

Harvesters described that, by participating in harvesting activities, they are encouraging Tsimshian and Gitga’at cultural continuity and described how harvesting according to what their Elders have taught them allows for sustainability. For example, many participants described the teaching of only harvesting mature individual fish or shellfish. However, some participants attributed ecological changes in Gitga’at territory to a rupture in the practice of traditional harvesting practices and protocols to younger generations due to the ongoing impacts of colonial assimilationist policies (i.e. Residential and Indian Day School). For example, they stressed that the erosion of knowledge about traditional harvesting protocols and of the location of harvesting areas has led to potential unsustainable levels of harvest at some shellfish beaches. Many expressed a desire to see more young people participating in harvesting activities alongside more experienced harvesters to learn. Others stressed that access to harvesting areas and having the time available to harvest are crucial to ensuring cultural continuity.

Some participants also linked these physical changes to a decline in traditional ceremonial practices and forgetting the lessons held in oral histories. As explained by Spencer Greening when reflecting on possible reasons for decreasing abundance of spring salmon, which also included industrial fishing, climate change and mismanagement (Figure 4):

So many of our stories, and some of our most prevalent stories that exist in almost all of our [Tsimshian]
communities, are that when you stop taking care of them [the salmon] and honoring them they start to die out. And it happened ten thousand years ago when we came out of Temlaxam, and it’s happening now. And I think it relates to, not only is there a level of physical earth changing, there’s an ancestral spiritual level that we should be singing to them when the first salmon shows up and we should be honoring them when we do the hatchery even. But there isn’t that. We’re not singing to them, we’re not talking to them in a spiritual way. (S. Greening, 5 July 2018)

3.7 Sharing and trading institutions

During the design phase of this study, several harvesters stressed the importance of documenting how traditional foods are being

FIGURE 3 Species and landscape abnormalities observed in Gitga’at territory during the spring, fall and winter 2017. (a) Ian Eaton with non-native tent caterpillars on pacific crab-apple tree (photo: Kim-Ly Thompson); (b) Numerous landslides in Gitga’at territory (photos: Bruce Reece, Chris Picard, Donald Reece); (c) Black bear entering Hartley Bay to forage in September 2017 (photo: Angela Clifton)

FIGURE 4 Harvesters’ observations of the change in abundance and quality of the three most commonly harvested traditional foods in the spring and fall/winter of 2017. Harvesters’ answers were about the general direction of change they had observed in their lifetimes, not bound to a specific time frame.

- **La’ank, seaweed** ($n = 16$)
- **Yee, spring salmon** ($n = 13$)
- **Tusn, kahntar** ($n = 11$)
- **Ghoon, cockles** ($n = 12$)
- **T’ma’ut, clams** ($n = 8$)
- **Ux, coho salmon** ($n = 8$)
shared since sharing and trading institutions continue to be an important facet of Gitga’at livelihoods. For millennia, trading and sharing have been key to building and maintaining personal and political relationships within and between different villages and tribal groups. This trading and sharing system also has links to sustainability of harvesting, and the ability to meet needs for traditional foods. One harvester, who preferred to remain anonymous, said:

One thing I learned from the old people. When you go out you get lots of clams, you share it. Give it to people that can’t go out... So I helped a lot of old people, eh. I was taught that by my parents and my grandparents. And the old man used to say that when you do that, you have no trouble the next time you go out there. No trouble getting food. (Anonymous 4, 5 March 2018)

### 3.8 Accessibility

Participants often brought up issues of access when discussing observations of change and requested that post-harvest season interviews include a question to prompt harvesters to reflect on the reasons why they may not have harvested certain species. Many interviewees did not feel that their needs for harvested foods had been met, or would have preferred to harvest more to share and/or trade with friends and family. Given that we interviewed people we knew to be involved in food harvesting activities, we estimate that these are conservative figures.

Several participants described how their involvement in the wage economy reduced the amount of time available to participate in harvesting activities. A reduction of available time has resulted in the reliance on travel by speedboats to reach harvest sites quickly, as opposed to slower gillnetters or small rowboats. The cost of fuel to power speedboats requires harvesters to have a cash income, reinforcing the need to be involved in the wage economy. Other participants spoke of physical barriers to harvesting, such as the tubeworms impeding cockle harvesting (C. Hill, 12 July 2017).

