

## A Review of the Deep-sea Cephalopod Fauna off the Pacific Coast of Northeastern Japan

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**Abstract:** The deep-sea cephalopod fauna in the waters off the Pacific coast of northeastern Japan was investigated, including benthic continental shelf and slope, and offshore mesopelagic habitats. Cephalopods collected by research bottom-trawl were used, and previous studies of deep-sea cephalopod fauna in this region were reviewed, allowing confirmation of 84 species of cephalopods belonging to 22 families. Subtropical, subarctic and transitional species were represented, and by combining the present survey and published information, each of these three zones is divided into seven ecological components, characterized by specific taxa.

**Key words:** deep-sea, cephalopod fauna, western North Pacific, bottom-trawl, mid-water trawl, stomach contents of higher predators, ecology

### Introduction

The waters off the Pacific coast of northeastern Japan are some of the most productive fishing grounds in the world. The richness of sea-life in this region is supported by large-scale mixing of the cold Oyashio Current from the north and the warm Kuroshio Current from the south; among others, substantial pelagic fisheries for the Japanese common and neon flying squids have developed. Local neritic fisheries also target some loliginids and octopuses. Many biological studies have been conducted on these fisheries' target species (Araya, 1976; Murata *et al.*, 1976; Okutani, 1983, among others); however, the deep-sea cephalopod fauna in this region remains largely uninvestigated.

A comprehensive study on the cephalopod fauna of the Japanese continental shelf and slope was conducted by Okutani *et al.* (1987), as part of the Fiscal 1986 Project entrusted by the Fisheries Agency of Japan. 74 species were reported, with systematic descriptions and color photographs, including 12 from off the Pacific coast of northeastern Japan. Kubodera (1996) investigated cephalopods in nearly the same area, off the Sanriku and Joban Districts, under the "Natural History Researches of the Japanese Archipelago" project conducted by the National Science Museum, Tokyo, and reported 46 species from bottom-trawl catches between depths of 150 and 2000 m.

In 1996, large mid-water trawl surveys were conducted at two fixed stations in the transition region of the western North Pacific, investigating diel vertical migration of mesopelagic organisms. From these, cephalopods were sorted out and examined by the present author (Watanabe *et al.*, 2006). We reported 31 species of cephalopod and described detailed vertical distributions of the 11 dominant species, recognizing three diel vertical migration patterns.

Additionally, valuable information on deep-sea cephalopods can be gained from the stomach contents of large predators that dive deeply to feed. Okutani *et al.* (1976), Kawakami (1976) and Okutani and Satake (1977) examined squids eaten by sperm whales caught off Joban and northeastern Honshu, and reported 18 species of deep-sea squids. Kubodera and Miyazaki (1993)

examined the stomach contents of short-finned pilot whales caught off Ayukawa, the Pacific coast of northeastern Japan, and found 11 species of cephalopods in their prey. Since 2000, studies on the feeding habits of sperm whales in the western North Pacific have started under JARPN2-The Japanese Whale Research Program under Special Permit in the western North Pacific, conducted by the Institute of Cetacean Research, Tokyo, in which the author has also been involved. To date, 36 species of cephalopods have been recognized in local sperm whale diets (unpublished preliminary data).

Under the “Research on Deep-sea Fauna and Pollutants off Pacific Coast of Northern Japan” research project conducted by the Department of Zoology, National Museum of Nature and Science, Tokyo, in 2005–2008, the deep-sea cephalopod fauna in the waters off the Pacific coast of northeastern Japan (including benthic habitats of the continental shelf and slope off the Joban and Sanriku Districts, and off-shore mesopelagic waters in the western North Pacific) were investigated, and are reported herein, using cephalopod specimens collected by research bottom-trawl. Information from previous studies on the deep-sea cephalopod fauna in this region is also summarized and synthesized.

### Materials and Methods

Cephalopod specimens were sub-sampled from large otter bottom-trawl catches conducted by the R/V *Wakataka-maru* of the Fisheries Research Agency (FRA), on the continental shelf and slope area, between 200 m and 1500 m, off the Sanriku and Joban Districts (northeastern Japan) during 2005–2007. Several benthic specimens were collected at bottom depths of 500 m to 2000 m, by small beam-trawls operated from the R/V *Tansei-maru* of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and R/V *Soyo-maru* of the FRA in 2006 and 2007 (see Saito *et al.*, 2009). A total of 178 individual cephalopods from 98 lots were examined (Appendix).

The following previously published literature relating to the northeastern Japanese deep-sea cephalopod fauna was also surveyed (see Discussion): Okutani *et al.* (1987), bottom-trawl survey on the continental slope from 800 to 1500 m, off the Pacific coast of the Joban and Sanriku Districts in 1979; Kubodera (1996), bottom-trawl survey on the continental shelf and slope from 150 to 2000 m, off the same Pacific coast of the Joban and Sanriku Districts in 1995; Watanabe *et al.* (2006), large mid-water trawl survey at two fixed stations (40° 00' N, 145° 00' E; 39° 00' N, 143° 30' E) in several layers between the subsurface and 700 m depth, in the transitional region of the western North Pacific in 1996, plus the stomach contents of sperm whales; Okutani *et al.* (1976), 55 individuals caught off the Joban District in 1976; Kawakami (1976), 8 individuals caught off the northern Joban District in 1972; Okutani and Satake (1977), 38 individuals caught off the same northern Joban District in 1977, plus the stomach contents of short-finned pilot whales; Kubodera and Miyazaki (1993), 25 individuals caught within 100 nautical miles of Ayukawa in 1982 and 1983 (Fig. 1). A preliminary list of cephalopod species found in the stomach contents of 41 sperm whales caught in the offshore Japanese waters in 2000 and 2007 is also included (Fig. 2).

The present study includes those species that could be confirmed using the descriptions and figures shown in the literature, and those represented by the specimens identified and registered in the National Museum of Nature and Science, Tokyo by the author.

### Results

From the cephalopod specimens collected during the 2005–2007 bottom-trawl survey, 29 species belonging to 13 families were identified. The following information is given in Appendix:

