

Further to the Occurrence of Red Abalone, *Haliotis rufescens*, in British Columbia

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We report on additional occurrences of Red Abalone (*Haliotis rufescens* Swainson, 1822) that bring the total to seven from British Columbia coastal waters. Possible causes of the presence of Red Abalone include northward (winter) transport via kelp rafts from the Oregon-California area. We tested this hypothesis by performing DNA barcoding analyses on a fragment of kelp holdfast on the surface of one such shell establishing its identity as *Nereocystis luetkeana* (Mertens) Postels & Ruprecht – a giant kelp with a hollow stipe terminating in a bulbous pneumatocyst (gas-filled float). The occurrence of Red Abalone due to natural processes, besides being important biogeographically, has had important implications for indigenous peoples' pre- and post-contact trade and material culture.

Key Words: Red Abalone, *Haliotis rufescens*, Northern Abalone, *Haliotis kamtschatkana*, giant kelp, *Nereocystis luetkeana*, indigenous people, Haida Gwaii, British Columbia.

A live purebred Red Abalone (*Haliotis rufescens* Swainson, 1822) was confirmed from British Columbia coastal waters (Campbell et al. 2010). The only resident abalone species from British Columbia was previously considered to be the Northern Abalone (*Haliotis kamtschatkana* Jonas, 1845) (Geiger 2000; Sloan 2004). Another live Red Abalone, and a beached shell, have also recently been recorded from British Columbia (Merilees 2008). These confirm a significant range extension, as the northern limit for Red Abalone was recorded as the Oregon area (Geiger 2000). We recount four more shells of Red Abalone from British Columbia, reflect upon possible causes and discuss implications for indigenous trade and material culture.

Illustrated in Figure 1 are seven confirmed locations of Red Abalone in British Columbia, all within the last 25 years and separated by more than 600 km. The two beached shells from the southwest coast of Haida Gwaii (Queen Charlotte Islands), are shown in Figure 2. It is interesting that recreational diving, the diving commercial fisheries for Northern Abalone (*Haliotis kamtschatkana*) that occurred until its closure in 1990, and on-going coast-wide diving fisheries for sea urchins (*Strongylocentrotus* species) and Geoduck Clam (*Panope abrupta*) yielded no reports of Red Abalone. Further, over 30 years of government population surveys for Northern Abalone coast-wide have also not documented Red Abalone (Campbell et al. 2010).

Speculation on how Red Abalone got to British Columbia includes northward range extension influenced by climate change (ocean warming) and human intervention relating to aquaculture, as discussed by Camp-

bell et al. (2010). Merilees (2008) suggested northward transport via kelp rafts from the Oregon-California area. This is intriguing because kelp holdfasts on two of the shells listed in Figure 1 could indicate transport by drift kelp (discussed below). A live abalone has been seen attached to a holdfast in drift Bull Kelp (*Nereocystis luetkeana*) off northern California (J. Kashiwada, California Department of Fish and Game, personal communication). Violent winter storms can dislodge enormous quantities of kelp from rocky California reefs (Tegner et al. 1997). Further, currents run northward along the Pacific coast in winter and Merilees (2008) speculated that Haida Gwaii could be reached in six to eight weeks from southern Oregon.

If kelp rafting does explain the discovery of Red Abalone in northern British Columbia, then remnants of holdfasts on these shells would likely derive from the pneumatocyst – (large gas containing floats) bearing kelp such as *Macrocystis* or *Nereocystis*. To test this hypothesis, we generated sequence for the 5' region of the mitochondrial cytochrome c oxidase 1 (COI-5P) gene, the standard DNA barcode marker in red and brown algae (Saunders 2005; McDevit and Saunders 2009), from a holdfast fragment on the shell from Louscoone Inlet, following McDevit and Saunders (2009). The protocols were completed with modifications to reduce possible contamination: all procedures were completed in isolation of other collections; a blank was included (no sample, but tube taken through all stages including DNA extraction, PCR, except sequencing [there was not a PCR product]) were included in addition to the standard negative control used in PCR; and the entire process was completed in duplicate. All blanks and negative controls were clean and all posi-

