



Synthesis

Culturally significant fisheries: keystones for management of freshwater social-ecological systems

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ABSTRACT. Indigenous peoples of North America, Australia, and New Zealand have a long tradition of harvesting freshwater animals. Over generations of reliance and subsistence harvesting, Indigenous peoples have acquired a profound understanding of these freshwater animals and ecosystems that have become embedded within their cultural identity. We have identified trans-Pacific parallels in the cultural significance of several freshwater animal groups, such as eels, other finfish, bivalves, and crayfish, to Indigenous peoples and their understanding and respect for the freshwater ecosystems on which their community survival depends. In recognizing such cultural connections, we found that non-Indigenous peoples can appreciate the deep significance of freshwater animals to Indigenous peoples and integrate Indigenous stewardship and Indigenous ecological knowledge into effective comanagement strategies for sustainable freshwater fisheries, such as Indigenous rangers, research partnerships, and Indigenous Protected Areas. Given that many of these culturally significant freshwater species also play key ecological roles in freshwater ecosystems, their recognition and prioritization in management and monitoring approaches should help sustain the health and well-being of both the social and ecological components of freshwater ecosystems.

Key Words: *adaptive freshwater management; aquatic resources; bivalve; comanagement; crayfish; cultural keystone species; eel; Indigenous ecological knowledge; Indigenous water rights; lamprey; salmon; social-ecological resilience*

INTRODUCTION

Freshwaters are often an intrinsic part of place and central to linking human values and relationships with areas of cultural significance (Langton 2002, 2006, Harmsworth et al. 2011). Accordingly, many Indigenous peoples have value systems and concepts that recognize interconnections between people and freshwaters (Table 1), which typically seek to balance the human use of freshwaters by respecting them as a gift (e.g., Blackstock 2001, Tipa 2013) and harvesting in a manner that does not compromise ecosystem integrity (Kahui and Richards 2014). Indigenous people have managed their freshwater environments accordingly for thousands of years (Haggen et al. 2006, Gunditjmarra people 2010, Aboriginal Water Initiative 2012), often with a keen awareness of seasonal cycles of hydrological change (Blackstock 2001). Through thousands of years of stewardship, Indigenous peoples have developed deep cultural connections to freshwaters and the freshwater animals that help maintain their cultural, social, and economic health and well-being.

Aquatic animals are often central to human connections to freshwaters by providing an important food source and/or a focal point for culturally significant events, ceremonies, and intergenerational teachings about the natural world (Cristancho and Vining 2004, Garibaldi and Turner 2004, Schnierer 2011, Alfred 2014). As such, these cultural keystone species (CKS) influence the cultural identity of a group of people via the species role in subsistence, spirituality, and/or Indigenous economies (Garibaldi and Turner 2004, Butler et al. 2012, McCarthy et al. 2014). Maintaining connections to these species through traditional practices is crucial for the social-ecological resilience

of Indigenous cultures. Despite this importance, freshwater CKS are often not formally recognized in modern management and monitoring approaches, which have traditionally focused on threatened species and, more recently, ecological keystone species that perform key roles in maintaining biodiversity, ecosystem health, and bolstering resilience to disturbance (Bond 1994, Gunderson 2000, Caro 2010). Equitable integration of Indigenous ecological knowledge (IEK) into modern fisheries management can empower Indigenous people via recognition of their sovereignty (Bohnesky and Maru 2011, Alfred 2014) and support of customary harvest values and practices (Schnierer 2011, Butler et al. 2012). If we are to bolster social-ecological resilience in freshwaters, we must recognize culturally significant species, engage a range of people in building cross-cultural capacity and understanding of freshwaters, and include IEK in adaptive management plans (Berkes et al. 2000, Moller et al. 2004, Stephenson and Moller 2009, Ruiz-Mallén and Corbera 2013).

In this review, we explore the cultural significance of some key freshwater animals that underpin Indigenous fisheries and communities around the world and how their recognition as CKS can enhance management approaches to sustain Indigenous and non-Indigenous people, as well as the freshwater ecosystem goods and services on which we all depend. We focus on freshwater animal groups with cross-continental importance to draw on multicultural examples of Indigenous freshwater fisheries management in North America, including the United States and Canada; Australia; and New Zealand. Our specific aims were to (1) identify species that facilitate cultural connections to freshwaters and have cross-cultural, ecological, and economic importance; (2) explore cross-cultural approaches to fisheries

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Table 1. Examples of the terms used to embody Indigenous approaches to stewardship of fisheries and/or freshwaters in North America, Australia, and New Zealand.

Indigenous Group	Location	Term	Description
First Nations	North America	<i>Fons et origio</i> (Blackstock 2001)	Describes source of all possible existence and symbolizes potentiality of nature.
Mi'kmaq	North America	<i>Netukulimk</i> (Prosper et al. 2011)	Holistic natural resource management concept that ensures sustainability and prosperity of a resource for the present and future generations.
Mid-Columbia Plateau Tribes (Sahaptin native language)	North America	<i>Shukwat</i> (Close et al. 2002)	All life believed to have a spirit and a conscience. Promotes respect for all things in nature and is interwoven with Sahaptin culture via myths and legends.
		<i>Tamanwit</i> (Close et al. 2002)	Sacred law of how humans should live with the brothers and sisters of the natural world. If someone abuses <i>Tamanwit</i> , the <i>Shukwat</i> will make life difficult for that person.
Māori	New Zealand	<i>Mauri</i> (Marsden and Henare 1992)	The binding force between the physical and the spiritual that interpenetrates all things to bind and knit them together. The capacity for air, water, or soil to support life. <i>Mauri</i> is found in water, land, and forests, as well as mist, wind, soil, and rocks.
		<i>Mātauranga Māori</i> (Waitangi Tribunal 2011)	The unique Māori way of viewing the world, a dynamic and evolving knowledge system encompassing traditional knowledge, language, and culture.
		<i>Kaitiakitanga</i> (Roberts et al. 1995)	The inherited nurtured responsibility of Māori to look after the resources within their tribal area. Derived from the verb <i>tiaki</i> , which means to guard, to protect, to keep, to watch for, to wait for.
Aboriginal	Australia	Various (Langton 2002, 2006)	Multiple regional terms used across Australia to represent each tribes' strong connections to freshwaters as part of their spiritual and cultural identity. A common belief is the following: "If the water is healthy, Country is healthy. If Country is healthy then the People and Culture will be healthy" (Moggridge and Mihinui 2010:1).

management, using the case study of freshwater eels to illustrate the diversity of approaches and benefits of recognizing culturally significant freshwater animals; (3) examine barriers and issues with Indigenous access to culturally significant fisheries; and (4) suggest future approaches to improve freshwater management via recognition of CKS and adoption of IEK in comanagement, research partnerships, and Indigenous custodianship.