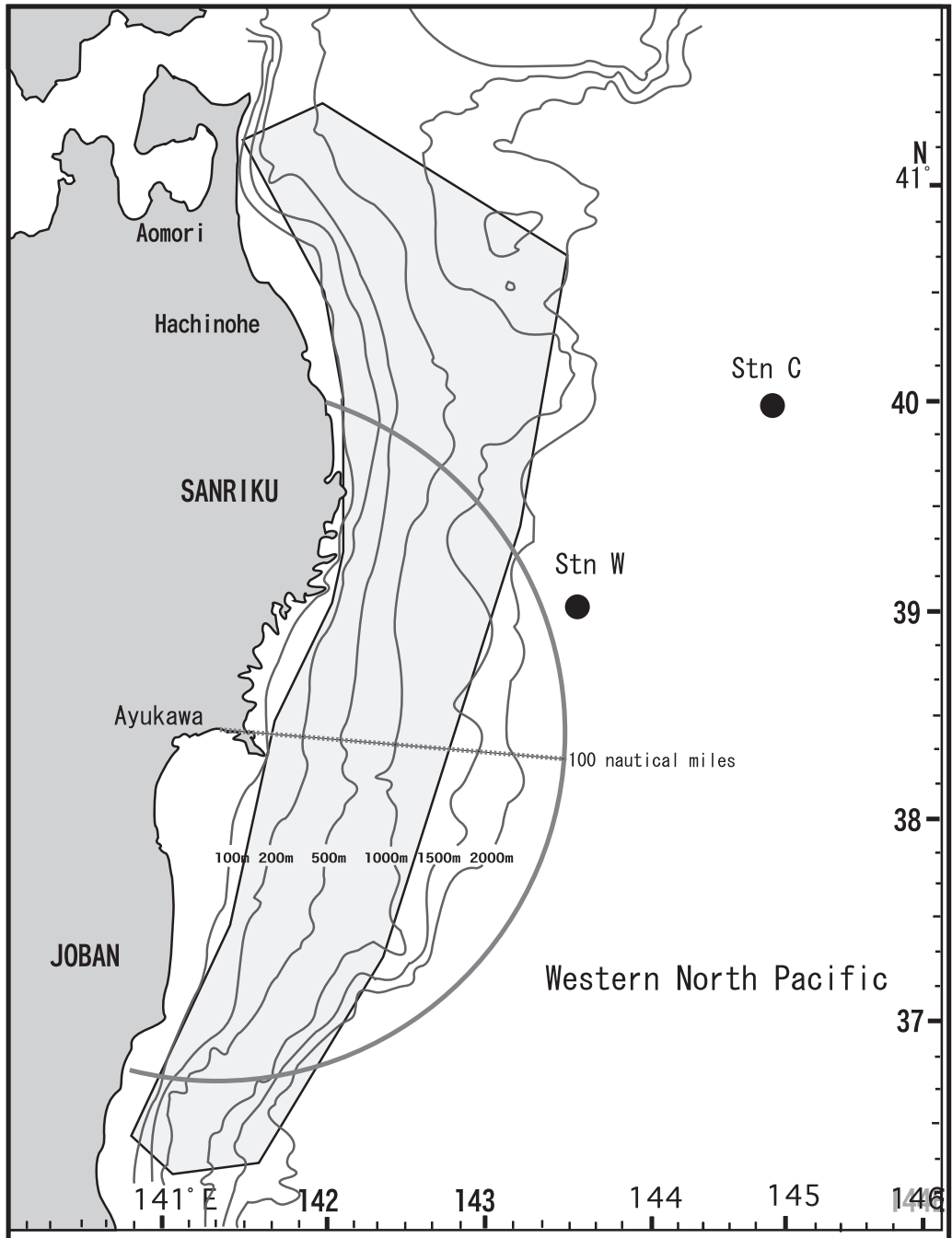


Fig. 1. Map showing the research area and stations in the present study. Area shaded: bottom-trawl survey area including Okutani *et al.*, 1987; Kubodera, 1996, 2005–2007 survey; solid circle: two fixed stations for mid-water trawl survey (Watanabe *et al.*, 2006); semicircle: pilot whale survey area, 100 nautical miles off Ayukawa (Kubodera and Miyazaki, 1993).

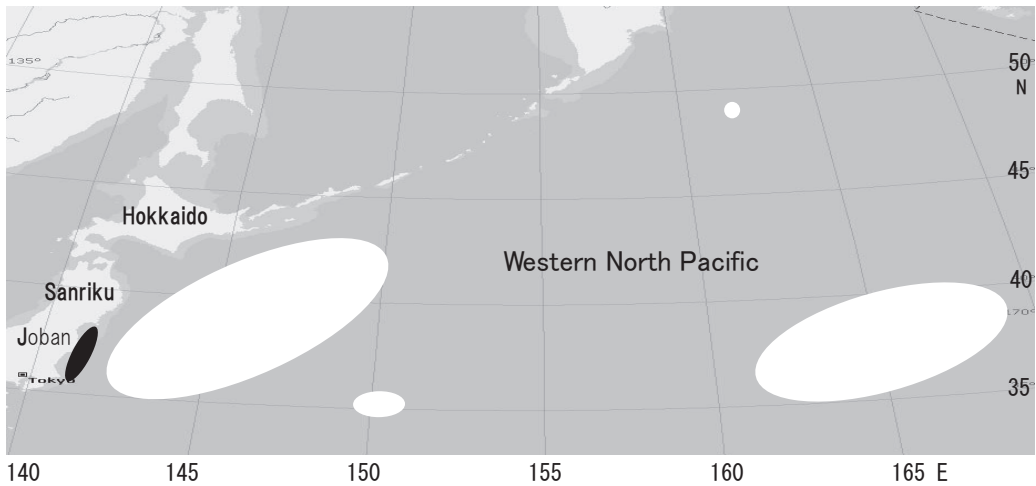


Fig. 2. Map showing the areas from which cephalopods in the stomach contents of sperm whales were available for the present study. Black area: Okutani *et al.* (1976); Kawakami (1976), Okutani and Satake (1977); white areas: 2000–2007 survey.

Museum registration number, family, genus, species, number of individuals, dorsal mantle length (DML), sampling date, collection coordinates, sampling gear, station number, depth towed, and research vessel. Of these 29 species, 21 have been previously reported by Okutani *et al.* (1987) and Kubodera (1996), while the following are new records: *Abralia* sp., *Onychoteuthis 'banksii'*, *Histioteuthis inermis*, *Nototodarus hawaiiensis*, *Mastigoteuthis magna*, *Octopus (Paroctopus) longispadiceus*, *Bathypolypus selebrosus* and *Benthoctopus profundorum*.

All cephalopod species identified from the 2005–2007 survey, and those recorded by previous studies (84 species belonging to 22 families in total), are summarized in Table 1, including sampling methods, depth range of occurrence, and relative abundance where data are available.

#### Order Sepiolidae

##### Family Sepiolidae

Five species—*Sepiolo birostrata*, *Euprymna morsei*, *Rossia pacifica*, *Rossia bipapillata* and *Heteroteuthis* sp. A—were collected only by bottom-trawl, indicating their habitats near the bottom and/or in soft sediments. Most occurred at the shoulder of the continental shelf and slope areas, at 150–300 m, although *R. pacifica* had wider range of distribution, between 250 m and 800 m. A small bobtail squid belonging genus *Heteroteuthis* was also collected at 1000 m (Kubodera, 1996), and is the subject of ongoing detailed systematic study.

#### Order Teuthoidea

##### Family Loliginidae

A large number of *Heterololigo bleekeri* have previously been caught by bottom-trawl on the continental shelf, shallower than 250 m, along the Joban and Sanriku Districts (Kubodera, 1996). This is a commercially important species in local neritic fisheries.

##### Family Enoploteuthidae

Four species, *Watasenia scintillans*, *Enoploteuthis chuni*, *Abraliopsis felis* and *Abralia* sp. The former two were collected by both bottom-trawl and mid-water trawl, indicating their habitats as both near the bottom of the continental slope and in offshore mesopelagic waters. Diel vertical migration of *W. scintillans* was observed in offshore waters (Watanabe *et al.*, 2006), with

Table 1. Species list of cephalopods recorded from the waters off the Pacific coast of northeastern Japan by various sampling methods. Abbreviations for sampling methods and data. BT: bottom trawl, MWT: mid-water trawl, SCS: stomach contents of sperm whales, SCP: stomach contents of pilot whales, O87: Okutani *et al.* (1987), K96: Kubodera (1996), 05-07: present survey, W96: Watanabe *et al.* (2006), O76: Okutani *et al.* (1976), O78: Okutani and Satake (1978), 00-06: unpublished preliminary data, K93: Kubodera and Miyazaki (1993). +: occurred, ++: abundant

Family/Subfamily	Species	Depth (m)	Sampling methods*							
			BT		MWT	SCS		SCP		
			O87	K96	05-07	W06	O76	O78	00-06	K93
<b>SEPIOLIDAE</b>										
	<i>Sepiolo birostrata</i> Sasaki, 1913	150-350		++	+					
	<i>Euprymna morsei</i> (Verrill, 1881)	150-279			+					
	<i>Rossia pacifica</i> Berry, 1911	250-800	+	++	+					
	<i>Rossia bipapillata</i> Sasaki, 1920	250			+					
	<i>Heteroteuthis</i> sp. A	1000			+					
<b>LOLIGINIDAE</b>										
	<i>Loligo bleekeri</i> Keferstein, 1866	<250			++					
<b>ENOPLOTEUTHIDAE</b>										
	<i>Watasenia scintillans</i> (Berry, 1911)	20-750		+	+	++				
	<i>Enoploteuthis chuni</i> Ishikawa, 1914	379-1000		+	+	+				+
	<i>Abraliopsis felis</i> McGowan & Okutani, 1968					+				
	<i>Abralia</i> sp.	350-560			+					
<b>ANCISTROCHEIRIDAE</b>										
	<i>Ancistrocheirus lesueurii</i> (Orbigny, 1848)					+	+			+
<b>OCTOPOTEUTHIDAE</b>										
	<i>Octopoteuthis deletron</i> Young, 1972					+				+
	<i>Octopoteuthis</i> cf. <i>sicula</i> Rüppell, 1844									+
	<i>Octopoteuthis</i> cf. <i>megaptera</i> (Verrill, 1885)									+
	<i>Octopoteuthis</i> n. sp.						+	++		
	<i>Taningia danae</i> Joubin, 1931					+	+	+	+	+
<b>ONYCHOTEUTHIDAE</b>										
	<i>Onychoteuthis 'banksii'</i> (Leach, 1817)	20-700			+	+				
	<i>Onychoteuthis borealijaponica</i> Okada, 1927	20-600				++			+	+
	<i>Onykia robusta</i> (Verrill, 1876)	400-510	+	+	+		++	+	+	+
	<i>Onykia loennbergii</i> Ishikawa & Wakiya, 1914	384-1000		++	+	+	+	+	+	
<b>GONATIDAE</b>										
	<i>Gonatus berryi</i> Naef, 1923	60-1500		+		++		+	+	
	<i>Gonatus onyx</i> Young, 1972					+				
	<i>Gonatus pyros</i> Young, 1972	600-2000		+	+	+				+
	<i>Gonatus californiensis</i> Young, 1972					+				
	<i>Gonatus madokai</i> Kubodera & Okutani, 1977									+
	<i>Gonatus middendorffi</i> Kubodera & Okutani, 1981									+
	<i>Gonatopsis borealis</i> Sasaki, 1923	20-1000	+	+	+	++		+	+	+
	<i>Gonatopsis</i> sp. A (slender)	1500		+	+					
	<i>Gonatopsis</i> aff. <i>makko</i> Okutani & Nemoto, 1964							+	+	+
	<i>Gonatopsis</i> aff. <i>japonicus</i>									+
	<i>Gonatopsis octopedatus</i> Sasaki, 1920							+		
	<i>Berryteuthis magister</i> (Berry, 1913)	200-800	+	+	+		+		+	+