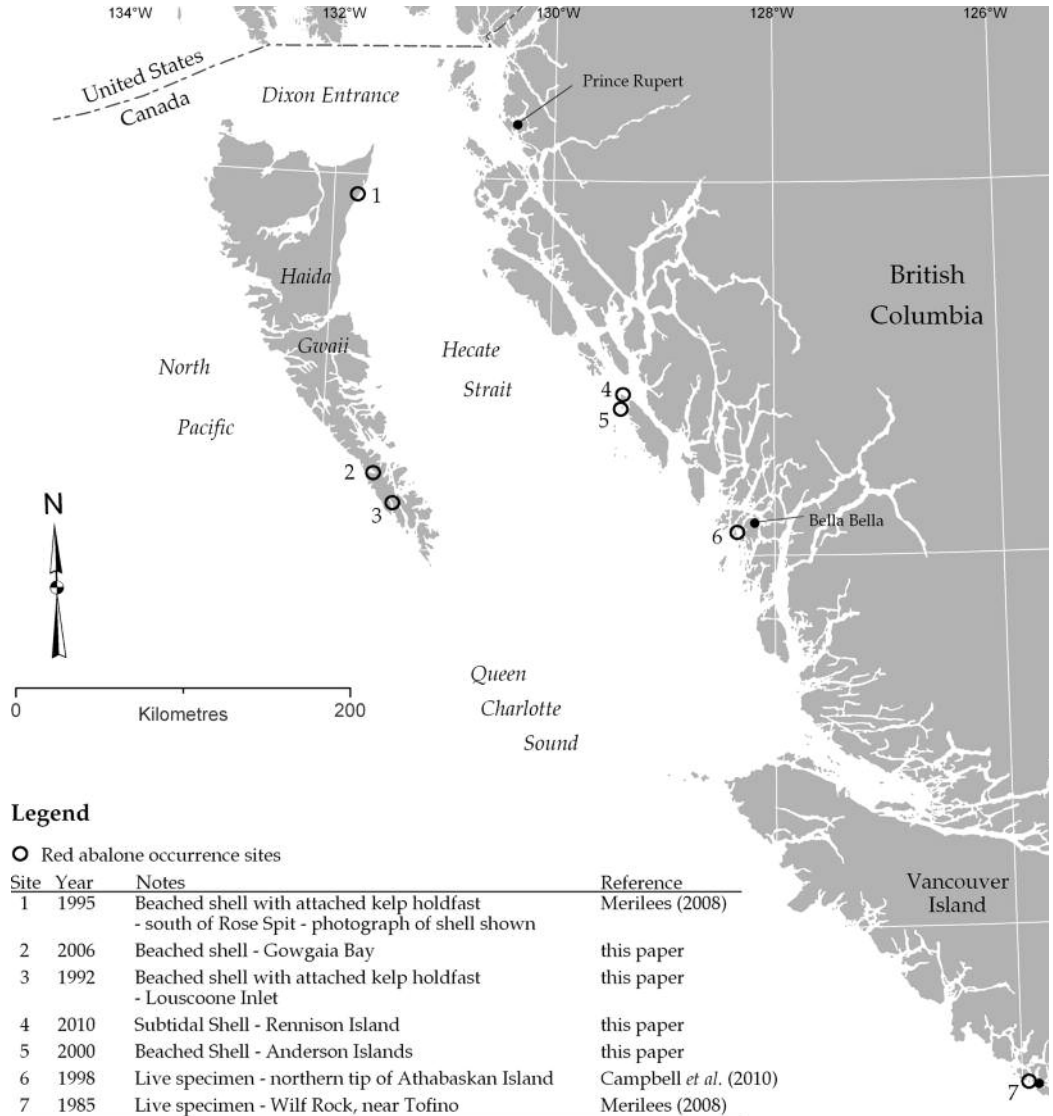


FIGURE 1. Locations with notes about occurrences of live Red Abalone, or their shells, around British Columbia.

tive tests resulted in a COI-5P sequence assignable to *Nereocystis luetkeana*, which is consistent with our initial hypothesis. The resulting sequence was deposited in the Barcode of Life Data Systems (BOLD – www.boldsystems.org) as accession MACRO2982-10.

Unfortunately, whereas COI-5P is an excellent species-discriminating tool in brown algae (e.g., McDevit and Saunders 2009, 2010) it is typically not sufficiently variable to facilitate population level analyses and thus to determine the provenance of the kelp holdfast fragment and the putatively co-transported shell. We anticipate that, owing to the generally low levels of molecular diversity typical of floating kelp (e.g., *Mac-*

rocystis; Coyer *et al.* 2001), microsatellites will need to be developed to address this question (e.g., Alberto *et al.* 2009). Only a few studies have actually looked at the transportation of kelp rafts, these typically confined to local scales and focused on *Macrocystis* (e.g., Harold and Lisin 1989), but results indicate continued zoospore production and germination over extended periods of time (Hernández-Carmona *et al.* 2006), which could contribute to a reduction of genetic structure. Considering the putative distance that this plant has travelled (Oregon? to northern British Columbia), it could be that *Nereocystis* has little population structure along the coast of North America (although see



FIGURE 2. Two beached Red Abalone shells collected from Haida Gwaii, British Columbia. The top shell is from Gowgaia Bay (shell length 200 mm) and the bottom shell is from Louscoone Inlet (shell length 235 mm).

evidence to the contrary for *Macrocystis* [Alberto et al. 2010]). Regardless, our results potentially record the longest distance travelled by an individual of *Nereocystis luetkeana* (ca. 1000 km), assuming that the putatively co-transported abalone shell derived from its native range in Oregon or further south.

If northward transport of kelp rafts occurs, then the British Columbia coast could have received kelp-transported live Red Abalone or their shells in prehistory. This would have provided indigenous peoples coast-wide with abalone shell that was, and still is, used for personal adornment and decoration such as carving inlay (Dubin 1999; Sloan 2003). The shells of large abalone species, such as Red Abalone, were preferred for cultural use coast-wide compared to the smaller and thinner local Northern Abalone shell (Sloan 2003).

On Haida Gwaii, the Haida people (the only indigenous group) traded for abalone shell with the Spanish (from the California area) at the first recorded contact in July 1774 (Sloan 2003). American and British Sea Otter (*Enhydra lutris*) fur traders used abalone shell as a commodity and abalone shell was in wide circulation along the coast and well into the interior. This post-contact abalone shell exchange flourished with the Sea Otter fur trade that peaked from the 1790s to the 1830s. There is also the prospect of pre-contact abalone shell trade coast-wide (Dubin 1999, page 429). Haida traditional (oral) knowledge asserts that Haida canoed far south and acquired abalone shell in pre-contact intertribal trade (Cove 1985, page 143; B. Wilson, Gwaii Haanas, personal communication). Indeed, the British Columbia area marine shell trade, for a range of species, goes back over 6000 years (Carlson 1994). If Red Abalone shells came ashore attached to kelp, perhaps over centuries, it would be difficult to differentiate between shell acquired through pre-contact trade, post-contact trade or beach-gathering. There is therefore, besides the inherent biogeographic interest, an important cultural dimension to the presence of Red Abalone in British Columbia.

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