CULTURALLY SIGNIFICANT FRESHWATER FISHERIES

Our exploration of Indigenous freshwater fisheries in North America, Australia, and New Zealand identified four common animal groups playing particularly important cultural roles within the Indigenous communities of these nations: eels/lampreys, other finfish, freshwater bivalves, and crayfish. Through their role in traditional subsistence foods, ceremonies, celebrations, and/or other spiritual practices, these freshwater animals reveal some trans-Pacific similarities in Indigenous recognition and values, as well as some notable differences (Tables 2-5). Ecological research to date also suggests that many of these freshwater animals are vital for maintaining good water quality, nutrient cycling, trophic webs, habitat engineering, and/or other key components of freshwater ecosystem integrity and function. We explore both the cross-cultural and ecological importance of these freshwater animals, as well as the extent to which these species fit the characteristics described by Garibaldi and Turner (2004) to be recognized as CKS.

Eels and lampreys

Eels (Anguilliformes) and lampreys (Petromyzontiformes) are eel-shaped fishes that are thought to be CKS because of their central role in trans-Pacific Indigenous cultures as food, medicines, and raw materials in ceremonies and celebrations (Table 2). Eels and lampreys undergo large migrations between freshwaters and the open ocean and so provide a key form of

aquatic connectivity and nutrient transport (Haro et al. 2000, Lewis 2002, Casselman 2003). Indigenous peoples have developed substantial knowledge of their spatial and seasonal distributions, habitat requirements, behavior, and migratory patterns. Cultural fishing for eels and lampreys is important for Indigenous community well-being, capacity and capability development, and the passing down of IEK among generations across Indigenous nations spanning the Pacific Ocean (Fig. 1).

Fig. 1. Indigenous fishing for eels: (A) Richard Bamblett, Lake Condah, Australia, using a traditional spear to capture *kooyang* and *puumyuurt* reed basket (photo: Denis Rose). (B) A Mi'kmaq youth in Nova Scotia learning to use a winter spear to fish for *ka't* (photo: Kerry Prosper).



Table 2. Cultural and ecological significance of selected eel and lamprey species to Indigenous peoples in North America, Australia, and New Zealand, along with a summary of key threats and selected species-specific management plans and/or approaches where available.

Common and Scientific Name		Location	Indigenous Groups	Cultural Importance	Ecological Importance	Key Threats	Management Approaches
Indigenous Name							
Short-finned eel (<i>Anguilla australis</i>)							
<i>Kooyang</i>		Australia	Gunditjmara	Important cultural subsistence fishery, had historical management strategies (Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation 2004, Pease 2004, McKinnon 2007, Gunditjmara people 2010, Richards 2011).	Once abundant, nutrient cyclers, apex predator (McKinnon 2007).	Wetland habitat and spawning ground drained for agriculture. Commercial fishing pressure (Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation 2004, McKinnon 2007, Gunditjmara people 2010).	Recent agreements to start wetland restoration and integrate IEK (Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation 2004, McKinnon 2007, Gunditjmara people 2010).
Long-finned eel and short-finned eel (<i>Anguilla dieffenbachii</i> and <i>A. australis</i>)							
<i>Tuna</i>		New Zealand	Māori	Important cultural fisheries throughout the entire country. Important in ceremonial practices (Best 1929, Marshall 1987, McDowall 2011).	Dominant part of stream fish biomass, apex predator, longfin females are often largest and oldest freshwater fish. Undertake mass migrations. Capable of occupying full range of freshwater habitats (McDowall 1990, Chisnall and Hicks 1993, NIWA 2010a, Jellyman 2012).	Instream barriers that inhibit upstream and downstream passage, extensive loss of habitat including wetlands. Historical extermination campaigns and overfishing (McDowall 1990, NIWA 2010a, Jellyman 2012, Te Wai Māori 2014).	Recognized as culturally important species. Mātaitai reserves allow exclusive customary fisheries, along with comanagement approaches in selected waterways (Jellyman 2007, Ngā Papatipu Rūnanga Working Group 2013, Shortland 2013, New Zealand Government 2010, 2014c).
American eel (<i>Anguilla rostrata</i>)							
<i>Ka't</i>		North America	Mi'kmaq	Important cultural food source used to strengthen customary practices. "First Foods" for newborn babies and "Last Foods" for sick and elderly (Prosper 2002, Davis et al. 2004, Denny and Paul 2010, Weiler 2011).	Historically abundant source of biomass for the streams, important cyclers of nutrients in the stream and apex predators (Haro et al. 2000, Casselman 2003).	Declining access to upper streams and lake habitats through infrastructure blockages. Commercial fishing pressure (Haro et al. 2000, Casselman 2003, Weiler 2011).	Recent treaties extend Mi'kmaq Nation access and commercial fishing rights. Working with Parks Canada to integrate IEK (Prosper 2002, Denny and Paul 2010).
Pacific lamprey (<i>Lampetra tridentata</i>)							
<i>ksuyas</i> or <i>asum</i>		North America	Sahaptin, Nez Perce, Umatilla, Yakama, and Warm Springs	Culturally important food source. Part of the "First Foods" ceremonies and plays important role in tribal celebrations (Close et al. 2002, CRITFC 2011, Dittmer 2013).	Historical high stream biomass. Provide nutrient transport and food for other species. Filter feed and influence detrital cycles that positively affect water quality (Close et al. 2002, CRITFC 2011, Dittmer 2013).	Dam infrastructure blocking passageways and degradation of habitat. Historically used by settlers for salmonid fishmeal and livestock feed (Close et al. 2002, CRITFC 2011).	Fishery largely ignored by federal, state, and land-use management agencies. CRITFC Tribal Pacific Lamprey Restoration Plan started in 2011 (CRITFC 2011, Dittmer 2013).

CRITFC, Columbia River Inter-Tribal Fish Commission; IEK, Indigenous ecological knowledge.

Table 3. Cultural and ecological significance of selected finfish species to Indigenous peoples in North America, Australia, and New Zealand, along with a summary of key threats and selected species-specific management plans and/or approaches where available.

