First Specimens of the Marine Eels *Venefica ocella* and *V. tentaculata* (Nettastomatidae) from British Columbia

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Until recently, only the following seven species of marine eels were known to exist in waters off British Columbia (based on literature sources and museum records): *Nemichthys scolopaceus*, and *Avocettina infans* (Nemichthyidae, snipe eels), *Xenomystax atrarius* (Congridae, conger eels), *Serrivomer jesperseni* (Serrivomeridae, sawtooth eels), *Cyema atrum* (Cyematidae, bobtail eels), *Synaphobranchus affinis* (Synaphobranchidae, cutthroat eels), and *Thalassenchelys coheni* (Colocongridae, worm eels). *Histiobranchus bathybius* (also in the Synaphobranchidae) is expected to occur in British Columbia, since its range extends from Mexico to Alaska. Recent surveys to determine the viability of crab fisheries facilitated the collection of non-game fishes from by-catch in bottom-trawl samples. Several eels were collected between 2004 and 2006, and they were originally identified as *Serrivomer jesperseni* (Serrivomeridae). Re-examination of these specimens indicates that they all are duckbill eels (Nettastomatidae), the first records of this family north of 45°39'N along the North American Pacific coast. Both *Venefica ocella* and *V. tentaculata* are represented, with *V. ocella* found farther north than *V. tentaculata*. All British Columbia specimens are housed at the Royal British Columbia Museum. The collection of new deep-water species in British Columbia reinforces the value of survey sampling to improve our knowledge of biodiversity.

Key Words: Nettastomatidae, *Venefica ocella, Venefica tentaculata,* British Columbia.

There is little research on non-game fishes in Canadian coastal waters. Eels (orders Anguilliformes and Saccopharyngiformes) seem to be particularly underrepresented in the literature, even though they appear in fishery by-catch. The first attempts to summarize coastal fish diversity by Clemens and Wilby (1949, 1961) listed only two nemichthyid eels, *Nemichthys avocetta* and *Avocettina gilli* (now *Nemichthys scolopaceus* and *Avocettina infans*, respectively). Peden (1972) detailed the distribution of *Xenomystax atrarius*, and Hart (1973) summarized what was known for *Serrivomer jesperseni*, *Nemichthys scolopaceus*, *Avocettina infans*, and *Xenomystax atrarius* from British Columbia waters. Peden (1974) listed records of rare fishes and first records of several species along the British Columbia coast, but no new eels were mentioned. Lamb and Edgell (1986, 2010) dealt only with fishes from shallow depths, and Peden et al. (1985) recorded only *Avocettina infans* from the region of Ocean Station Papa (50°N, 145°W). Peden and Hughes (1986) extended the range of *Serrivomer jesperseni* along the British Columbia coast, the only eel species mentioned in their paper. Coad (1995) also did not list any nettastomatid (duckbill) eels from the Pacific coast of Canada. In addition to the taxa listed in Hart (1973), Mecklenburg et al. (2002) list *Synaphobranchus affinis* and *Histiobranchus bathybius* from Alaskan waters, and include *Cyema atrum* and *Nemichthys larseni* as probable additions to the north east Pacific fauna, but not duckbill eels.

Thalassenchelys coheni has been collected in British Columbia (Mecklenburg et al. 2002), with specimens deposited at the Royal British Columbia Museum, as well as farther south along the United States coastline (Shimokawa et al. 1995, Figure 2). Until recently, the relationships of *Thalassenchelys coheni* were uncertain, but Lopez et al. (2007) used mitochondrial DNA to show that *T. coheni* is a colocongrid eel.

Jordan et al. (1930) listed three species of *Venefica* from North America, two of which, *V. procera* and *V. tentaculata,* were known from the Pacific offshore of California. Until now, the northern-most record of nettastomatid eels in the eastern Pacific, more specifically, *Venefica procera*, was offshore of Oregon at 45°39'N, 125°18'W, at a depth of 2112 m (Edwards and Peden 1976), southwest of the Columbia River mouth.