Table 1. (Continued)

Family/Subfamily	Species	Depth (m)	Sampling methods*							
			BT		MWT		SCS		SCP	
			O87	K96	05-07	W06	O76	O78	00-06	K93
	<i>Berryteuthis anonychus</i> Percy & Voss, 1963									
	<i>Eogonatus tinro</i> (Nesis, 1972)				+					
CYCLOTEUTHIDAE										
	<i>Discoteuthis discus</i>				+					+
	<i>Discoteuthis</i> sp.	800		+						
	<i>Cycloteuthis akimushkini</i> Filippova, 1968									+
HISTIOTEUTHIDAE										
	<i>Histioteuthis celataria pacifica</i> (Voss, 1962)	400-480		+	+					
	<i>Histioteuthis inermis</i> (Taki, 1964)	410-556			+	+				+
	<i>Histiototeuthis dofleini</i> (Peeffer, 1912)	400-1500	+	+		+	++	++	+	++
	<i>Histioteuthis meleagroteuthis</i> (Chun, 1910)									+
LEPIDOTEUTHIDAE										
	<i>Lepidoteuthis grimaldii</i> Joubin, 1895						+			
	<i>Pholidoteuthis boschmai</i> Adam, 1950									+
BATHYTEUTHIDAE										
	<i>Bathyteuthis</i> aff. <i>abyssicola</i> Hoyle, 1885					+				
ARCHITEUTHIDAE										
	<i>Architeuthis</i> cf. <i>japonica</i> Pfeffer, 1912						+			+
CTENOPTERYGIIDAE										
	<i>Ctenopteryx siculus</i> (Verany, 1851)					+				
OMMASTREPHIDAE										
	<i>Todarodes pacificus</i> Steenstrup, 1880	300>	+	++	+					+
	<i>Ommastrephes bartramii</i> (Lesueur, 1821)	400	+	+		+	++	+	+	++
	<i>Eucoleoteuthis luminosa</i> (Sasaki, 1915)	20-800		+		+				+
	<i>Ornithoteuthis volatilis</i> (Sasaki, 1915)	800		+						+
	<i>Nototodarus hawaiiensis</i> (Berry, 1912)	450			+					
CHIROTEUTHIDAE										
	<i>Chiroteuthis picteti</i> Joubin, 1894	1500		+						+
	<i>Chiroteuthis calyx</i> Young, 1972	1000		+		+		+	+	
	<i>Asperoteuthis acanthoderma</i> (Lu, 1977)									+
MASTIGOTEUTHIDAE										
	<i>Mastigoteuthis glaukopsis</i> Chun, 1908	1500		+		+				+
	<i>Mastigoteuthis magna</i> Joubin, 1913	1500			+					
CRANCHIIDAE										
	<i>Cranchia scabra</i> Leach, 1817	600		+	+		+			
	<i>Liocranchia reinhardti</i> (Steenstrup, 1856)	415-1478		+		+				+
	<i>Belonella borealis</i> Nesis, 1972	400-1500		+	+	+				+

Table 1. (Continued)

Family/Subfamily	Species	Depth (m)	Sampling methods*							
			BT			MWT	SCS		SCP	
			O87	K96	05-07	W06	O76	O78	00-06	K93
	<i>Taonius</i> n. sp. (aff. <i>megalops</i> Prosch, 1849)						+	+		
	<i>Galiteuthis phylura</i> Berry, 1911		+			+				+
	<i>Galiteuthis</i> cf. <i>armata</i> Joubin, 1898							+		
	<i>Sandalops melancholicus</i> Chun, 1906	450-1000		+	+	+				
	<i>Megalocranchia maxima</i> Pfeffer, 1884									+
VAMPYROTEUTHIDAE										
	<i>Vampyroteuthis infernalis</i> Chun, 1903				+	+				+
OPISTHOTEUTHIDAE										
	<i>Opisthoteuthis depressa</i> Ijima & Ikeda, 1895		+							
	<i>Opisthoteuthis californiana</i> Berry, 1949	400-1000		+	+					
BOLITAENIDAE										
	<i>Japetella diaphana</i> Hoyle, 1885	800		+	+	+				+
OCTOPODIDAE										
OCTOPODIDINAE										
	<i>Octopus (Paroctopus) dofleini</i> (Wülker, 1910)	400>	+	++	+					++
	<i>Octopus (P.) conispadiceus</i> (Sasaki, 1917)	400>		++						
	<i>Octopus (P.) yendoi</i> (Sasaki, 1920)	400-800		+						
	<i>Octopus (P.) longispadiceus</i> (Sasaki, 1917)	250			+					
	<i>Octopus</i> sp. A (enlarged suckers)	250-400		++						
	<i>Octopus</i> sp. B (with two cirri)	150-250		+						
	<i>Danoctopus hoylei</i> (Berry, 1909)	250		+						
BATHYPOLYPODINAE										
	<i>Bathypolypus salebrosus</i> (Sasaki, 1920)	505			+					
	<i>Benthoctopus profundorum</i> Robson, 1932	556			+					
	<i>Benthoctopus</i> aff. <i>abruptus</i> (Sasaki, 1929)	300-1000		+						
	<i>Benthoctopus</i> aff. <i>sibiricus</i> Löyning, 1930	300-800		+						
	<i>Benthoctopus</i> cf. <i>hokkaidensis</i> (Berry, 1921)	400-1000		+						
	<i>Benthoctopus</i> cf. <i>violescens</i> Taki, 1964	550-1500	+	+	+					
	<i>Benthoctopus</i> cf. <i>fuscus</i> Taki, 1964	1000-1500		+						
	<i>Benthoctopus</i> sp. A (matures at small size)	2000		+						
GRANELEDONINAE										
	<i>Graneledone</i> sp.	1000-2000		+						
OCYTHOIDAE										
	<i>Ochthoe tuberculata</i> Rafinesque, 1814									
HALIPHRONIDAE										
	<i>Haliphron atlanticus</i> Steenstrup, 1852	420-800	+	+	+	+				+

individuals found at 20–60 m during the night and 300–400 m during the day. *A. felis* was found in mid-water trawl samples in offshore waters. Three small individuals of *Abralia* were collected by bottom-trawl between 350 m and 560 m; their generic status is obvious, having no round distal photophores on Arms IV, but species identification is difficult due to their immaturity.

#### Family Ancistrocheiridae

One juvenile of *Ancistrocheirus lesueurii* (DML 182 mm) was found in the mid-water trawl samples at 500–600 m. Larger individuals of *A. lesueurii* were occasionally found in the stomach contents of sperm whales by Okutani *et al.* (1976), and in our recent study (unpublished preliminary data), indicating mesopelagic distribution of this species in the study area.

#### Family Octopoteuthidae

Five species—*Octopoteuthis deletron*, *Octopoteuthis* cf. *sicula*, *Octopoteuthis* cf. *megaptera*, *Octopoteuthis* n. sp., and *Taningia danae*—were found in the stomach contents of sperm whales (Okutani *et al.*, 1976; Okutani and Satake, 1978; unpublished preliminary data). A single individual of *O. deletron* (DML 231 mm), and several juveniles of *T. danae* (DML 32–57 mm) were collected by mid-water trawl at 25–500 m depths (Watanabe *et al.*, 2006). Short-distance diel vertical migration by adults of *T. danae* was observed in the waters off the Ogasawara Islands by Kubodera *et al.* (2007), with individuals recorded at 600–900 m during the day and 240–500 m during the night. All members of this family are considered to be mesopelagic.