### 3.9 Weather

Many participants said that they pay close attention to the relative air temperature and amount of precipitation since these factors influence the growth, quality and abundance of several cultural keystone species including salmon and seaweed. Weather also plays a crucial role in the ability access to coastal and marine resources. Thus, many harvesters said they pay particularly close attention to weather conditions such as the strength and direction of winds. In an interview after the spring harvest season, Cameron Hill said:

The wind’s been pretty bad. Not storm-wise, but just windy enough to make it, I’d say treacherous to get your stuff... As a kid I always remember the outflow winds happening in the morning, and then it calms and it stays calm, and hot, and that’s how our late spring and early summer was. But for the last few years that southerly wind that happens down in Ky’el has been making its way further this way. (C. Hill, 12 July 2017)

### 3.10 External factors

Many participants stressed the importance of monitoring external factors that exert pressure on key elements of the system and have the potential to compound changes caused by changing weather patterns. For example, the combined pressures of commercial, recreational and illegal fisheries directly impact the abundance and availability of several traditional food species. In particular, harvesters said they were intent on preventing the repetition of the mismanagement of commercial harvest and subsequent illegal fisheries that led depletion of northern abalone (bilhaa, *Haliotis kamtschatkana*) under the watch of the Canadian Department of Fisheries and Oceans (DFO; Campbell, 2000). While traditional harvesting followed strict protocols, including not harvesting immature individuals and only harvesting during low tides in the spring months without diving, commercial harvesting occurred year-round and included subtidal harvest. This led to rapid depletion and a moratorium on all harvesting, including for Indigenous food, social or ceremonial purposes. Many participants were concerned that a similar scenario might unfold with decreasing numbers and quality (size) of coho and chinook salmon (Figure 4).

Participants also described unbalanced predator-prey dynamics as an external pressure on harvested species. Harvesters are also concerned about the effects of man-made pollutants including polycyclic aromatic hydrocarbons from fossil fuel spills and combustion, plastics and microplastics, and radiation released by the tsunami that hit nuclear reactors in Fukushima, Japan in 2011, on their ability to consume traditional foods.

### 3.11 Abnormal species and landscape features

Finally, harvesters described abnormalities in species composition and behaviour, and components of the landscape that were noteworthy to interviewees as features of monitoring. These include non-native and invasive species, such as tent caterpillars that devastate pacific crab apple trees (sgran moolks, *Malus fusca*), and unusual animal behaviour such as the large numbers of bears entering the village of Hartley Bay in the Fall of 2017 (Figure 3a,c). Harvesters also noted an unusually high number of landslides in the fall of 2017, which impacted their ability to travel safely due to large quantities of woody debris in the water (Figure 3b). Such abnormalities may potentially impact access.
to traditional foods, habitat quality, and the abundance and quality of traditional food species.

4 | DISCUSSION

In this case study, we analysed Gitga’at harvesters’ observations of change in their territory to outline the elements and indicators they monitor through harvesting. Our analysis revealed that interlinked social and ecological elements are monitored by Gitga’at land and sea people. It is important to note that the distinction between social and ecological elements of the monitoring framework was not made by Gitga’at participants, as occurrences in the spiritual and social-political world and the natural world are understood as inseparable. In fact, when we first designed the framework, we did not find it necessary to delineate social from ecological or social-ecological components. We have since chosen to make this distinction to demonstrate its relevance to the broader body of social-ecological systems and related literature (e.g. Anderies, Janssen, & Ostrom, 2004; Folke, 2006; Ostrom, 2009). The framework of Gitga’at understandings of monitoring-through-harvesting that we have developed adds to examples from other Indigenous groups (e.g. Lyver et al., 2017; Parlee et al., 2005). Together, these examples can further the discussion on the development of appropriate regional and global indicators of social-ecological resilience and can help to situate the appropriate inclusion of scientific methodologies within Indigenous approaches to monitoring. Furthermore, our framework highlights the connections between cultural continuity and sustainable management of resources, thus encouraging efforts to revitalize Indigenous knowledge. We discuss these points further in the paragraphs that follow.