Study Area and Methods

Fisheries and Oceans Canada performed deepwater sampling to determine the viability of a Tanner Crab (*Chionoecetes tanneri*) fishery using a Campelen 1800 shrimp trawl between 1999 and 2006, from the Canadian Coast Guard stern trawler W. E. Ricker. The systematic survey plans, locations surveyed, and methods are detailed by Gillespie et al. (2004) and Workman et al. (2000). All organisms in the catch were identified to species if possible. Damage to specimens prevented identification of some fishes, but representative specimens, rarely collected fishes, range extensions, and first records for British Columbia, were taken from the by-catch for preservation. Specimens were bagged, labelled and frozen, after tissue samples had been taken for DNA barcoding. Specimens later were thawed, and fixed for

TABLE 1. Northern occurrences of *Venefica* spp. along the west coast of North America, including new records from 2004–2006 off British Columbia. Data from the Royal British Columbia Museum and the University of Washington Fish Collection (Burke Museum).

Museum Catalogue #	Specimen Identification	Specimen Length (cm)	Latitude	Longitude	Sample Depth (m)	Vessel	Gear	Collection Date	DNA Barcode
University of Washington Fish Collection									
19092	*Venefica procera*	80.2	45°38'53"	125°17'59"	2112	R/V John N. Cobb	?	Jun 17, 1966	n/a
47220	*Venefica* sp.	71.0	36°42'46"	122°16'54"	1171	Miller Freeman	bottom trawl	Oct 23, 1999	n/a
Royal British Columbia Museum									
010-200-007	*Venefica tentaculata*	88.4	50°33'13"	129°14'39"	1869	W.E. Ricker (CG2965)	bottom trawl	Oct 9, 2006	TZFPB738-05
006-029-005	*Venefica tentaculata*	55.0	48°58'26"	127°6'17"	1757	Frosti (CFL3773)	bottom trawl	Oct 16, 2005	TZFPB313-05
006-029-006	*Venefica tentaculata*	63.6	48°58'26"	127°6'17"	1757	Frosti (CFL3773)	bottom trawl	Oct 16, 2005	TZFPB314-05
006-029-007	*Venefica tentaculata*	70.3	48°58'26"	127°6'17"	1757	Frosti (CFL3773)	bottom trawl	Oct 16, 2005	TZFPB315-05
012-180-001	*Venefica ocella*	69.3	52°0'40"	131°34'55"	1669	W.E. Ricker (CG2965)	bottom trawl	Sep 5, 2004	n/a

a week in a 10% solution of Formaldehyde in water. Once fixed, all specimens were rinsed in freshwater, and then transferred to 70% Ethanol for long-term storage at the Royal British Columbia Museum. All specimens are catalogued in the Royal British Columbia Museum ichthyology collection (Table 1). Specimen measurements were compared to those from historical literature and original species descriptions (e.g., Garman 1899; Gilbert 1915; Günther 1887; Goode and Bean 1883, 1895). In all cases, specimen damage limited the accuracy of measurements as noted in the following species accounts.

Results

Venefica *spp.*

The five Canadian *Venefica* specimens were caught in trawl samples between 5 September 2004 and 9 October 2006 in depths between 1669 and 1869 m (Table 1). Most were damaged after being hauled to the surface; however, the eel collected on 9 October 2006 (RBCM 010-200-007) is in remarkably good shape, having lost only the last few centimetres of the body.

While on the Canadian Coast Guard Ship (CCGS) *W. E. Ricker* in 2006, GH suggested that the eel collected during that trip was a nettastomatid, based only on outline drawings in Eschmeyer et al. (1983, page 67) (we lacked the literature aboard ship to make a more precise identification). Despite this suggestion, the 2006 specimen was labelled *Serrivomer jespersenі*. The other eels collected in 2004 and 2005 (listed in Table 1) show the same suite of characters as the well-preserved 2006 specimen, and none belong to the genus *Serrivomer*.