Common and Scientific Name		Location	Indigenous Groups	Cultural Importance	Ecological Importance	Key Threats	Management Approaches
Indigenous Name							
Murray cod (<i>Maccullochella peelii</i>) <i>Pondi, Ponde, Goodoo, Guddhu, Ponkoo, Barnta, Googoobul, Kurrumerruck, Pandiyil, Burnanga</i>		Australia	Murray Darling River Tribes	Cultural totem with role in creation of Murray River. Traditional food source. Economic income through cultural ecotourism (Scott 2005, Weir 2009, Ginns 2012).	Important apex predator that helps balance the freshwater ecosystem (Ebner 2006).	Habitat loss, flow regulation, water quality, loss to irrigation systems, movement barriers, invasive species, overfishing (Koehn 2005).	Recent recognition of cultural importance, inclusion in species management. Cultural harvest limit (S. Schnierer and H. Egan, unpublished manuscript).
Whitebait (<i>Galaxias maculatus, G. brevipinnis, G. fasciatus, G. argenteus, and G. postvectis</i>) <i>Īnanga, kōaro, banded kōkopu, giant kōkopu, and shortjaw kōkopu</i>		New Zealand	Māori	Juvenile migratory form is an abundant food source harvested in large quantities, which could be dried for future use (Best 1929, McDowall 2011). Presence of large numbers is indicator of river health.	Once made up a large biomass of the streams. Provides a food source for aquatic and terrestrial species (Rowe et al. 2002, Department of Conservation 2004, McDowall 2010).	Poor water quality, land-use disturbance, including riparian and wetland habitat loss, and instream migration barriers (Rowe et al. 2002, Department of Conservation 2004, McDowall 2010, NIWA 2010b).	Whitebait fishing (West Coast) regulations 1994, prepared under the Conservation Act 1986. Some customary fisheries management plans, such as Waikato River and Te Arawa (Rotorua) Lakes Treaty Settlements (New Zealand Government 2013, 2014a).
Salmon (<i>Oncorhynchus</i> spp.) <i>wy-kan-ush</i> in Sahaptin		North America	Alaska, Canada, and the Pacific Northwest (300+ tribes)	Strong cultural significance, food source (subsistence/commercial). First salmon ceremony creates sense of traditional place. Part of nutrition, health, and generational knowledge transfer. Cultural identity of Columbia River Valley “salmon people” (<i>wy-kan-ush-pum</i>) (Landeen and Pinkham 1999, Haggen et al. 2006, Johnsen 2009, Cozzetto et al. 2013, Dittmer 2013, CRITFC 2014, Galbreath et al. 2014).	Important nutrient transport across both aquatic and terrestrial systems. Critical food source for many aquatic and terrestrial species. Considered a keystone species (Landeen and Pinkham 1999, CRITFC 2014, Galbreath et al. 2014).	Habitat destruction, hydroelectric and dam infrastructure blocking passageways. Poor nursery stream habitats. Pollution, low water quality and sedimentation (Landeen and Pinkham 1999, Dittmer 2013, CRITFC 2014, Galbreath et al. 2014).	Intertribal basin-wide plan “Spirit of the Salmon,” Columbia River Inter-Tribal Fish Commission, USA. Indigenous hatchery to rebuild stocks. Many tribes still fighting for customary fishing rights (Landeen and Pinkham 1999, Haggen et al. 2006, Johnsen 2009, Cozzetto et al. 2013, Dittmer 2013, CRITFC 2014, Galbreath et al. 2014).

In North America, the Pacific lamprey (*Lampetra tridentata*) is considered sacred to elders of the river and is used in “First Foods” ceremonies for the Columbia River Tribes (CRITFC 2011, 2014) and for bathing and special medicinal uses (Close et al. 2002). Adult lampreys have historically been a major component of animal biomass in North American streams, and

tribal members of the Yurok and Karuk tribes in Northern California have long recognized the significant role of lampreys in the Klamath River ecosystem as essential contributors of marine-derived nutrients and organic matter (Close et al. 2002, CRITFC 2011). North American First Nation tribes, such as the Mi’kmaq, also share a rich cultural history with the American eel

Table 4. Cultural and ecological significance of freshwater mussels to Indigenous peoples in North America, Australia, and New Zealand, along with a summary of key threats and selected species-specific management plans and/or approaches where available.

Common and Scientific Name		Location	Indigenous Groups	Cultural Importance	Ecological Importance	Key Threats	Management Approaches
Indigenous Name							
Freshwater mussels (<i>Hyriidae</i>)							
Tribe specific	Australia		Aboriginal	Once an abundant food source for tens of thousands of years as shown by widespread middens (Walker et al. 2001, Humphries 2007, Humphries and Winemiller 2009).	Important filter feeders and nutrient cyclers in the ecosystem. Biological indicators (Walker et al. 2001, Boulton et al. 2014).	Poor river regulation, pollution, siltation. In some places, the mussels are too toxic to consume (Walker et al. 2001, Boulton et al. 2014).	Restoration projects are slow to start because of the complexity of the issues.
New Zealand freshwater mussel (<i>Echyridella menziesi</i>)							
<i>Kākahi kāeo</i> , and <i>torewai</i>	New Zealand		Māori	Important customary food source and part of spiritual practices and medicinal purposes, and shells were used for tools (Hiroa 1921, McDowall 2002, 2011).	Filter feeders that cycle nutrients and support good water quality. Biological indicators (McDowall 2002, 2011).	Poor river regulation and hydrological dam infrastructure. Pollution and bioaccumulative contaminants, sedimentation, and decline in host fish needed to complete life cycle (McDowall 2002, 2011).	A component of customary fisheries management plans, such as the recent Waikato River and Te Arawa (Rotorua) Lakes Treaty Settlements (New Zealand Government 2010, 2013, 2014a).
Freshwater mussels (+300 species)							
<i>Nay-ker</i> (tribe specific)	North America		CTUIR, Tennessee River, Mississippi River Basin, Choctawhatchee, Yellow River, and Conecuh Escambia River Basins, USA (Parmalee and Klippel 1974, Hughes and Parmalee 1999, Box et al. 2006).	Highly exploited food source for tribes across North America, especially in winter, evidence in the large shell middens, up to 10,000 years ago (Parmalee and Klippel 1974, Hughes and Parmalee 1999, Box et al. 2006).	Critically important filter feeders, consume detritus and microorganisms keeping the ecosystem in balance and good water quality. Also an important food source for fish species. Biological indicators (Box et al. 2006, Machtinger et al. 2007).	Deforestation, siltation, and pollution of the rivers. More than 75% are listed extinct or threatened. Invasive species. Historically, overfished by settlers for buttons and livestock feed (Parmalee and Klippel 1974, Hughes and Parmalee 1999, Box et al. 2006, Machtinger et al. 2007).	CTUIR, tribal and federal agencies are working together to restore freshwater mussels to the Umatilla River Basin (Box et al. 2006).

CTUIR, Confederated Tribes of the Umatilla Indian Reservation.