#### Family Onychoteuthidae

Four species, *Onychoteuthis 'banksii'*, *Onychoteuthis borealijaponica*, *Onykia* (formerly *Moroteuthis*) *robusta*, and *Onykia* (formerly *Moroteuthis*) *loennbergii*. A recent molecular study of the genera *Onykia* and *Moroteuthis* revealed that the latter is a junior synonym of the former (Wakabayashi *et al.*, 2007); therefore those species historically included in the genus *Moroteuthis* are moved to *Onykia* in the present list. *Onychoteuthis 'banksii'* in Japanese waters is probably a different species from *O. banksii* (*sensu stricto*) in the Atlantic (Bolstad, pers. comm.), but *O. 'banksii'* is retained for the Japanese specimens until the disambiguation of this genus is published. Both *O. 'banksii'* and *O. borealijaponica* were abundant in the mid-water trawl catches. Watanabe *et al.* (2006) reported that *O. 'banksii'* undertook diel vertical migrations and was found at 20–100 m during the night and 400–700 m during the day. The main population of *O. borealijaponica* stayed at 500–600 m both day and night, while a small part of the population migrated to 20–100 m depth during the night. Large adults of *O. robusta* and *O. loennbergii* were rarely caught by bottom-trawl and mid-water trawl but were frequently found in the stomach contents of sperm whales (Okutani *et al.*, 1976; Okutani and Satake, 1978; unpublished preliminary data).

#### Family Gonatidae

The most diverse family in the study area—14 species of gonatid are recognized: *Gonatus berryi*, *Gonatus onyx*, *Gonatus pyros*, *Gonatus californiensis*, *Gonatus madokai*, *Gonatus midendorffi*, *Gonatopsis borealis*, *Gonatopsis* sp. A, *Gonatopsis* aff. *makko*, *Gonatopsis* aff. *japonicus*, *Gonatopsis octopedatus*, *Berryteuthis magister*, *Berryteuthis anonychus* and *Eogonatus tinro*. Of these, *G. berryi*, *G. pyros*, and *G. borealis* were collected by both bottom-trawl and mid-water trawl, and from the stomach contents of sperm whales, indicating a broad distribution from the continental slope area to the offshore mesopelagic waters in this region. *B. magister* was collected by bottom-trawl and fed upon by sperm whales, indicating its habitat on the continental slope to offshore mesopelagic waters. *G. berryi* and *G. borealis* were abundant in the mid-water trawl catches; diel vertical migration from 500–600 m during the day to 20–60 m during the night was



reported for both species (Watanabe *et al.*, 2006). Stomach contents of sperm whales revealed that the other large species such as *G. madokai*, *G. middendorffi*, *G. aff. makko*, *G. aff. japonicus*, and *G. octopedatus*, which are rarely captured by research nets, are found throughout mesopelagic waters in this region. Systematic study on *Gonatopsis* sp. A, collected by bottom-trawl at 1500 m (Kubodera, 1996), is in progress. *Gonatopsis* 'sp. B' reported by Kubodera (1996) was confirmed as a *Gonatus pyros* that had lost both tentacles.

#### Family Cycloteuthidae

Two species, *Discoteuthis discus* and *Cycloteuthis akimushkini*. *D. discus* was collected by mid-water trawl and found in the stomach contents of sperm whales, indicating offshore mesopelagic distribution of this species. *C. akimushkini* was originally described by Filippova (1968) from the central Indian Ocean. Clarke (1980) also found this species in the stomach contents of sperm whales caught in the South Atlantic. One almost intact specimen was also obtained from the stomach contents of a sperm whale by Kubodera (2003), indicating broad distribution of this species in world oceans.

#### Family Histioteuthidae

Four species—*Histioteuthis celataria pacifica*, *Histioteuthis inermis*, *Histioteuthis dofleini* and *Histioteuthis meleagroteuthis*. *H. inermis* and *H. dofleini*—were collected by both bottom-trawl and mid-water trawl, and from the stomach contents of sperm whales, indicating their broad distribution and abundance from the continental slope area to offshore mesopelagic waters. *H. dofleini* was reported as the most numerous species in the diet of sperm whales caught off the Joban and Sanriku districts (Okutani *et al.*, 1976, Okutani and Satake, 1978). A few individuals of *H. c. pacifica* were collected by bottom-trawl at 400–480 m off the Joban District. A small number of lower beaks identified as *H. meleagroteuthis* were found in the stomach contents of sperm whales (unpublished preliminary data).

#### Family Lepidoteuthidae

Two rare species, *Lepidoteuthis grimaldii* and *Pholidoteuthis boschmai*, were found in the stomach contents of sperm whales. *L. grimaldii* was identified from a single mantle measuring DML 22 cm (Okutani *et al.*, 1976); *P. boschmai* was identified by two intact, mature females of about DML 30 cm (unpublished preliminary data). Their absence from bottom and mid-water trawl samples suggests a bathypelagic distribution in waters deeper than 700 m.

#### Family Bathyteuthidae

Three individuals of *Bathyteuthis* aff. *abyssicola* (DML 60–63 mm) were collected by mid-water trawl at 650–679 m depth at Station W (Watanabe *et al.*, 2006), indicating their offshore mesopelagic distribution. Species identification remains unconfirmed, pending a detailed comparison between these specimens and *B. berryi*.

#### Family Architeuthidae

Okutani *et al.* (1976) reported an intact specimen (DML 58.5 cm) of *Architeuthis japonica*, along with several fragments of mantle and tentacles, from the stomach contents of sperm whales caught off the Joban District. Our recent survey on feeding habits of sperm whales also found several undigested specimens and more than a few beaks of the genus *Architeuthis* in their stomach contents (unpublished preliminary data). Although Förch (1998) proposed that the family Architeuthidae should be reduced to a single genus and species, *A. dux*, we retain *A. japonica* for Architeuthidae in Japanese waters until concrete evidence for synonymy between *A. dux* and *A.*

*japonica* is recognized. The absence of this species from bottom and mid-water trawl samples suggests an ability to avoid nets, and/or bathypelagic distribution in waters deeper than 700 m.

#### Family Ctenopterygiidae

Three individuals of *Ctenopteryx siculus* (DML 39–46 mm) were collected by the mid-water trawl at 550–579 m, indicating their mesopelagic distribution. A juvenile of this species (DML 18.6 mm) was observed *in situ* by ROV (Okutani *et al.*, 2007), hovering at 489 m off the Pacific coast of central Honshu, Japan.

#### Family Ommastrephidae

Five species, *Todarodes pacificus*, *Ommastrephes bartramii*, *Eucleoteuthis luminosa*, *Ornithoteuthis volatilis* and *Nototodarus hawaiiensis*. Both *T. pacificus* and *O. bartramii* are abundant and commercially important in this region. *T. pacificus* is usually fished using squid jigs and strong fishing lights in offshore surface waters during the night; it is also caught by bottom-trawl on the continental shelf area shallower than 300 m during the day, suggesting diel vertical migration from the benthic continental shelf waters during the day to surface waters during the night, with horizontal migration from inshore to offshore waters. The absence of *T. pacificus* from the stomach contents of sperm whales suggests that this species is distributed in shallower waters than those in which sperm whales feed. *O. bartramii* was found in both bottom and mid-water trawls as well as in the stomach contents of sperm whales, indicating its broad distribution from the continental slope to offshore mesopelagic waters. *E. luminosa* was mainly collected by the mid-water trawl and undertakes distinct diel vertical migrations from 400–600 m during the day to 20–60 m during the night (Watanabe *et al.*, 2006). One single individual each of *O. volatilis* and *N. hawaiiensis* was collected by bottom-trawl, at 800 m and 450 m respectively, off the Joban District.

#### Family Chiroteuthidae

Three species, *Chiroteuthis picteti*, *Chiroteuthis calyx* and *Asperoteuthis acanthoderma*. *C. calyx* was present frequently but in low numbers in bottom and mid-water trawls, and in the stomach contents of sperm whales. *C. calyx* was originally described from off Oregon (Young, 1972), suggesting trans-Pacific northern mesopelagic distribution of this species. A few individuals of *C. picteti* (reported as *C. imperator* in Kubodera, 1996) were collected by bottom-trawl at 1500–2000 m in the southern part of the study area; it was also found in the stomach contents of sperm whales (unpublished preliminary data). The very rare species *A. acanthoderma*, which was described from the Banda Sea in the tropical Pacific (Lu, 1977) and was reported by Tsuchiya and Okutani (1933) from off Okinawa Islands, was found in almost intact condition in the stomach contents of sperm whales (unpublished preliminary data), suggesting considerable northern extension of its distribution in the North Pacific.

#### Family Mastigoteuthidae

Two species, *Mastigoteuthis glaukopis* and *Mastigoteuthis magna*, were confirmed. *M. glaukopis* was collected by both bottom and mid-water trawls, and was found in the stomach contents of sperm whales (unpublished preliminary data), indicating a broad distribution from the continental slope to offshore mesopelagic waters in this region. A single individual of *M. magna* (DML 86 mm) was collected by bottom-trawl at 1478 m.