Features that distinguish all British Columbia specimens in this report from *Serrivomer* include pectoral fin absent; gill openings as small pores not connected ventrally; anterior nostrils tubular and at tip of snout; posterior nostril opening oval to elongate and immediately ahead of the eye; dorsal fin origin at or just behind level of gill opening and far forward of the position of the anus; lateral line complete, with distinct pores along mid-flank; teeth all small and villiform/cardiform; enlarged serrated rows of vomerine teeth lacking; snout with a distinct fleshy proboscis; and upper jaw longer than lower jaw in all specimens (Eschmeyer et al. 1983; Smith 1999a, 1999b; Nelson 2006).

Serrivomer jesperseni also occurs in British Columbia waters (Hart 1973; Peden and Hughes 1986; Mecklenburg et al. 2002). *Serrivomer* specimens in the Royal British Columbia Museum collection (RBCM 980-299-001 and RBCM 002-207-001) were examined to confirm the distinguishing features at the family level (e.g., Eschmeyer et al. 1983; Smith 1999b; Nelson 2006). Within the family Nettastomatidae, the British Columbia specimens correspond to the genus *Venefica* based on the following choices from Smith (1999a): posterior nostrils high on the head; posterior nostril level with top of eye; tip of snout with elongate proboscis.

TABLE 2. Measurements used to resolve species identity of *Venefica* spp. from British Columbia.

Characters	*V. procera*	*V. proboscidia*	*V. ocella*	*V. tentaculata*	RBCM 012-180-001 *V. ocella*	RBCM 006-029-005 *V. tentaculata*	RBCM 006-029-006 *V. tentaculata*	RBCM 006-029-007 *V. tentaculata*	RBCM 010-200-007 *V. tentaculata*
Proboscis length / Eye diameter	2	5	6.3–7.4*	3–4.1*	7.63	3.18	3.13	2.78	2.80
Proboscis length / Snout length		0.5	.55–.71*	.33–0.475*	0.92	0.60	0.39	0.36	0.35
Eye diameter / Head length	0.025	0.05	.0476–0.048*	.0625–0.067*	0.05	0.07	0.05	0.06	0.06
Head length / Total length			0.11	0.11	0.11	0.11	0.12	0.11	0.10
Head length / Snout-vent length	0.27			0.27	0.27	0.26	0.26	0.27	0.26
Proboscis length / Snout-vent length				0.06	0.11	0.05	0.04	0.04	0.04
Snout length / Snout-vent length				0.125	0.12	0.09	0.11	0.12	0.12
Snout to Angle of Mouth / Snout-vent length				0.15	0.15	0.13	0.14	0.16	0.14
Snout length / Head length	.35–.55		0.6	0.463–.504*	0.43	0.35	0.44	0.44	0.46
Eye diameter / Snout-vent length				0.02	0.01	0.02	0.01	0.02	0.02
Distance Gape extends past Eye / Eye diameter	1	far	1–1.33*	0.33–0.75*	1.00	0.50	0.50	-	0.60
Eye diameter / Gill Opening diameter			.8–1*	1–1.07*	1.60	1.60	1.33	1.80	1.25
Snout-Vent length / Total length	0.33	.5–.6	0.33	0.33	0.41	0.42	0.44	0.42	0.37
Dorsal Fin Rays			417	397	298	255	283	265	372
Anal Fin Rays			324		203	194	176	197	243
Dorsal Fin Ray level with Anal Origin	73		99	113–115†	96	106	95	93	102
Lateral Pores along Maxillary ahead of Eye	12			12	10	10	12	–	12
Median Pores along Snout	4 pairs		7–8 pairs	7 pairs	7 pairs	?	7 pairs	–	9 pairs
Pores behind Eye	3			4	3	3	3	–	3
Mandibular Pores	17			12	10+	11+	10	12	14
Lateral Line Pores ahead of Anus	60–64	59–60	52	53	60	–	56	61	60
Lateral Line Pores ahead of Gill Opening		8–9	6*	7–9*	9	5+	6	7	6

* estimated measurements based on historic drawings (Garman 1899)