(*Anguilla rostrata*), or *ka't*, which is an important traditional food (Prosper 2002, Casselman 2003). Eeling is considered a group activity that strengthens the community groups by passing down the important customary practice to future generations (Davis et al. 2004, Denny and Paul 2010, Weiler 2011) and helping to support community bonds by sharing the catch with people not able to fish for themselves (Prosper 2002). *Ka't* is also part of important spiritual offerings, such as a gift to the grandfathers (*Apuknajit*) on the last day of January to give thanks for surviving the prior winter months (Prosper 2002). Legends of the Mi'kmaq depict eels as significant in shaping both the earth and human

lives, along with interacting with other important spirits (Weiler 2011).

Across the Pacific Ocean, eels also play a key role in the lives and identity of Indigenous peoples. New Zealand freshwater eels (*Anguilla dieffenbachia*, *A. australis*, and *A. reinhardtii*), or *tuna*, were the most important freshwater fish to Māori, with this species permeating place names, proverbs (*whakataukī*), legends, songs (*waiata*), and artwork. Eels were widespread, abundant, and often grew to a large size. This is particularly true of the long-finned eel (*A. dieffenbachii*) that is found only in New Zealand,

Table 5. Cultural and ecological significance of freshwater crayfish to Indigenous peoples in North America, Australia, and New Zealand, along with a summary of key threats and selected species-specific management plans and/or approaches where available.

Common and Scientific Name		Indigenous Groups	Cultural Importance	Ecological Importance	Key Threats	Management Approaches
Indigenous Name	Location					
Murray crayfish (<i>Euastacus armatus</i>), marron (<i>Cherax tenuimanus</i> and <i>C. cainii</i>), and yabby (<i>C. destructor</i>)						
<i>Yabji</i> (tribe specific)	Australia	Aboriginal	Important food source. Largest inland invertebrate food species. Yabbies 40% of yearly cultural catch (Humphries 2007; S. Schnierer and H. Egan, unpublished manuscript).	Ecosystem engineers, maintain streambed health; keystone species, maintain tropic cycles (Reynolds et al. 2013).	Poor water quality, unseasonal regulation of rivers, and potential overharvest (Furse and Coughran 2011).	Very complex issue, some attempts at restoration, integration of Indigenous ecological knowledge not apparent.
Freshwater crayfish (<i>Paranephrops planifrons</i> and <i>P. zealandicus</i>)						
<i>Kōura</i>	New Zealand	Māori	A valued and significant food source now considered a delicacy by some tribes. Once prized as a bartering item with Māori from outlying districts (Hiroa 1921, Kusabs and Quinn 2009, McDowall 2011).	Omnivorous role in stream ecosystem (Parkyn et al. 2001).	Invasive species, poor water quality, eutrophication, bioaccumulation of heavy metals (Parkyn et al. 2001, Kusabs and Quinn 2009, McDowall 2011).	Some customary fisheries management plans, including the Waikato River and Te Arawa (Rotorua) Lakes Treaty Settlements.
Freshwater crayfish (<i>Cambarus</i> spp. and <i>Astacus</i> spp.)						
<i>tsi-s-dv-ni</i>	North America	Cherokee, Chitimachas, Houmas, Choctaw, Attakapas, and many other tribes	Once plentiful and significant food source. Especially in Midwest and Southeast USA (Assembly of First Nations, Environmental Stewardship Unit 2007, Cherokee Nation History and Culture 2014).	Maintain good water quality by grazing algae and engineering streambeds. Bioindicators of stream health (Reynolds et al. 2013).	Poor water quality and flow regulation. Bioaccumulation of toxins and heavy metals (Assembly of First Nations, Environmental Stewardship Unit 2007).	Interest to be involved but no apparent integration or comanagement plans (Assembly of First Nations, Environmental Stewardship Unit 2007, Cherokee Nation History and Culture 2014).

which was easy to catch and preserve and provided a critical source of dietary fat (McDowall 2011). Prior to taxonomic systems of describing eels, the Māori had many cultural names for *tuna* according to their coloration, season, size, behavior, locality, and palatability (e.g., McDowall 2011). In southeast Australia, the Gunditjmarra people of the Budj Bim lava flow also have a long history of harvesting *kooyang*, or short-finned eels (*A. australis*), as well as the oldest known aquaculture of eels dating to 6600 years before present (Gunditjmarra people 2010, Richards 2011, McNiven et al. 2012). Smoked *kooyang* was a treasured food source and was traded for valuable flint along the coastline, where Australian Aboriginal reliance on freshwater eels was recorded in petroglyphs (Sefton 2013) and the naming of culturally important areas, such as the Kooyang Sea Country (Gunditjmarra people 2010). *Kooyang* continues to be a culturally important subsistence

fishery for Aboriginal peoples throughout southeast Australia, with large ceremonial gatherings coinciding with the seasonal eel migrations helping to connect Indigenous people of the region to the oceans beyond Australia (Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation 2004, Pease 2004).

Ecologically, adult lampreys have historically been a major proportion of the large-bodied animal biomass within streams, where the juveniles are important detritivores and filter feeders that help to maintain good water quality and provide a food source for other animals such as salmonid fishes (Close et al. 2002, Jellyman 2012, NIWA 2013). Eels have also been a large part of the freshwater animal biomass in a wide variety of freshwater habitats, including coastal estuaries, lakes, wetlands, rivers, mountain streams, and alpine tarns, and can penetrate large distances inland (McDowall 2011). Adult eels are often the top

predators in freshwater ecosystems and are opportunistic feeders consuming a diverse range of food, including stream insects, terrestrial insects, snails, freshwater crayfish, fish, and even small birds (Haro et al. 2000, McDowall 2011, Jellyman 2012). Through their diadromous migrations, eels also play a critical role in nutrient transport between the ocean and freshwater ecosystems (Haro et al. 2000, Casselman 2003). Given their ecological and cultural importance, eels and lampreys can be characterized as ecological keystone species and CKS, and so should be of key concern for freshwater management, research, and monitoring that considers the values, practices, and rights and interests of Indigenous peoples across these trans-Pacific nations.

Other finfish

Salmon (*Oncorhynchus* spp.) are a prime example of a culturally significant finfish in North America, where Native American and First Nations peoples have sustainably harvested salmon for subsistence and trade for more than 11,500 years (Table 3). The cultural importance of salmon is reflected in First Nations peoples of the Pacific Northwest collectively calling themselves *wy-kan-ush-pum* ("salmon people") where salmon are considered to unite all tribes and races of the region (CRITFC 2014). Like eels and lampreys, salmon provide a key link between freshwaters and the ocean and a food source for both aquatic and terrestrial ecosystems (Willson and Halupka 1995, Cederholm et al. 1999). Although Native American tribes have managed salmon species with a deep understanding of how to sustain healthy populations (Landein and Pinkham 1999, Haggen et al. 2006, Johnsen 2009), severe declines since European settlement have created an urgency to restore salmon populations in freshwater ecosystems for both their cultural and ecological importance.