#### Family Cranchiidae

Eight species, *Cranchia scabra*, *Liocranchia reinhardti*, *Belonella borealis*, *Taonius* n. sp. (aff. *megalops*), *Galiteuthis phyllura*, *Galiteuthis* cf. *armata*, *Sandalops melancholicus* and

*Megalocranchia maxima*. Both *L. reinhardti* and *B. borealis* (the latter reported as *Taonius pavo* in Kubodera, 1996) were collected by bottom and mid-water trawls, and from the stomach contents of sperm whales, suggesting broad distributions from the continental slope area to offshore mesopelagic waters. Watanabe *et al.* (2006) reported that *B. borealis* was found at 400–600 m during both day and night. One single individual of the small species *C. scabra* was collected by bottom-trawl at 600 m (Kubodera, 1996). The '*C. scabra*' reported from the stomach contents of sperm whales by Okutani *et al.* (1976) is likely a misidentification, as they commented; judging from its external appearance and size (DML 20 cm), this taxon might be closely related to the genus *Galiteuthis*. Okutani *et al.* (1976) and Okutani and Satake (1978) also reported *Taonius* n. sp. (aff. *megalops*) from the stomach contents of sperm whales, with detailed descriptions and comparisons between it and *T. megalops*. Nesis (1987) considered this species as a species in genus *Megalocranchia* but a full systematic study has not been achieved. *G. phyllura* was occasionally collected by the mid-water trawl at 500–650 m depth (Watanabe *et al.*, 2006) and is one of the most common squids found in the stomach contents of sperm whales (unpublished preliminary data), suggesting abundance and broad distribution of this species in mesopelagic waters in this region. The *Galiteuthis* 'sp. cf. *armata*' reported from the stomach contents of sperm whales by Okutani and Satake (1978) is likely identical to *G. phyllura*. The small species *S. melancholicus* was occasionally caught by bottom-trawl at depths of 500–1000 m, and by mid-water trawl at 450 m (Watanabe *et al.*, 2006). Finally, *M. maxima*, one of the largest cranchiids, attaining nearly DML 2 m, was represented by digested beaks and occasionally found intact in the stomach contents of sperm whales (unpublished preliminary data).

#### Order Vampyromorpha

##### Family Vampyroteuthidae

Two individuals of *Vampyroteuthis infernalis* were collected by mid-water trawl at 650 m and 677 m (Watanabe *et al.*, 2006) and a single individual by the beam trawl at 2040 m. The beam trawl catch might have been contamination during deployment or retrieval of the net.

#### Order Octopoda

##### Family Opisthoteuthidae

Okutani *et al.* (1987) reported *Opisthoteuthis depressa* from bottom-trawl catches south of Hokkaido to the East China Sea at 200–600 m. A large flapjack octopus, *Opisthoteuthis californiana*, was also commonly caught by bottom-trawl at 400–1000 m in northern part of this region (Kubodera, 1996).

##### Family Bolitaenidae

A small semi-gelatinous octopus, *Japetella diaphana*, has occasionally been collected by mid-water trawl at 500–677 m (Watanabe *et al.*, 2006), and is occasionally found in bottom-trawl catches; Kubodera (1996) reported one individual at 800 m, and another was collected at 1400 m in the present survey, indicating mesopelagic distribution of this octopus. Beaks of this species were seldom found in the stomach contents of sperm whales (unpublished preliminary data).

##### Family Octopodidae

###### Subfamily Octopodinae

Seven species—*Octopus (Paroctopus) dofleini*, *Octopus (P.) conispadiceus*, *Octopus (P.) yendoi*, *Octopus (P.) longispadiceus*, *Octopus (P.)* sp. A, *Octopus* sp. B and *Danoctopus hoylei*—were all caught by bottom-trawl on the continental slope and shoulder regions, shallower than 400 m (except for *O. yendoi*, which occurred at 400–800m (Kubodera, 1996)). *O. dofleini* and

*O. conispadiceus* are abundant in this region and are important targets for local neritic fisheries. Species characters of *O. longispadiceus* were recently re-described in detail (Gleadall, 1993; Takeda, 2003) and a single male specimen (DML 45 mm) was collected by bottom-trawl at 250 m in the present survey. *Octopus* sp. A and *Octopus* sp. B were reported by Kubodera (1996) from bottom-trawl collections, with brief remarks; detailed systematic study of these taxa is in progress. One small individual of *D. hoylei* (DML 28 mm) was collected at 250 m off the Joban District (Kubodera, 1996).

#### Subfamily Bathypolypodinae

Eight species—*Bathypolypus salebrosus*, *Benthooctopus profundorum*, *Benthooctopus* aff. *abruptus*, *Benthooctopus* aff. *sibiricus*, *Benthooctopus* cf. *hokkaidensis*, *Benthooctopus* cf. *violescens*, *Benthooctopus* cf. *fuscus* and *Benthooctopus* sp. A—were all caught by bottom-trawl on the continental slope, deeper than 300 m. Both *B. salebrosus* and *B. profundorum* were collected during the 2005–2007 bottom-trawl survey, and are new additions to the systematic list of cephalopods proposed by Kubodera (1996). Kubodera (1996) stated that the species identities of *B.* aff. *abruptus*, *B.* aff. *sibiricus* and *B.* sp. A were confused, but no additional specimens collected during the 2005–2007 survey have permitted clarification. *B. hokkaidensis*, *B. violescens* and *B. fuscus* are distinct. Our collection still includes several *Benthooctopus* specimens that are only provisionally identified to the species level. Detailed systematic study of this deep-sea octopus group is badly needed.

#### Subfamily Graneledoninae

A single species, *Graneledone* cf. *boreopacifica*, has been recognized from the study area (Kubodera, 1996). Another *Graneledone* specimen has recently been collected from 1100 m in Suruga Bay (the Pacific coast of central Japan), which could be different from *G. 'boreopacifica'* as reported by Kubodera (1996), since its morphologically more closely fits the original description and figures by Nesis (1982). Kubodera (2000) therefore attributed the latter specimen to *G. boreopacifica* and changed the former to *Graneledone* sp. in the omnibus book "Marine Mollusks in Japan". As Kubodera (1996) pointed out, no satisfactory systematic study on *Graneledone* octopuses in the northern North Pacific has been conducted. Species identification remains tentative.

#### Family Haliphronidae

A single species, *Haliphron atlanticus*, was collected by both bottom-trawl and mid-water trawl, and was found in the stomach contents of sperm whales, indicating a broad distribution from the continental slope area to offshore mesopelagic waters.

### Discussion

In the present study, the occurrence of 84 species of cephalopods belonging to 22 families was confirmed in waters off the Pacific coast of northeastern Japan. Bottom-trawl surveys on the continental shelf and slope at 150–2000m collected 56 species from 18 families, and offshore mid-water trawl surveys from the surface to 700 m collected 31 species from 16 families. 19 species were collected by both methods. Therefore 34 species were collected exclusively by bottom-trawl, while 12 were exclusively taken by mid-water trawl. 43 species from 17 families were also identified from the stomach contents of sperm whales and pilot whales, with 17 species exclusively collected in this manner. It is apparent that the species composition of cephalopods collected differs greatly according to the sampling methods; thus combined collection methods, as utilized in the

present study, are the most appropriate and comprehensive for understanding deep-sea cephalopod fauna.

Kubodera (1996) analyzed the community structure of benthic cephalopods in this region by using a clustering method, recognizing a horizontal subtropical zone in the southern area, and a subarctic zone in the northern area. Circalittoral, transitional, and bathyal vertical zones were also recognized, with boundary depths of about 300 m and 900 m, respectively. Each zone was characterized by a specified group or species: in the subtropical, *Eucleoteuthis luminosa*, *Ornithoteuthis volatilis*, species of the families Chiroteuthidae and Cranchiidae except *Belonella borealis*; in the subarctic, species of the family Gonatidae, *Onykia* (*M.*) *robusta* and *Octopus dofleini*; in the circalittoral, species of the family Sepiolidae except *Rossia pacifica*, and *Loligo bleekeri*; in the transitional, *Benthoteuthis* spp.; and in the bathyal, *Benthoteuthis* cf. *fuscus* and *Graneledone* cf. *boreopacifica*.

Watanabe *et al.* (2006) classified cephalopods collected by mid-water trawl into three groups: a subarctic and transition, a subtropical, and a slope-water group. They also found three diel vertical migration patterns in the 11 dominant species, and divided them into migrants, semi-migrants and non-migrants. The migrants were defined by having peak abundance deeper than 300 m during the day and shallower than 300 m at night, and included *Gonatopsis borealis*, *Gonatus berryi*, *Gonatus onyx*, *Eucleoteuthis luminosa*, *Onychoteuthis 'banksii'*, *Enoploteuthis chunii* and *Watasenia scintillans*. The semi-migrants were defined as having daytime depth ranges of 500–600 m, with a portion of the population migrating to the upper 100 m at night; *Onychoteuthis borealijaponica* was nominated. The non-migrants were distributed consistently below 400 m both day and night, and included *Histioteuthis dofleini*, *H. inermis* and *Belonella borealis*.