† 93-98 in other specimens Garman (1899) and Gilbert (1915) thought also were *V. tentaculata*

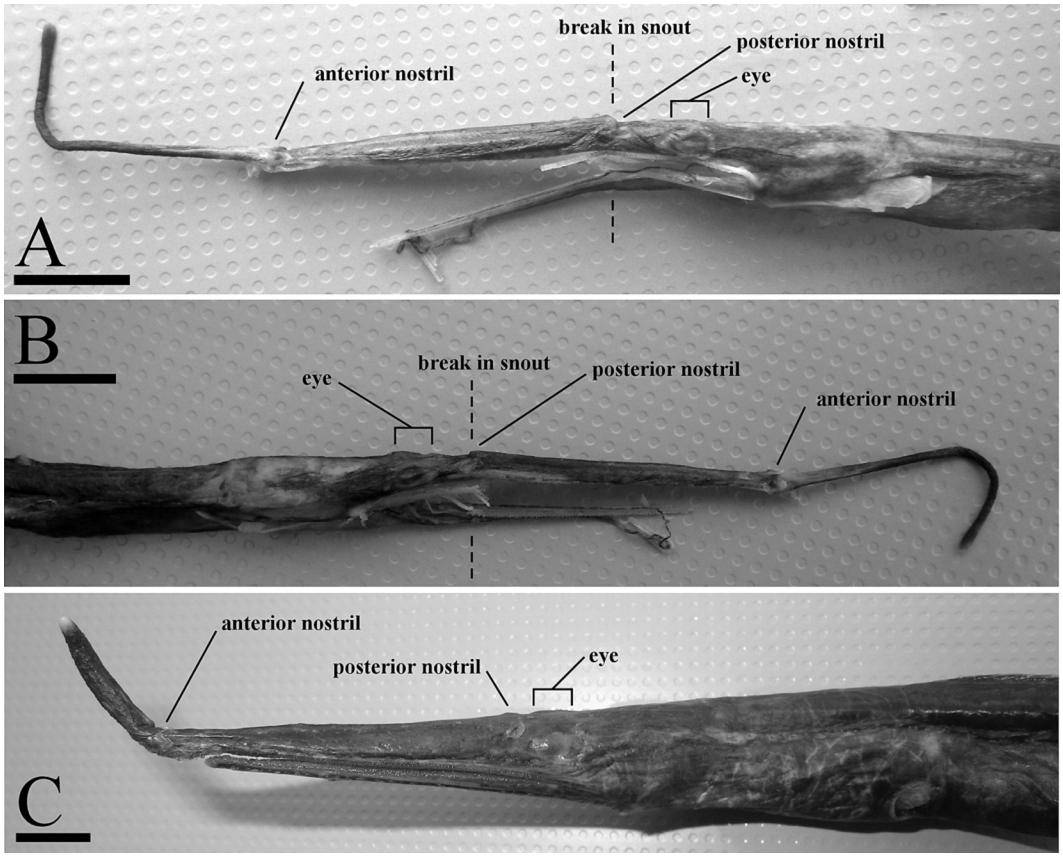

FIGURE 1. Photographs of the heads of each species found off British Columbia showing relative lengths of the proboscis: A) *Venefica ocella* (RBCM 012-180-001), left side; B) right side of the same specimen; and C) *V. tentaculata* (RBCM 010-200-007), left side. Scale bars = 1 cm.

All *Venefica* specimens in this report have damage incurred while in the trawl net, and snout measurements for some (Table 2) and dorsal/anal fin ray counts are therefore underestimates. Unfortunately, the bags containing the labels/collection data on several of the 2005 specimens were tied tightly round each fish's head or snout rather than farther back along the body, where there are fewer features needed for species identification. The identification of those fishes is tentative because several features (e.g., eye diameter, sensory pores on the head) now are obscured or damaged.