In Australia, Murray cod (*Maccullochella peelii*) have a particularly strong cultural significance for Australian Aboriginal communities living within the Murray-Darling Basin (Table 3). Being part of the dreamtime creation story of the Murray-Darling system, Murray cod play a significant role in Indigenous cultural identity (Ginns 2012). Once a significant food source, fishing for Murray cod would often occur as a group activity, with Murray cod representing 25% or more of the edible freshwater cultural catch in some areas (S. Schnierer and E. Egan, *unpublished manuscript*). Indigenous cultural connections to this species remain strong, despite severe regional declines since European settlement, and their important ecological role as apex predators is now well recognized (Ebner 2006).

In New Zealand, the Māori have deep cultural, social, and economic connections to the New Zealand whitebait, which are juveniles of five different *Galaxias* spp. (Table 3). They provide a subsistence food for the Māori who target annual whitebait migrations and preserve (dry) their catches for many months (McDowall 2011). Whitebait species have a complex life cycle that typically involves mass migrations between freshwaters and the open ocean, although several whitebait species have developed landlocked populations in river systems associated with large lakes. Whitebait provide a primary food source for many other aquatic and terrestrial species but have been overfished by European settlers (Department of Conservation 2004, McDowall 2010, 2011, Morris et al. 2013) and are now in decline across much of New Zealand because of the loss of spawning habitat, trout predation, poor water quality, and infrastructure blocking stream

passageways (Department of Conservation 2004, NIWA 2010a, McDowall 2011).

Although there are many finfishes that support connections between Indigenous people and their freshwater environments, we have chosen these three species as prime examples of finfish CKS. Declines in the abundance and/or range of these species has had severe consequences for Indigenous well-being. Even though some efforts have been made to address these species declines through understanding the effects on non-Indigenous peoples, their cultural significance is yet to be fully recognized so that a more equitable approach to freshwater finfish comanagement can be fully realized.

Bivalves

Bivalves have facilitated Indigenous cultural connections to freshwaters in multiple ways (Table 4), but severe declines in bivalve diversity and abundance have severely altered contemporary Indigenous usage. Freshwater bivalves were an abundant food for Indigenous peoples in North America, New Zealand, and Australia for more than 60,000 years, with the shells used in medicines, tools, and jewelry, and incorporated into legends, songs, and proverbs (Hiroa 1921, Parmalee and Klippel 1974, Lyman 1984, Humphries and Winemiller 2009). Archeological evidence within middens indicates that Native Americans sustainably harvested freshwater mussels for at least 6000 years before the arrival of European settlers, but since then mussel biodiversity has severely declined, with 75% of U.S. freshwater mussel species endangered (Hughes and Parmalee 1999, Machtinger et al. 2007, Thorp and Covich 2010). New Zealand freshwater bivalves, or *kākahikāeo*, were also once an abundant cultural resource, reflected in middens, place names, Māori tradition, legend, and mythology (McDowall 2011). Likewise, Aboriginal people in Australia sustainably harvested freshwater bivalves for more than 10,000 years within the Murray-Darling Basin, which were seen as a reliable food source by the Aboriginal people when they would travel and/or gather together for large groups during ceremonies. However, there are now minimal modern freshwater bivalve harvests by Indigenous peoples across these nations because of severe population declines arising from habitat loss, poor water quality, and pollution (Table 4). Although the ecological consequences of such losses are yet to be fully resolved, the role of bivalves in maintaining good water quality via filter feeding (Box et al. 2006, Howard and Cuffey 2006, Machtinger et al. 2007) suggests cause for serious concern. Indeed, the loss of the New Zealand freshwater mussel (*Echyridella menziesi*) from lake systems in New Zealand has been linked to a lowering of water quality and increased toxic phytoplankton blooms (Walker et al. 2001, McDowall 2002). Notably, natural resource management and fisheries agencies have been slow to address declines in freshwater bivalve populations, perhaps because of the lack of general public interest and/or knowledge of these species. Given the importance of this CKS group, a more formal recognition of bivalves is needed and could be addressed through better recognition of IEK for this group to reveal pre-European baselines and key information for their recovery.

Crayfish

Evidence is emerging for the cultural importance of freshwater crayfish, with their remains in middens suggesting crayfish may

have once been an abundant food source for Indigenous communities across North America, New Zealand, and Australia (Table 5). Australian Aboriginals are thought to have utilized Murray crayfish (*Euastacus armatus*) as food (Kohen and Merrick 1998), and historical accounts report Aboriginal women using crayfish for body decoration (Humphries 2007). Recent research has revealed that freshwater crayfish and yabbies (*Cherax destructor*) are still taken in reasonable numbers for food by Aboriginal cultural fishers in parts of the Murray-Darling River basin (S. Schnierer and E. Egan, unpublished manuscript). Traditional use of freshwater crayfish (*Paranephrops planifrons* and *P. zealandicus*), or *kōuralkēwai*, by Māori as a food source and focal species for Māori customary practices is also evident in New Zealand. For instance, in the Te Arawa Lakes region, *kōura* are harvested using a variety of traditional methods, including the *tau kōura*, which involves placement of bracken fern bundles (known as *whakaweku*) on the lake bed, in which *kōura* take refuge and are captured (Hiroa 1921, Kusabs and Quinn 2009). Freshwater crayfish (*Cambarus* spp. and *Astacus* spp.) are also an abundant food source for the First Nations and the Native American people across North America (Assembly of First Nations, Environmental Stewardship Unit 2007, Cherokee Nation History and Culture 2014), particularly for the Chitimachas, Houmas, Choctaw, and Attakapas tribes of the Mississippi, Teche, and Lafourche river basin in Louisiana (Irwin 2014). Ecologically, crayfish are known to be critical for maintaining streambed health by processing detritus and cycling nutrients in freshwater ecosystems, as well as “engineering” streambed sediments via their burrowing activities (Reynolds et al. 2013). Although crayfish have started to become a target for freshwater conservation and fisheries management through their increasingly threatened status (Richman et al. 2015), their recognition as CKS would provide clearer pathways toward effective comanagement, whereby both IEK and social relevance could be integrated into their management and recovery plans.