Our findings that Gitga’at harvesters monitor social and ecological indicators through land- and sea-based practices are similar to reports from other Indigenous communities. For example, Māori in New Zealand monitor forest health and community well-being using indicators that include prevalence of certain species, sounds associated with the forest, intensity of weather and the strength of people’s connection to the forest (Lyver et al., 2017). In northern Canada, Denésolíné hunters monitor barren ground caribou migrations using physical indicators such as body condition and population size as well as spiritual indicators to explain variability in migration patterns (Parlee et al., 2005). Such culturally grounded indicators are well suited to trace the effects of human processes on ecological outcomes and vice versa (see Bliege Bird & Nimmo, 2018; Crabtree, Bird, & Bird, 2019). While the culturally specific nature of Indigenous indicators can present challenges of comparability across scales, starting with local cultural perspectives and recognizing feedbacks between ecological and human well-being can help link regional, national and global decision-making to local realities (Sterling et al., 2017). The Tracking Change project conducted with communities across the Mackenzie, Mekong and Amazon River basins, as well as community-based observation networks across coastal Arctic communities, are demonstrating this potential by building local monitoring indicators, and networking knowledge gained (Alessa et al., 2016; Michell, Tsannie, & Adam, 2018; Parlee & Mahoney, 2017). Given the scale and rate of global environmental change, complex systems and resilience scholars have been stressing the need for such social-ecological monitoring (Anderies et al., 2004; Caillon, Cullman, Verschuuren, & Sterling, 2017), and examples exist of how such community-based efforts are informing autonomous local adaptation (Huntington et al., 2017). These examples, including ours, illustrate that relational values are crucially important in Indigenous monitoring.

There are some key differences between the approaches taken by Indigenous monitoring-through-resource-use and other types of monitoring that are prevalent in Indigenous territories (e.g. scientific monitoring for wildlife conservation). First, the objectives set by Gitga’at participants for a monitoring programme based on their knowledge and observations of change are ultimately about community well-being and survival. Furthermore, monitoring through harvesting activities is anchored within longstanding place-based knowledge which includes social and ecological elements. On the other hand, the objectives of scientific monitoring for conservation or climate change are set at larger scales, often across regional, national or international scales (e.g. Bellfield et al., 2015). In as much, conservation indicators are generally quantifiable and standardized across scales. However, they rarely take social or linked social-ecological indicators into account (Thompson et al., 2020), thus potentially missing important connections and feedback loops. There is, however, some overlap between indicators monitored by Gitga’at harvesters and scientific conservation efforts, such as species abundance and distribution. This can create opportunities for Indigenous groups to seek scientific methods to enrich ecological understanding by complementing the place-based nature and longer historical baselines of Indigenous monitoring methods (e.g. Gitga’at harvesters’ knowledge of places in their territory where food species are typically abundant) with the larger spatial scales and quantitative nature of scientific ones (Ban et al., 2018; Moller et al., 2004).

As has been highlighted elsewhere, the findings of scientific and Indigenous monitoring methods can sometimes be at odds with each other (e.g. Fernandez-Gimenez, 2000; Fernandez-Gimenez, Huntington, & Frost, 2006; Riseth et al., 2011). In Gitga’at territory, such an incongruency exists in the diverging conclusions on the toxicity of butter clams following the sinking of the M.V. Queen of the North in March 2006. While laboratory analyses of polycyclic aromatic hydrocarbons in shellfish sampled by the Gitga’at Guardian programme indicated that levels were lower than those deemed of concern by toxicologists 4 months later (Thompson, Picard, & Chan, 2017), many harvesters and Elders have deemed that clams from the affected beach remain unpalatable and discourage harvests there to this day. This particular divergence, among others, is a potent site to deliberate on the legacies of industrial contaminants on local communities (e.g. Sandlos & Keeling, 2016) and how best to leverage the technologies of science to assess these in the context...
of resurgent Indigenous food sovereignty and governance (Grey & Patel, 2015; Settee & Shukla, 2020; Simpson, 2014).