Venefica species descriptions, and descriptions of captured specimens from survey work, provide precious little information on each fish's anatomy and body proportions. Furthermore, features detailed in the original species descriptions vary among publications (compare: Garman 1899; Gilbert 1915; Günther 1887; Goode and Bean 1883, 1895). This variability creates problems when trying to identify species in new samples. Table 2 lists measurements and ratios of body proportions that were used to determine the identity of the five new Canadian specimens. These species identifications must be considered tentative pending a complete re-evaluation of the anatomy and limits of variation in *Venefica* species.

Venefica ocella

One specimen (RBCM 012-180-001) (Figure 1A-B) stands out from all other *Venefica* collected in British Columbia. It possesses a longer proboscis relative to its snout length, eye diameter, and snout–vent length (all other specimens have a short proboscis, for example, Figure 1C) relative to the same features (Table 2). This one specimen with its long proboscis (RBCM 012-180-001) resembles historical drawings in Garman (1899, Plate 61, Figure 2) and proportions for specimen 28438 at the Museum of Comparative Zoology, Harvard University (MCZ), and we assign this fish to *Venefica ocella*. This species was originally found along the west coast of Central America (5°30'N, 86°45'W), and its range now extends north to Moresby Island (52°0'40"N, 131°34'55"W) (Figure 2).