Sperm whales are considered among the deepest and longest divers of all marine mammals and apex predators in the deep-sea food-web. Although the composition of sperm whales' diets varies by ocean areas, they are exceptional consumers of deep-sea squid (Clarke, 1980, among others). Diving depth and behavior of sperm whales had been hypothesized indirectly from the known distributions of their prey, but recent developments in electronic devices make it possible to record their diving behavior more precisely. Aoki *et al.* (2007) investigated diel diving behavior of sperm whales off Japan by attaching small data-loggers directly to the sperm whales, and reported that individuals recorded off the Ogasawara Islands dived deeper and swam faster during the day ( $853 \pm 130$  m,  $2.0 \pm 0.3$  m/s) than during the night ( $469 \pm 122$  m,  $1.5 \pm 0.3$  m/s), while those off central Honshu (Kumano-nada) showed no apparent differences between day ( $645 \pm 212$  m,  $1.9 \pm 0.5$  m/s) and night ( $561 \pm 229$  m,  $1.6 \pm 0.5$  m/s). They suggested that the environmental differences between these two areas contributed to the difference in diel behavior of the whales, which was influenced by the diel behavior of their prey. Although the survey areas were different, sperm whales in the western North Pacific would probably have the same diving behavior, since they forage around 470–850 m. Therefore species only found in the stomach contents of sperm whales (i.e. *Octopoteuthis* cf. *sicula*, *Octopoteuthis* cf. *megaptera*, *Octopoteuthis* n. sp., *Gonatus madokai*, *Gonatus middendorffi*, *Gonatopsis* aff. *makko*, *Gonatopsis* aff. *japonicus*, *Gonatopsis octopedatus*, *Cycloteuthis akimushkini*, *Histioteuthis meleagroteuthis*, *Architeuthis* cf. *japonica*, *Asperoteuthis acanthoderma*, *Taonius* n. sp., *Galiteuthis* cf. *armata*, and *Megalocranchia maxima*) would mainly be distributed in offshore waters deeper than 700 m (the maximum depth of the mid-water trawl survey), and avoid apparent diel vertical migration.

The region off the Pacific coast of northeastern Japan is defined as a transitional zone between subtropical and subarctic waters. It is a complex marine environment characterized by large-scale water-mixing of the warm Kuroshio Current from the south, and the cold Oyashio Current from the north. The cephalopod fauna in the study area therefore includes subtropical, subarctic and transition elements. Using the present study and published information on cephalopod fauna

around Japanese waters (Kubodera, 1977, 2001, Kubodera and Lu, 2002; Kubodera and Horikawa, 2005), the deep-sea cephalopod fauna in each of these three elements can be divided into seven ecological components:

### Subarctic

Upper continental slope benthic (shallower than ~300 m)

*Octopus dofleini*, *Octopus conispadiceus*,

Lower continental slope benthic (deeper than ~300 m)

*Rossia pacifica*, *Opisthoteuthis californiana*, *Benthoctopus profundorum*, *Benthoctopus* aff. *sibiricus*

Upper bathyal slope benthic (deeper than ~900 m)

*Benthoctopus* cf. *fuscus*, *Graneledone* sp.

Slope-associated mesopelagic (shallower than ~600 m)

*Onykia robusta*, *Gonatus berryi*, *Gonatopsis borealis*, *Berryteuthis magister*, *Histioteuthis dofleini*

Slope-associated bathypelagic (deeper than ~600 m)

*Gonatus pyros*, *Gonatopsis* sp. A, *Histioteuthis dofleini*, *Bolonella borealis*, *Galiteuthis phyllura*

Offshore mesopelagic (shallower than ~700 m)

*Gonatus onyx*, *Gonatus californiensis*, *Eogonatus tinro*

Offshore upper bathypelagic (deeper than ~700 m)

*Gonatus madokai*, *Gonatus middendorffi*, *Gonatopsis* aff. *makko*, *Gonatopsis* aff. *japonicus*, *Gonatopsis octopedatus*

### Transitional

Upper continental slope benthic (shallower than ~300 m)

*Octopus longispadiceus*, *Octopus* sp. A, *Octopus* sp. B, *Danoctopus hoylei*, (*Loligo bleekeri* = nektonic)

Lower continental slope benthic (deeper than ~300 m)

*Octopus yendoi*, *Bathypolypus salebrosus*, *Benthoctopus* aff. *abruptus*, *Benthoctopus* cf. *hokkaidensis*, *Benthoctopus* cf. *violescens*

Upper bathyal slope benthic (deeper than ~900 m)

*Benthoctopus* sp. A

Slope-associated mesopelagic (shallower than ~600 m)

*Watasenia scintillans*, *Todarodes pacificus*

Slope-associated bathypelagic (deeper than ~600 m)

*Chiroteuthis calyx*, *Bolonella borealis*, *Galiteuthis phyllura*

Offshore mesopelagic (shallower than ~700 m depth)

*Abraliopsis felis*, *Onychoteuthis borealijaponica*

Offshore upper bathypelagic (deeper than ~700 m depth)

*Ancistrocheirus lesueurii*, *Octopoteuthis deletron*, *Octopoteuthis* n. sp.

### Subtropical

Upper continental slope benthic (shallower than ~300 m depth)

*Sepiolo birostrata*, *Euprymna morsei*, *Rossia bipapillata*

Lower continental slope benthic (deeper than ~300 m depth)

*Opisthoteuthis depressa*

Upper bathyal slope benthic (deeper than ~900 m depth)

*Heteroteuthis* sp. A

Slope-associated mesopelagic (shallower than ~600 m depth)

*Enoploteuthis chuni*, *Abralia* sp., *Onychoteuthis 'banksii'*, *Onykia (M.) loennbergii*, *Histioteuthis celataria pacifica*, *Histioteuthis inermis*, *Ommastrephes bartramii*, *Eucleoteuthis luminosa*, *Ornithoteuthis volatilis*, *Nototodarus hawaiiensis*, *Sandalops melancholicus*

Slope-associated bathypelagic (deeper than ~600 m depth)

*Chroteuthis picteti*, *Haliphron atlanticus*

Offshore mesopelagic (shallower than ~700 m depth)

*Histioteuthis meleagroteuthis*, *Bathyteuthis abyssicola*, *Ctenopteryx siculus*, *Cranchia scabra*, *Liocranchia reinhardti*

Offshore upper bathypelagic (deeper than ~700 m depth)

*Octopoteuthis* cf. *sicula*, *Octopoteuthis* cf. *megaptera*, *Taningia danae*, *Discoteuthis discus*, *Discoteuthis* sp. *Cycloteuthis akimushkini*, *Lepidoteuthis grimaldii*, *Pholidoteuthis boschmai*, *Architeuthis* cf. *japonica*, *Asperoteuthis acanthoderma*, *Mastigoteuthis glaukopis*, *Mastigoteuthis magna*, *Taonius* n. sp. aff. *megalops*, *Galiteuthis* cf. *armata*, *Megalocranchia maxima*, *Vampyroteuthis infernalis*

### Acknowledgements

The author would like to express his gratitude to the captains and crew members of the R/Vs *Wakataka-maru* of the Fisheries Research Agency (FRA), *Tansei-maru* of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and *Soyo-maru* of the Fisheries Research Agency (FRA) for their help in sampling cephalopod specimens during the research cruises. Thanks are also due to all the members who participated in the research project on the feeding habits of sperm during 2000-2006, namely Drs. T. Tamura, K. Konishi, T. Isoda, Institute of Cetacean Research, Tokyo and Dr. H. Ohizumi, School of Marine Science and Technology, Tokai University and his students S. Arai, K. Aoki, Z. Hasegawa and W. Komatsu for permitting me to cite preliminary cephalopod species list for the present study. Dr. Takashi Okutani and Dr. K. S. Bolstad (Auckland University of Technology) kindly gave valuable comments on the manuscript.

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Appendix. Cephalopod specimens collected during the 2005–2007 bottom-trawl survey. Abbreviations for gears. BT: Large Otter Bottom-Trawl, 3mBT: 3 m ORE Beam-Trawl, BN: 2 m Sigsbee-Agassiz Type Beam-Trawl.