Describing how interconnected social and ecological elements and indicators are monitored through Indigenous harvesting activities, centres Indigenous approaches to monitoring while demonstrating that scientific approaches can be leveraged where appropriate. Bohensky and Maru (2011) describe the integration of scientific and Indigenous monitoring methods as ‘... a process in which the originality and core identity of each individual knowledge system remains valuable in itself and is not diluted through integration with other types of knowledge’. A key part of this process is to frame objectives within local Indigenous values, identify the pre-existing Indigenous methods of generating knowledge, then seeking relevant scientific knowledge to enhance research and monitoring (Ban et al., 2018). Using this approach, several Indigenous communities have leveraged scientific approaches to meet their needs. Notably, the Heiltsuk, Kitsaoo/Xais Xais, Nuxalk and Wuikinuxv Nations have joined to create the Central Coast Resource Alliance (CCIRA) which partners with ecologists to conduct marine monitoring and research projects based on local needs (Eckert et al., 2017; Frid, McGreer, & Stevenson, 2016). These Nations and the Gitga’at Nation have also partnered with scientists to monitor bear populations on the central coast by anchoring their objectives in local Indigenous values, identify the pre-existing Indigenous methods of generating knowledge, then seeking relevant scientific knowledge to enhance research and monitoring (Ban et al., 2018). Using this approach, several Indigenous communities have leveraged scientific approaches to meet their needs.

Participants’ answers to questions about changing abundance and quality were not bound by temporal references (i.e. harvesters commented on the general direction of change in their lifetimes) and were rarely unanimous, thus we cannot yet conclusively comment on directionality of changes.

Some aspects of the lack of unanimity can be attributed to participants’ broad range of harvest experience, and that younger harvesters may not be aware of past ecological conditions (i.e. shifting ecological baseline syndrome; Papworth, Rist, Coad, & Milner-Gulland, 2009). Furthermore, there may be a generational difference in the needs for traditional foods as store bought food become more readily accessible and diets shift (Kuhnlein & Receveur, 1996). Parsing and comparing observations by age group can identify opportunities for Elders to share their knowledge of ecological (i.e. abundance of food species) and social–ecological (i.e. how often traditional foods were consumed) baselines with younger generations. However, intragenerational differences in observations of change may point to the fact that some participants may be more knowledgeable in some areas than others. This difference in specific knowledge can be attributed to gendered roles or expertise in harvesting and preparing specific food species (Butler, 2004). The identification of experts by Gitga’at peers and community members for each indicator and element of the monitoring framework is an important next step for the proposed monitoring programme (Davis & Wagner, 2003). Despite our small sample size and varied responses, we maintain that harvesters’ observations of decreasing abundance and quality of important food resources, as well as a portion of interviewees not meeting their needs for traditional foods point to crucial resource management and governance considerations. This is particularly striking in the case of cockles, spring salmon and coho salmon for which over half of participants indicated a decreasing abundance. Given the important role traditional foods in the institutions of Tsimshian and Gitga’at society (i.e. feasting, sharing networks), there is a pressing need for restorative ecological management practices.

Participants’ emphasis on harvesting as an act of cultural continuity and the role of traditional harvesting protocols in ensuring sustainability highlights the importance revitalizing and promoting Indigenous ways of knowing as an avenue for the restoration and resilience of ecological systems (Corntassel & Bryce, 2012; Kimerer, 2000). For Tsimshian people, this continuity is conceptualized as ‘gugwilx’ya’ansk’, which translates literally as ‘for all time walking/distribute’, and is an everyday occurrence through hunting, gathering or spending time with Elders and is practiced more formally through feasts during which specific teachings and laws are shared (Greening, 2017). Longstanding experience and monitoring of human–nature interactions can lead to incremental learning of how to best live sustainably, and lessons are often perpetuated and strengthened though worldview, oral histories and social institutions (Turner & Berkes, 2006). This is the case in Tsimshian society where traditional harvesting practices and governance has built in checks and balances to guide sustainable resource use, including harvest protocols and management rights and responsibilities of clan and house leaders (Gitga’at First Nation, 2011). These protocols and teachings, which have developed over thousands of years of occupancy, are alive in the Tsimshian adaawx (true-tellings or oral histories) and the ayaawx (law; Greening, 2017). However, as with many other Indigenous communities, some of these teachings have been eroded due to ongoing colonization and assimilationist policies (e.g. residential schools and the Indian Act in Canada; Simpson, 2017; Truth & Reconciliation Commision, 2015). Thus, there are moral and practical obligations for settler governments to support efforts of Indigenous resurgence and resource management. In addition to
ensuring the physical sustenance of coastal Indigenous peoples, the revitalization of Indigenous knowledge systems necessitates access to the traditional territories and the resources within them as well as the rights to exercise knowledge through management. As has been highlighted in by other coastal first nations in British Columbia (i.e. Bennett et al., 2018; Salomon, Quinlan, Pang, Okamoto, & Vazquez-Vera, 2019). Gitga’at harvesters’ direct observations of social–ecological change emphasize that Indigenous people’s access to territory, resources and rights to cultural continuity must have a central place in governance, resource management and policy discussions in Canada.