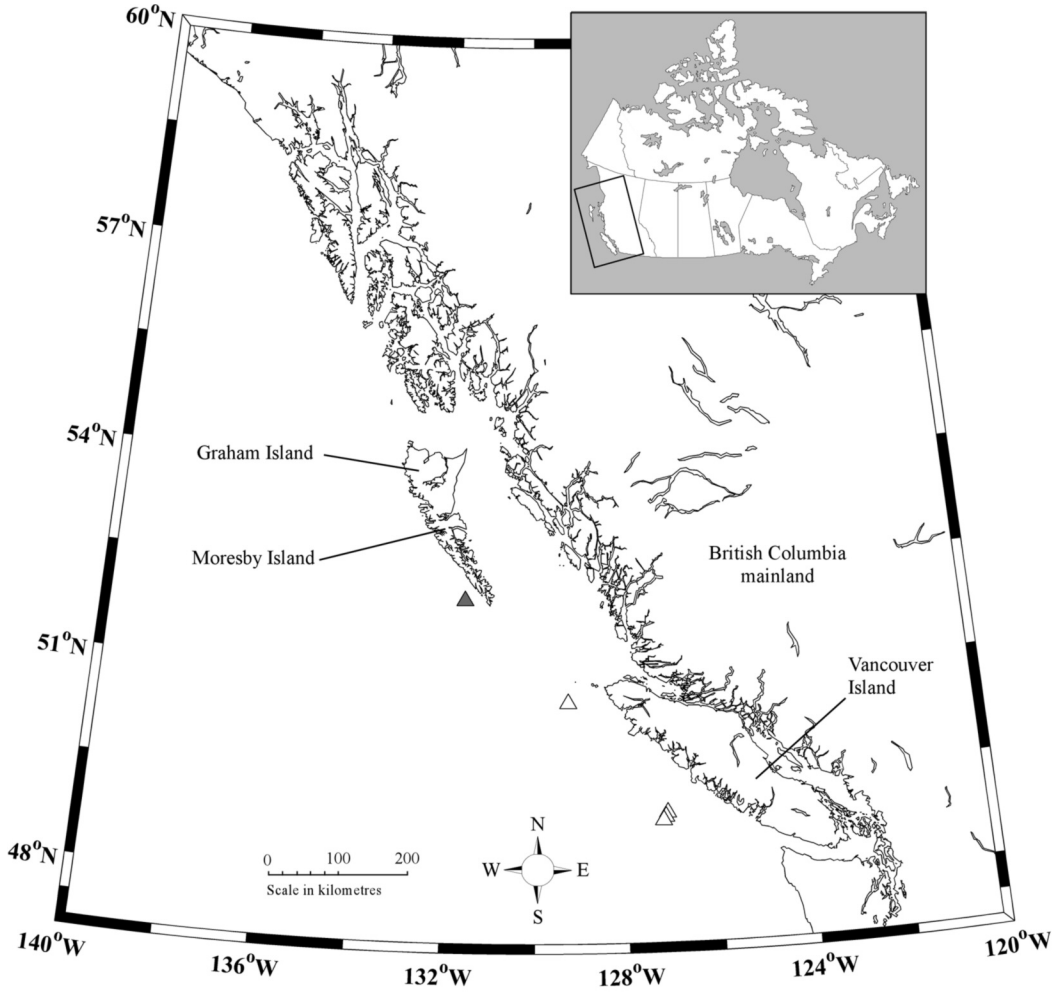

FIGURE 2. A simplified chart showing locations of trawl samples which returned specimens of *Venefica* spp. in British Columbia. Three specimens of *V. tentaculata* from 48°58'36"N, 127°6'17"W were from a single trawl sample and are splayed artificially to indicate three specimens were present ▲ = *Venefica ocella*, △ = *Venefica tentaculata*.

Venefica tentaculata

The remaining four specimens from British Columbia show a far shorter proboscis relative to snout length and eye diameter (Table 2). Based on comparisons with known species, they show proportions similar to *Venefica tentaculata* (see Garman 1899, plate M, Figure 1a, and MCZ 28439). *Venefica tentaculata* originally was described from four specimens (Garman 1899, page 320) found between Cocos Island (Isla del Coco, off the west coast of Costa Rica) and Acapulco, Mexico. The species' range now extends from 5°26'N, 86°55'W to near the northern tip of Vancouver Island (50°33'13"N, 129°14'39"W) (Figure 2).

Two of the four specimens of *V. tentaculata* (RBCM 006-029-006 and RBCM 010-200-007) (Figure 1C) both have intact snouts, and their proboscis measurements are reliable relative to the snout length. Unfortunately, RBCM 006-029-006 had a label tied tightly round the head level with the eyes, so proboscis to eye proportions are close but not precise, due to distortion of the head. Two specimens assigned to *V. tentaculata* (RBCM 006-029-005 andRBCM 006-029-007) also have broken snouts, and measurements are based on best estimates with the bones of the snout realigned for measurement.

Discussion

New records reported in this paper extend the known range of the genus *Venefica* roughly 844 km north along the west coast of North America into Canadian waters to 52°00'N, near the south end of Moresby Island, with additional locations in Canadian waters along the coast

Anguilliformes (true eels)		
Congroidei		
	Colocongridae (short-tail eels)	*Thalassenchelys coheni*
	Congridae (conger eels)	*Xenomystax atrarius*
	Serrivomeridae (sawtooth eels)	*Serrivomer jesperseni*
	Synaphobranchidae (cutthroat eels)	*Synaphobranchus affinis* *Histiobranchus bathybius*
	Nemichthyidae (snipe eels)	*Nemichthys scolopaceus* *Avocettina infans*
	Nettastomatidae (duckbill eels)	*Venefica tentaculata* *Venefica ocella*

FIGURE 3. Eel diversity in British Columbia coastal waters.

of Vancouver Island at 48°58'N (Figure 2). With the addition of *Venefica tentaculata* and *V. ocella*, the diversity of eels in British Columbia now equals 9 species (Clemens and Wilby 1949, 1961; Hart 1973; Peden 1974; Peden et al. 1985; Peden and Hughes 1986; Coad 1995; Mecklenburg et al. 2002) (Figure 3).

The increased sampling along the British Columbia coast during bottom-trawl surveys between 2003 and 2006 revealed many new species living in deep water offshore of the Canadian Pacific coast. This recent increase in knowledge underscores the importance of survey collections. New species and range extensions of species already known to occur in both freshwater (Hanke et al. 2006; McPhail 2007; Cope 2011*) and marine water (Peden 1972, 1973, 1974; Peden and Anderson 1978; Peden 1979a, 1979b; Stein and Peden 1979; Peden and Ostermann 1980; Peden and Anderson 1981; Peden and Hughes 1986; Anderson and Peden 1988) would be harder to detect without broad-scope survey sampling.

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