CROSS-CULTURAL APPROACHES TO CONSERVATION AND MANAGEMENT: FRESHWATER EELS AS A CASE STUDY

Despite their cultural and ecological significance, all the freshwater animals mentioned previously have suffered severe declines as a result of environmental degradation and historical overfishing following European colonization (Revenga and Kura 2003, Dudgeon et al. 2006, Darwall et al. 2008). Such declines have greatly affected the subsistence economies of Indigenous people, who have lost access to freshwater fisheries and the ability to sustain cultural fishing practices and knowledge (Haggen et al. 2006, Dick et al. 2012). In response, many Indigenous people are driving the improved management, restoration, and conservation of freshwater species in North America, New Zealand, and Australia (e.g., Fraser et al. 2006, Woodward et al. 2012, Galbreath et al. 2014). Indigenous people have been working with other agencies to develop approaches that involve cooperative, community-based, and collaborative comanagement strategies (Tipa and Welch 2006, NIWA 2010a, Hill et al. 2012). The main goal has been an equitable framework for Indigenous people to incorporate their requirements for freshwater resources and share their wealth of IEK (Jackson et al. 2012, Ens et al. 2015). We draw on trans-Pacific examples of the Mi'kmaq of Nova Scotia, the Māori of New Zealand, and the Gunditjmarra of Australia to

illustrate how Indigenous peoples are working to sustain, revive, and restore cultural freshwater eel fisheries (Fig. 1).

Historically, the cultural and ecological importance of eels has been overlooked by fisheries management agencies in North America, Australia, and New Zealand, probably because of their low commercial food value, conflicting social values, and community misconceptions around their role in freshwater social-cultural ecosystems (Mattson 1949, Close et al. 2002, Jellyman, 2012, Dittmer 2013). Consequently, historical eel management plans and strategies have largely failed to recognize the social impacts of the loss of important eel subsistence fisheries for Indigenous communities (Davis et al. 2004, Jellyman 2007, Gunditjmarra people 2010, CRITFC 2011). Indigenous custodianship and customary fishing of eels, however, is starting to reemerge as a priority in contemporary management. For example, the Kooyang Sea Country Plan (Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation 2004) reasserts the Gunditjmarra Indigenous people of southeast Australia as managers and caretakers within country declared as an Indigenous Protected Area (IPA; Weir 2009). In this IPA, the Gunditjmarra people have been rehabilitating critical wetland habitats and stream connectivity for migrating eels (Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation 2004, Pease 2004, Gunditjmarra people 2010). Similarly, in New Zealand, rapidly declining *tuna* stocks have prompted Māori-led initiatives to manage and restore critical eel habitats in freshwater ecosystems (e.g., New Zealand Government 2013, Shortland 2013, Te Wai Māori 2013). In North America, declines of *ka't* abundance have brought many First Nations tribes together to work on communicating the importance of these species to the wider public and developing strategies for rehabilitating eel populations on their traditional, self-governed lands (Prosper 2002, Goodbrand 2009, Denney and Paul 2010). A commonality among all of these examples is the coming together and empowerment of Indigenous tribes to rehabilitate and protect a culturally important fishery that unites many people.

Indigenous-led rehabilitation projects have often evolved into innovative comanagement strategies with local and federal governments. For example, recommendations and outcomes from the Kooyang Sea Country Plan (Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation 2004) motivated negotiations with commercial fishers and the state of Victoria to remove commercial netting in tributaries of Lake Condah, to allow eels to complete their migration and increase in abundance within this significant cultural eel fishing place (McKinnon 2007). A key aspect of this work has been collaborations between the Gunditjmarra and government scientists, nongovernmental organizations, and universities to mesh cutting-edge science with traditional management practices (Gunditjmarra people 2010). In New Zealand, eels are undisputed as a culturally important species, with *mātaimai* reserves, which are exclusive customary fishing areas, and unique comanagement approaches underway in several waterways to protect eels and the ecosystems that support them (e.g., New Zealand Government 2013, 2014d, Ngā Papatipu Rūnanga Working Group 2013). Outreach by First Nations people about the cultural importance of eels has also developed into comanagement decision-making strategies with Parks Canada to integrate IEK into management, with field monitoring by local Indigenous people (e.g., Goodbrand 2009).

At a national level, Mi'kmaq people are also working with Environment Canada and Fisheries and Oceans Canada to identify important cultural fishing grounds that need special recognition (Weiler 2011).

Collectively, these examples around a key freshwater animal illustrate how different groups of Indigenous people have been able to use CKS recognition to motivate new management strategies. Management agencies that have traditionally overlooked cultural dimensions to eel fisheries have now become aware of their CKS status, from which comanagement and other innovative frameworks have evolved for more equitable management of both the social and ecological dimensions of these globally important fishes. Promoting the cultural importance of eels has also empowered Indigenous people to gain an equal voice in the future management plans and approaches. Ultimately, recognition of these species as keystones in both a social (CKS) and ecological sense, has provided a platform to unite non-Indigenous and Indigenous worldviews and values to progress our equitable management of freshwater ecosystems (Garibaldi and Turner 2004, Caro 2010, Butler et al. 2012).

INDIGENOUS ACCESS TO FRESHWATER FISHERIES

Recognition of Indigenous rights and needs to access culturally significant freshwater animals has been important for overcoming legal barriers to Indigenous connections to freshwaters since European settlement and colonization. Traditional use of culturally significant animals was largely determined by territorial occupation of Indigenous peoples and their complex tribal social-political systems. Since European settlement, however, Indigenous peoples' access to water and cultural fishing practices has become regulated by colonizing governments that may or may not recognize such cultural traditions and values (Appendix 1). In New Zealand, Māori possession and control of *taonga* (all things highly prized) and management of freshwater species was originally granted in 1840 with the Treaty of Waitangi, with the second article granting rights to *taonga* and habitats, which encompasses fisheries (Waitangi Tribunal 1988, 1992). However, these rights have often had to be reasserted through modern legal challenges. Similarly, Native American tribes have often had to gain rights to access culturally important freshwater animals in traditional locations through legal challenges supported by the *Winters* water rights doctrine, inside or outside reservation lands, including private lands (*Winters v. United States* 1908, Osborn 2013, CRITFC 2014). Such rights can sometimes be recognized in compensation for loss, such as that made by the U.S. Congress to Native Americans who lost access to tribal fishing sites along the Columbia River after these areas were inundated by numerous dams (CRITFC 2014). In other cases, equitable Indigenous access rights have come much later after European settlement. For example, First Nations people were given the right by the Supreme Court of Canada to fish for food, ceremonial, and cultural reasons, which was applied across Canada to establish freshwater access priorities in the 1990s (see *R v. Sparrow* 1990, Issac 1999). In Australia, legal recognition for Aboriginal access to freshwater fisheries came with the passing of the Native Title Act 1993 (OPC 2014: section 211), which defines Aboriginal rights to hunting, fishing, and gathering, along with cultural and spiritual activities in relation to both land and waters (Altman 2004, Jackson and Morrison 2007, OPC 2014). Further amendments have provided the basis for other state-level legislation, such as the New South

Wales fishing legislation on Aboriginal subsistence bag limits, which recognizes the customary significance of fisheries (Schnierer 2011, New South Wales Government 2016).