The Gitga’at monitoring framework also offers insights for national and global sustainability processes to improve policies and practices, and better include Indigenous perspectives. In particular, we would like to discuss parallels that exist between the Gitga’at monitoring framework and the NCP conceptual framework. The NCP is promoted by the United Nations and emphasizes the existence and importance of context-specific perspectives such as the one we have presented in this paper (Diaz et al., 2018; IPBES, 2019). Though there are many avenues to discuss the similarities and differences between our framework and the NCP framework, we would like to focus on the NCP concept of ‘maintenance of options’ and the Gitga’at concept of ‘gugwilx’ya’ansk’ (‘cultural continuity’). ‘Maintenance of options’ is an NCP reporting category described as the ‘capacity of ecosystems, habitats, species or genotypes to keep options open in order to support a good quality of life,’ and is the only category which spans material, non-material and regulating benefits according to the IPBES framework (Diaz et al., 2018, supplementary materials). This description is unidirectional, with nature conferring these benefits to people. The concept of cultural continuity is also about the quality of life for future generations of Gitga’at people but is anchored in the social and cultural systems which inform how to care for nature so that it may continue to take care of future generations in turn. This reciprocal loop is a salient example of how material and non-material contributions of nature arise from human practices anchored in relational values. Our example echoes Whyte et al. (2016) in demonstrating the multiple ways in which human and non-human entities uphold their responsibilities to each other and reflects how the acts of caring for the natural world—in this case through monitoring and harvesting—contribute to human well-being (Jax et al., 2018). We believe that NCP could be strengthened by emphasizing the bidirectional nature of reciprocal relationships between people and nature, particularly in respect to maintaining the options of material, non-material and regulating benefits for future generations.

Finally, these parallels prompt reflection on how western societies can restore, or develop, value-based ecosystem management systems (Artelle et al., 2018; Gould et al., 2019), and can inform the economic, political and social transformations that are necessary to curb the alarming decline of the natural systems we collectively depend on (Diaz et al., 2019). We are not suggesting that the framework presented here is suitable for all contexts, but rather point to the need for nation-state governing bodies to uplift pre-existing context-specific stewardship systems. In Canada, for example, provincial and federal governments have stated their intentions to build or rebuild honourable relationships with Indigenous people, in a process of reconciliation (Government of British Columbia, 2019; Government of Canada, 2018). Central to reconciliation are questions of how the policies and practices of Canadian resource management institutions, such as fisheries, forestry and environmental impact assessment agencies, interact with Indigenous ones, and their ultimate impact on the lands central to Indigenous identify and livelihoods. Canadian history is fraught with examples of how resource management decisions centred on neoliberal economic values have negatively impacted ecosystems as well as Indigenous and non-Indigenous livelihoods (e.g. collapse of the northern abalone fishery [Lee et al., 2019], and the decline of herring fishery [Salomon et al., 2019]), or dismissed the risk of such impacts (e.g. approval of Enbridge Northern Gateway project; Gunton & Broadbent, 2012; Hotte & Sumaila, 2014). We suggest that, by recognizing, learning from, and ultimately supporting pre-existing relational processes of Indigenous monitoring and management, Canadian institutions stand to make true on their responsibilities of reconciliation and sustainability.

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CONFLICTS OF INTEREST

The authors have no conflict of interest to declare.

AUTHORS’ CONTRIBUTIONS

K.-L.T., C.H., N.C.B. and C.R.P. conceived the ideas for this paper; K.-L.T. and N.C.B. designed the methodology; K.-L.T. collected the data; K.-L.T., C.H. and N.C.B. built the framework; K.-L.T. led the writing of the manuscript with significant contributions of N.C.B., C.R.P. and J.O. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

Data analysed in this paper are held by the Gitga’at Oceans and Lands Department and are not publicly available because it contains sensitive information.
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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section.

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