Reg.No	Family	Genus	species	N	Sex	DML (mm)	Date	Position	Gear	St. No.	Depth (m)	Vessel
75558	Allopsidae	<i>Haliphron</i>	<i>atlanticus</i>	1			2005/11/18	37 73.8 N 141	E BT	EF425	420	<i>Wakataka-maru</i>
75581	Cranchiidae	<i>Liocranchia</i>	<i>reinhardtii</i>	1		60	2005/11/13	36 62.5 N 141	E BT	GH410	415	<i>Wakataka-maru</i>
75582	Cranchiidae	<i>Liocranchia</i>	<i>reinhardtii</i>	1		76	2005/11/13	36 67.9 N 141	E BT	GH480	480	<i>Wakataka-maru</i>
75572	Enoploteuthidae	<i>Abralia</i>	sp.	1		32	2005/11/11	36 66.1 N 141	E BT	GH350	350	<i>Wakataka-maru</i>
75955	Enoploteuthidae	<i>Abralia</i>	sp.	1		15	2005/10/30	36 49.83 N 140	E BT	H150	156	<i>Wakataka-maru</i>
75956	Enoploteuthidae	<i>Abralia</i>	sp.	1		24	2005/11/3	36 96.95 N 141	E BT	G550	557	<i>Wakataka-maru</i>
75954	Enoploteuthidae	<i>Enoploteuthis</i>	<i>chumi</i>	1		44	2005/10/28	37 78.98 N 142	E BT	F750	744	<i>Wakataka-maru</i>
75953	Enoploteuthidae	<i>Enoploteuthis</i>	<i>chumi</i>	1		34	2005/11/4	37 64.3 N 141	E BT	F380	379	<i>Wakataka-maru</i>
75570	Enoploteuthidae	<i>Enoploteuthis</i>	<i>chumi</i>	1		34	2005/11/9	36 85.9 N 141	E BT	G510	508	<i>Wakataka-maru</i>
75571	Enoploteuthidae	<i>Enoploteuthis</i>	<i>chumi</i>	1		42	2005/11/14	37 30.2 N 141	E BT	FG480	480	<i>Wakataka-maru</i>
75855	Enoploteuthidae	<i>Enoploteuthis</i>	sp.	1		24	2005/11/14	37 31.51 N 141	E BT	FG410	411	<i>Wakataka-maru</i>
75957	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		26	2005/10/28	37 78.98 N 142	E BT	F750	744	<i>Wakataka-maru</i>
75574	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		40	2005/11/11	36 66.8 N 141	E BT	GH280	278	<i>Wakataka-maru</i>
75575	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		47	2005/11/11	36 67.1 N 141	E BT	GH310	308	<i>Wakataka-maru</i>
75577	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		42	2005/11/11	36 69.7 N 141	E BT	GH250	250	<i>Wakataka-maru</i>
75573	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	2	Y2	29-26	2005/11/13	36 62.5 N 141	E BT	GH410	415	<i>Wakataka-maru</i>
75576	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	4		41-40	2005/11/17	37 97.5 N 141	E BT	EF350	358	<i>Wakataka-maru</i>
75578	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		22	2005/11/18	38 3.6 N 142	E BT	EF450D	453	<i>Wakataka-maru</i>
75579	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		41	2005/11/19	38 64.8 N 142	E BT	DE380	376	<i>Wakataka-maru</i>
75961	Gonatidae	<i>Beryteuthis</i>	<i>magister</i>	1	Y	6	2005/10/25	38 37.73 N 142	E BT	E480	483	<i>Wakataka-maru</i>
75962	Gonatidae	<i>Beryteuthis</i>	<i>magister</i>	1	Y	36	2005/10/25	38 40.15 N 142	E BT	E425	425	<i>Wakataka-maru</i>
75963	Gonatidae	<i>Beryteuthis</i>	<i>magister</i>	1	Y	31	2005/10/28	37 71.35 N 142	E BT	F650	652	<i>Wakataka-maru</i>
75964	Gonatidae	<i>Beryteuthis</i>	<i>magister</i>	1	Y	27	2005/11/2	36 56.05 N 141	E BT	H750	758	<i>Wakataka-maru</i>
75960	Gonatidae	<i>Gonatopsis</i>	<i>borealis</i>	1	Y	12	2005/10/31	36 51.05 N 141	E BT	H510	510	<i>Wakataka-maru</i>
75959	Gonatidae	<i>Gonatus</i>	<i>pyros</i>	1	Y	56	2005/10/25	38 40.15 N 142	E BT	E425	425	<i>Wakataka-maru</i>
75580	Gonatidae	<i>Gonatus</i>	<i>pyros</i>	1	Y	65	2005/11/13	36 69.2 N 141	E BT	GH450	453	<i>Wakataka-maru</i>
75857	Histioteuthidae	<i>Histioteuthis</i>	<i>corona</i>	1	Y	60	2005/11/14	37 31.51 N 141	E BT	FG410	411	<i>Wakataka-maru</i>
75557	Octopodidae	<i>Benthoctopus</i>	sp.	1	Y	20	2005/11/15	37 28.2 N 141	E BT	FG510D	516	<i>Wakataka-maru</i>
75854	Octopodidae	<i>Benthoctopus</i>	<i>violescens</i>	2	F2	95,63	2005/10/26	38 377 N 142	E BT	E550	550	<i>Wakataka-maru</i>
75555	Octopodidae	<i>Octopus</i>	<i>longispadicus</i>	1	M	45	2005/11/11	36 6.97 N 141	E BT	GH250	250	<i>Wakataka-maru</i>
75947	Octopodidae	<i>Octopus</i>	sp.	1	Y	12	2005/10/29	36 95.21 N 141	E BT	G210	210	<i>Wakataka-maru</i>

Appendix. (Continued)

Reg.No	Family	Genus	species	N	Sex	DML (mm)	Date	Position	Gear	St. No.	Depth (m)	Vessel
75556	Octopodidae	<i>Octopus</i>	sp.	1	F	47	2005/11/19	67.6 N 141	BT	DE250D	249	Wakataka-maru
75965	Ommastrephidae	<i>Todarodes</i>	<i>pacificus</i>	1	Y	U	2005/10/30	49.83 N 140	BT	H150	156	Wakataka-maru
75856	Onychoteuthidae	<i>Moroteuthis</i>	<i>loembergi</i>	2		268, 225	2005/11/4	64.3 N 141	BT	F380	384	Wakataka-maru
75958	Onychoteuthidae	<i>Onychoteuthis</i>	<i>banksi</i>	1		86	2005/10/27	72.75 N 141	BT	F510	449	Wakataka-maru
75554	Opisthoteuthidae	<i>Opisthoteuthis</i>	<i>californiana</i>	2	F,Y	55,42	2005/11/9	83.6 N 141	BT	G650	650	Wakataka-maru
75553	Opisthoteuthidae	<i>Opisthoteuthis</i>	<i>californiana</i>	3	F,Y2	82-44	2005/11/11	67.1 N 141	BT	GH510	510	Wakataka-maru
75952	Sepiolidae	<i>Euprymna</i>	<i>morsei</i>	2		13, 10	2005/10/29	36 92.38 N 141	BT	G280	279	Wakataka-maru
75948	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	4		52-43	2005/10/25	38 39.48 N 142	BT	E410	409	Wakataka-maru
75949	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	2		15, 7	2005/10/29	36 92.38 N 141	BT	G280	279	Wakataka-maru
75562	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	1	M	34	2005/11/9	36 88.6 N 141	BT	G425	420	Wakataka-maru
75559	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	1	M(Y)	29	2005/11/11	36 66.8 N 141	BT	GH280	278	Wakataka-maru
75560	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	3		26-18	2005/11/11	36 67.1 N 141	BT	GH310	308	Wakataka-maru
75563	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	4	M,F,Y2	38-13	2005/11/11	36 69.7 N 141	BT	GH250	250	Wakataka-maru
75564	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	1	Y	12	2005/11/11	36 66.1 N 141	BT	GH350	350	Wakataka-maru
75561	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	1	F	43	2005/11/19	38 65.1 N 142	BT	DE380D	375	Wakataka-maru
75565	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	1	Y	20	2005/11/19	36 88.6 N 141	BT	G425	420	Wakataka-maru
75950	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	3		16-10	2005/10/29	36 95.21 N 141	BT	G210	210	Wakataka-maru
75951	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	2		U	2005/10/30	36 49.83 N 140	BT	H150	156	Wakataka-maru
75566	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	4	M2,F2	39-98	2005/11/11	36 66.8 N 141	BT	GH280	278	Wakataka-maru
75568	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	1	F	11	2005/11/11	36 69.7 N 141	BT	GH250	250	Wakataka-maru
75569	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	2		17,16	2005/11/11	36 66.1 N 141	BT	GH350	350	Wakataka-maru
76152	Cranchidae	<i>Liocranchia</i>	<i>reinhardtii</i>	1		47	2006/11/15	36 36.11 N 141	BT	H1500	1478	Wakataka-maru
76153	Cranchidae	<i>Sandalops</i>	<i>melancholiticus</i>	1		47	2006/11/10	37 16.53 N 141	BT	FG510	510	Wakataka-maru
76154	Cranchidae	<i>Taonius</i>	<i>pacifica</i>	1		272	2006/11/15	36 36.11 N 141	BT	H1500	1478	Wakataka-maru
76155	Cranchidae	<i>Taonius</i>	<i>pacifica</i>	1		150	2006/11/15	35 46.26 N 141	BT	G750	750	Wakataka-maru
76156	Enoploteuthidae	<i>Enoploteuthis</i>	<i>chumi</i>	4		43-17	2006/11/10	37 18.77 N 141	BT	FG410	410	Wakataka-maru
76157	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		26	2006/10/29	37 35.71 N 141	BT	F280	280	Wakataka-maru
76158	Enoploteuthidae	<i>Watasenia</i>	<i>scintillans</i>	1		190-158	2006/11/10	37 18.77 N 141	BT	FG410	410	Wakataka-maru
76159	Gonatidae	<i>Beryteuthis</i>	<i>magister</i>	4		29	2006/9/17	39 34.54 N 142	BT	St.8	650	Wakataka-maru
76160	Gonatidae	<i>Beryteuthis</i>	<i>magister</i>	1		29	2006/10/5	39 34.54 N 142	BT	C650	650	Wakataka-maru
76161	Gonatidae	<i>Gonatopsis</i>	<i>borealis</i>	2		157,145	2006/10/18	39 3.89 N 142	BT	D410	410	Wakataka-maru