In many cases, legal barriers have persisted until key challenges, often hard won, by Indigenous peoples to gain recognition that access to CKS is vital to their communities, traditional culture, and well-being. For instance, access to cultural eel fishing only came after targeted legal action by First Nations people in Canada in the *Marshall* case, which was monumental in defining how Indigenous access rights extend to commercial allowances and licenses and recognizing the deep cultural importance of these fisheries to the Mi'kmaq people (see *R v. Marshall* 1999a, b). This challenge was prompted by the arrest of Donald Marshall Jr. of the Membertou Band, who was charged by Fisheries and Oceans Canada for illegally fishing for *ka't* without a federal commercial license to sell eels (Prosper 2002, Davis et al. 2004). Although Marshall was fishing for eels from the shores of the Paqtnekek Reservation, he was charged outside the reservation boundaries (Prosper 2002, Davis et al. 2004). Following a six-year legal battle, charges were dropped and new provisions applied to allow Indigenous eel catches for both cultural purposes and a moderate commercial livelihood (Davis et al. 2004, Denny and Paul 2010, Cooke and Murchie 2015).

A further challenge for Indigenous peoples has been securing equitable roles in the decision-making processes for rehabilitation and management of freshwater animals that are CKS. For example, in the United States, each of the state-managed freshwater fisheries are overseen and regulated by the federal government, which adjudicates and mediates the fishing rights of Native American tribes (USFWS 1994). However, the United States' Columbia River Treaty with Canada does not take into consideration the cultural importance of salmon to tribes along the river nor the ecological health of the salmon populations (CRITFC 2014). As a result, the Columbia River Inter-Tribal Fish Commission (CRITFC) has requested to be involved in a review of the treaty, which it hopes will include its "Spirit of the Salmon" plan (*Wy-Kan-Ush-Mi Wa-Kish-Wit*).

Although relatively recent legal treaties, policy reforms, and the implementation of freshwater management approaches that recognize and support cultural connections to freshwater fisheries are promising steps forward (e.g., USFWS 1994, 2013, UN General Assembly 2007, Armstrong 2008, Aboriginal and Torres Strait Islander Social Justice Commissioner 2009, Duff et al. 2010, Durette 2010, Smyth et al. 2010, Schnierer 2011, Collings 2012, Osborn 2013), further challenges remain. Formal recognition of freshwater animals that are CKS for each Indigenous nation should be a priority in this regard. Although some, such as eels and salmon, have gained increasing recognition, there are many invertebrate species identified in this review that are yet to be recognized as CKS by the broader group of freshwater stakeholders and government agencies. Through recognition and subsequent protection of the rights of Indigenous people to access these CKS, we see the capacity for modern management to take better account of the dual social-ecological importance of these species and move forward to remove legal or other barriers to Indigenous access to these species. In so doing, we can develop a more inclusive approach to the adaptive management and long-term resilience of social-ecological freshwater ecosystems.

FUTURE PRIORITIES FOR MANAGING CULTURALLY SIGNIFICANT FRESHWATER ANIMALS

Severe declines in the well-being of both freshwater animals and Indigenous peoples worldwide indicate a clear need to improve our management of freshwaters as integrated social and ecological systems. In a basic recognition of human rights, management agencies need to take special consideration of Indigenous peoples' rights to cultural catches that should be negotiated separately from recreational and commercial fishing allowances. Barriers to cultural fisheries that restrict access to CKS can lead to a loss of cultural stability and a diminution of IEK, as well as aggravate social justice issues (Nursey-Bray 2009, McCarthy et al. 2014). In seeking both social and ecological resilience in increasingly disturbed freshwater ecosystems, CKS can provide focal species for identifying and monitoring key cultural and subsistence ecosystem services that affect the resilience of both Indigenous and non-Indigenous peoples. In supporting social groups that culturally and economically rely on these species, we will also increase the potential for better management and regulation of broader ecosystem health (Berkes et al. 2000, Tipa and Teirney 2003, Moller et al. 2004, Stephenson and Moller 2009, Ruiz-Mallén and Corbera 2013). This is because many CKS are also ecological keystones that underpin key ecosystem processes that provide resistance and resilience of freshwaters to environmental disturbances. As we have explored, this approach has the potential to bolster long-term sustainability of freshwater social-ecological ecosystems through the formal recognition and inclusion of Indigenous peoples in the management of CKS around the world.

Indigenous nations have deep historical knowledge of their ecosystems, ecological constraints, presettlement baselines, and holistic management approaches that are invaluable for adaptive resource management of human connections to freshwaters (Berkes 2008, Jackson et al. 2012, McCarthy et al. 2014). This is a priceless repository of long-term observations of environmental change and adaptation methods from which we can learn how to best manage our degrading freshwater ecosystems (Berkes et al. 2000, Moller et al. 2004, Haggen et al. 2006, Cozzetto et al. 2013). Many Indigenous groups have sought to work with contemporary management agencies to develop cooperative recovery and comanagement programs that recognize their cultural connections and draw on this depth of IEK. Importantly, IEK should not be exploited without transparent processes of consideration and incorporation into management and monitoring practices (Danielsen et al. 2009, Jackson et al. 2012) according to the principles of free prior informed consent (UN General Assembly 2007). In that regard, we see collaborative research partnerships as a key way of building trust and empowering Indigenous people in shaping long-lasting partnerships to solve environmental issues as equal collaborators. Importantly, Indigenous groups are willing to help other cultures understand how they as a people have survived in these landscapes for thousands of generations, often against a background of major climatic change and uncertainty.

In recognizing a freshwater animal as an Indigenous CKS, we take the first step toward improving freshwater access rights and our management of freshwaters as resilient social-ecological systems for all stakeholders. Critical to this recognition is the adoption of collaborative groups that work with local Indigenous

communities to formally recognize cultural dimensions of water rights and the importance of cultural access to freshwater fisheries (e.g., Tipa and Teirney 2003, Goodbrand 2009, Duff et al. 2010, Moggridge and Mihinui 2010, Schnierer 2011). Indigenous communities must be actively involved in the management of these species to balance competing needs and values. Effective consultation on management decisions (e.g., catch limits, listing of vulnerable species, modifications to river regulation, and availability of access) and freshwater policy changes may be best achieved through comanagement and comonitoring approaches, management plans that draw on IEK, and direct Indigenous custodianship (e.g., Indigenous rangers and IPAs). CKS also have the capacity to open cross-cultural lines of communication to build greater awareness, which in turn will optimize the recovery of the species, lead to better compliance of fisheries quotas, and build valuable partnerships. Therefore, it is important not only to formally recognize each culturally significant species, but also to follow through with active comanagement of the species so that decisions about necessary strategies, harvest allocations, and mechanisms for conservation/restoration are reached equitably for the long-term sustainability of freshwater social-ecological systems.