Appendix. (Continued)

Reg.No	Family	Genus	species	N	Sex	DML (mm)	Date	Position	Gear	St. No.	Depth (m)	Vessel
76162	Gonatidae	<i>Gonatus</i>	<i>pyros</i>	1		99	2006/11/11	36 51.8 N 141 47.99 E	BT	G1200	1200	Wakataka-maru
76163	Gonatidae	<i>Gonatus</i>	sp.	2		96, 86	2006/11/15	36 36.11 N 141 36.14 E	BT	H1500	1478	Wakataka-maru
76164	Gonatidae	<i>Gonatus</i>	sp.	3			2006/10/17	39 12.12 N 142 42.05 E	BT	D1500	1500	Wakataka-maru
76165	Gonatidae	<i>Gonatus</i>	sp.	1			2006/10/17	39 5.47 N 142 20.16 E	BT	D900	909	Wakataka-maru
76166	Histiotenuthidae	<i>Histiotenuthis</i>	<i>celetaria</i>	3		82-74	2006/11/10	37 18.18 N 141 49.47 E	BT	FG480	480	Wakataka-maru
76167	Histiotenuthidae	<i>Histiotenuthis</i>	<i>celetaria</i>	4		88-46	2006/11/10	37 18.77 N 141 45.8 E	BT	FG410	410	Wakataka-maru
76168	Histiotenuthidae	<i>Histiotenuthis</i>	<i>celetaria</i>	3		64-39	2006/11/10	37 18.81 N 141 47.19 E	BT	FG450	450	Wakataka-maru
76169	Histiotenuthidae	<i>Histiotenuthis</i>	sp.	1		103	2006/11/10	35 30.57 N 141 0.56 E	BT	H310	310	Wakataka-maru
76170	Mastigoteuthidae	<i>Mastigoteuthis</i>	<i>magna</i>	1		86	2006/11/15	36 36.11 N 141 36.14 E	BT	H1500	1478	Wakataka-maru
76171	Octopodidae	<i>Benthoctopus</i>	<i>profundorum</i>	1	M	72	2006/11/11	36 51.8 N 141 47.99 E	BT	G1200	1200	Wakataka-maru
76172	Octopodidae	<i>Benthoctopus</i>	<i>violenscens</i>	1	F	73	2006/11/10	37 18.18 N 141 49.47 E	BT	FG480	480	Wakataka-maru
76173	Ommastrephidae	<i>Nototodarus</i>	<i>hawaiiensis</i>	1		148	2006/11/12	37 18.81 N 141 47.19 E	BT	FG450	450	Wakataka-maru
76174	Onychoteuthidae	<i>Moroteuthis</i>	<i>loenbergi</i>	1		286	2006/10/18	39 3.89 N 142 9.43 E	BT	D410	410	Wakataka-maru
76175	Onychoteuthidae	<i>Moroteuthis</i>	<i>robusta</i>	1		39	2006/11/10	37 16.53 N 141 49.98 E	BT	FG510	510	Wakataka-maru
76176	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	2		15, 20	2006/10/29	37 35.71 N 141 41.02 E	BT	F280	280	Wakataka-maru
76177	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	1		32	2006/11/10	37 18.77 N 141 45.8 E	BT	FG410	410	Wakataka-maru
76178	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	1		9	2006/10/19	38 56.42 N 141 59.28 E	BT	D210D	210	Wakataka-maru
76179	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	1		8	2006/10/26	35 59.76 N 141 17.4 E	BT	G150	150	Wakataka-maru
76180	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	5	F5	12-8	2006/11/12	36 31.39 N 140 59.89 E	BT	H250	250	Wakataka-maru
76181	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	15		17-7	2006/10/19	38 55.54 N 142 1.35 E	BT	D250	250	Wakataka-maru
76182	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	12	F	9-4	2006/10/19	38 56.42 N 141 59.28 E	BT	D210D	210	Wakataka-maru
76183	Sepiolidae	<i>Sepiola</i>	<i>birostrata</i>	1		13	2006/10/9	40 51.54 N 141 38.75 E	BT	A210	210	Wakataka-maru
76184	Bolitaenidae	<i>Japetella</i>	<i>diaphana</i>	1		50	2007/10/11	40 19.7 N 142 21.3 E	BT	B750	759	Wakataka-maru
76185	Gonatidae	<i>Gonatopsis</i>	sp.	1	M	143	2007/11/7	42 27.6 N 144 58.4 E	3mBT	K3	2030	Tansei-maru
76186	Histiotenuthidae	<i>Histiotenuthis</i>	<i>corona</i>	1		150	2006/11/4	38 22.22 N 142 0.67 E	BT	E-350	349	Wakataka-maru
76187	Histiotenuthidae	<i>Histiotenuthis</i>	<i>corona</i>	1		45	2007/10/5	39 3.74 N 142 12.75 E	BT	D550	556	Wakataka maru
76188	Octopodidae	<i>Benthoctopus</i>	<i>profundorum</i>	1		60	2007/10/9	41 0.85 N 141 48.68 E	BT	A550	550	Wakataka maru
76189	Octopodidae	<i>Benthoctopus</i>	<i>profundorum</i>	6		95-22	2007/10/5	39 3.74 N 142 12.75 E	BT	D550	556	Wakataka maru
76190	Octopodidae	<i>Bathypolypus</i>	<i>salebrosus</i>	1		42	2007/10/17	39 4.18 N 142 11.75 E	BT	D510	505	Wakataka maru
76191	Octopodidae	<i>Benthoctopus</i>	sp.	1		20	2007/11/8	40 0.4 N 143 30.8	3mBT	H2	2040	Tansei-maru
76192	Octopodidae	<i>Benthoctopus</i>	sp.	1	F	85	2006/7/16	39 42.3 N 143 12.5 E	BN	M1B	2020	Soyo-maru

## Appendix. (Continued)

Reg.No	Family	Genus	species	N	Sex	DML (mm)	Date	Position	Gear	St. No.	Depth (m)	Vessel
76193	Octopodidae	<i>Benthoctopus</i>	sp.	1		55	2007/8/6	34.5 N 143	BN	K1	2000	<i>Soyo-maru</i>
76194	Octopodidae	<i>Octopus</i>	<i>doffleini</i>	2		ca.150	2005/11/4	64.3 N 141	BT	F380	384	<i>Wakataka-maru</i>
76195	Octopodidae	<i>Octopus</i>	sp.	1		52	2007/10/6	51.81 N 141	BT	A250	273	<i>Wakataka maru</i>
76196	Sepiolidae	<i>Rossia</i>	<i>pacifica</i>	2		24, 32	2007/10/6	51.81 N 141	BT	A250	273	<i>Wakataka maru</i>
76197	Vampyroteuthidae	<i>Vampyroteuthis</i>	<i>infernalis</i>	1		30	2007/11/8	0.4 N 143	3mBT	H2	2040	<i>Tansei-maru</i>