Responses to this article can be read online at:

<http://www.ecologyandsociety.org/issues/responses.php/8353>

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Appendix 1. Water policies, treaties, and agreements that support the rights of Indigenous peoples' access to freshwaters and/or culturally significant freshwater fisheries.

Country	Governance Level	Rights	Meanings	Notes
International	International Conventions and Treaties	International Covenant on Civil and Political Rights (OHCHR 1976a), International Covenant on Economic, Social and Cultural Rights (OHCHR 1976b), Agenda 21 (United Nations Sustainable Development 1992), the Rio Declaration (UN General Assembly 1992), United Nations Convention on Biodiversity (Secretariat of the Convention on Biological Diversity 2005), and UN Food and Agriculture Organization: Code of Conduct for Responsible Fisheries (FAO 2000).	Various International agreements have been made that includes the United States, Australia and New Zealand along with other countries to equitability grant access to freshwater and freshwater species by Indigenous peoples (OHCHR 1976a, b, UN General Assembly 1992, United Nations Sustainable Development 1992, FAO 2000, Secretariat of the Convention on Biological Diversity 2005).	Many of the International agreements have mentioned or contain clauses encouraging the inclusion of Indigenous people as equal stakeholders in freshwater negotiations, conservation, and access to culturally significant species.
	United Nations	United Nations Declaration on the Rights of Indigenous Peoples (UN General Assembly 2007)	Promote the right to participate in decision-making in regards to water, continue the right to maintain cultural connections to water and land, and ensure proper consultation for any changes to water access, which also includes fisheries species (UN General Assembly 2007, FPWEC 2012).	World agreement on the rights of Indigenous peoples', but does not have legal standing.
		Sovereignty	Federally each country recognizes Indigenous Tribes and Nations as domestic independent nations with inherent rights of self-governance. Treaties, court decisions and tribal legislation help to govern relationships between tribes and entities (McHugh 2004, Durette 2010, Osborn 2013).	Respects the self-determination of the each Tribe and Nation to have economic security and management of their freshwater resources.

Appendix 1. continued.

Country	Governance Level	Rights	Meanings	Notes
Australia	National	Native Title Act 1993 (OPC 2014)	Customary water access recognized through leases, licenses and permits (Altman 2004, Jackson and Morrison 2007, Aboriginal and Torres Strait Islander Social Justice Commissioner 2009, OPC 2014)	Section 211 of the Act protects the fishing right of Native Title Holders (Schnierer et al. 2011, OPC 2014).
		Cultural Flows (National Cultural Flows Research Project 2014)	Flow allocation requirement to Indigenous peoples through the Murray-Darling Basin (FPWEC 2012, NWC 2012, National Cultural Flows Research Project 2014).	Concept is still in the early stages of implementation. Objectives include establishing river flows that support cultural connections, facilitate economic development, and promote the recovery of culturally significant fisheries (tribe specific).
	State	Various	Every state has different access rights for Indigenous people and customary fisheries access (Smyth et al. 2010, Schnierer 2011, Schnierer et al. 2011, FPWEC 2012, NWC 2012).	Complex situation of each state having its own regulations on Aboriginal rights to access freshwater fisheries.
Canada and USA	National	Pacific Salmon Treaty 1985 (Government of Canada and Government of the United States of America 2014)	Treaty between Canada and the USA to recognize the importance of cross boundary migrations of salmon (CRITFC 2014, Government of Canada and Government of the United States of America 2014).	Mentions the treaty should meet objectives with Native Americans and First Nations people, but often they are not active participants in negotiations. CRITFC is working to be a part of recent review of the treaty (CRITFC 2014).
Canada	National	<i>R v. Sparrow</i> 1990 (<i>R v. Sparrow</i> 1990)	Supreme Court of Canada declared that First Nations People had the right to fish for food, ceremonial and cultural reasons (<i>R v. Sparrow</i> 1990, Issac 1999, CRITFC 2014).	Ruling applies Canada wide.
		<i>R v. Marshall</i> 1999 (<i>R v. Marshall</i> 1999a, b)	Supreme Court of Canada ruled that First Nations People had the legal right to fish for commercial purposes (<i>R v. Marshall</i> 1999a, b).	Gives the First Nations people the right to continue to fish for CKS for economic reasons.

Appendix 1. continued.

Country	Governance Level	Rights	Meanings	Notes
New Zealand	National	Treaty of Waitangi Act 1975 (New Zealand Government 2015)	National treaty that defines Māori relationships to freshwater resources and grants the right to access, along with the right to be consulted during decision-making processes (MFE 2010, Harmsworth et al. 2011, New Zealand Government 2015).	Defines rights as a stakeholder in water management. Validity and roles are still unclear.
		Regulation 27A of Fisheries (Amateur Fishing) Regulations 1986 (New Zealand Government 2014a: regulation 27A), Kaimoana Customary Fishing Regulations 1998 (New Zealand Government 2014b), and South Island Customary Fishing Regulations 1999 (New Zealand Government 2014c)	National guidelines to protect customary fishing practices and allows for ceremonial catches (MPI 2012, New Zealand Government 2014a: regulation 27A, New Zealand Government 2014b, c).	Directs councils to recognize and support of the Māori relationship to freshwater.
		The Native American Policy of the US Fisheries and Wildlife Service (USFWS 2013)	Policy that guides requires the Federal government to negotiate rights with individual Native American Tribes and helps to guide the co-management fisheries (Osborn 2013, USFWS 2013).	Defines on and off reservation management with no clear details of the management of individual species. Allows for legal cultural harvest of fish off reservation.
United States of America	National	Winters Water Rights Doctrine (<i>Winters v. United States</i> 1908)	Gives tribes the legal right to access cultural important species off of reservations and gives the individual Native American Tribes access to water on reservations (<i>Winters v. United States</i> 1908, Lewis 2002, Osborn 2013, USFWS 2013).	Guarantee allocation of water for the reservation in terms of water used for agriculture.
		Stevens Treaties	Gives Native Americans the rights to fish and to have enough water allocated to the reservations to support a healthy population of cultural important fisheries (<i>Winters v. United States</i> 1908, Lewis 2002, Osborn 2013, USFWS 2013).	Water allocations include the right to support a healthy population of fish species.