

Record body size of the beach conger *Conger japonicus* (Anguilliformes: Congridae) in the East China Sea

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A record body size, length of 1520 mm and weight of 12,600 g for the beach conger, Conger japonicus was recorded, which is approximately 120 mm and 2600 g larger than the previous international record. The specimen was female and obtained during an otter trawl survey on 4 April 2013 in the East China Sea (31°52.16'N 127°42.94'E) at a depth of approximately 140 m on the slope of the continental shelf. Morphometric measurements and meristic counts are reported in this paper. We also report profiles of water temperature, salinity, dissolved oxygen and chlorophyll-a taken immediately prior to the trawl, and species composition of concurrent catch with the otter trawling as environmental and biological characteristics of the habitat.

Keywords: *Conger japonicus*, record size, conger, East China Sea, trawl catches

INTRODUCTION

Congridae are found worldwide in tropical, sub-tropical and temperate latitudes and are one of the largest and most diverse families of the Anguilliformes (Smith, 1989). The Congridae family is formed of approximately 191 species in three subfamilies: Heterocongrinae, Bathymyrinae and Congrinae (Hatoooka, 2001; Nelson, 2006). Congrinae is formed of 22 genera (Hatoooka, 2001). Although the taxonomy of Congrinae has been debated, it is known that the genus *Conger* has approximately 14 species: *C. cinereus* (Rüppell, 1830); *C. conger* (Linnaeus, 1758); *C. erebennus* (Jordan & Snyder, 1901); *C. esculentus* (Poey, 1861); *C. japonicus* (Bleeker, 1879); *C. macrocephalus* (Kanazawa, 1958); *C. myriaster* (Brevoort, 1856); *C. oceanicus* (Mitchill, 1818); *C. oligoporus* (Kanazawa, 1958); *C. orbignianus* (Valenciennes, 1837); *C. philippinus* (Kanazawa, 1958); *C. triporiceps* (Kanazawa, 1958); *C. verreauxi* (Kaup, 1856); and *C. wilsoni* (Bloch & Schneider, 1801) (Kanazawa, 1958; Smith, 1989). In these *Conger* species, distribution, growth and reproductive ecology of *C. myriaster*, *C. conger*, *C. oceanicus* and *C. orbignianus* are partly known because of their economic importance (e.g. Richard *et al.*, 1986; Hood *et al.*, 1988; Bell *et al.*, 2003; O'Sullivan *et al.*, 2003; Gorie *et al.*, 2004; Katayama *et al.*, 2004; Correia *et al.*, 2006; Figueroa *et al.*, 2010; Miller *et al.*, 2011; Kurogi *et al.*, 2012). However biology of the other *Conger* species, including *C. japonicus*, is poorly known (Katayama & Kurogi, 2008).

Juvenile and adult beach conger *Conger japonicus* live on coastal and continental shelf areas along south-western Japan, the northern Yellow Sea and the Korean Peninsula

(Yongbo, 1996; Miller *et al.*, 2011). The fish is a demersal and carnivorous species, feeding on fish, crustaceans and other organisms. It usually inhabits rocky bottoms, ranging from 1 to 276 m in depth (Shouji, 2003; Hatoooka, 2013). Although this species is occasionally captured in coastal areas where fishermen employ fish-casting lines and set nets, the amount of catch is low compared with that of *C. myriaster*, and there is no information about where it spawns.

The present study was conducted in the East China Sea, located at temperate and subtropical zones bordered by China, Korea and Japan, covering a large continental shelf. The hydrography is mainly characterized by the Kuroshio, which flows north-eastward along the eastern margin of the continental shelf, the two branches of the Kuroshio, the northward flowing Tsushima and Taiwan warm current, and the southward flowing cold currents along the coast of China (Ichikawa & Beardsley, 2002). This area is an important fisheries area for many fish species including several species of marine eels and invertebrates. As far as we know, this is the first report to record body size of the beach conger. In addition, we show hydrographic profiles from the collection site and concurrently captured demersal fish and invertebrate fauna in the otter trawl in the East China Sea.

MATERIALS AND METHODS

Specimens were captured on 4 April 2013 in the East China Sea (31°52.16'N 127°42.94'E) (Figure 1) at a depth of 140 m by otter trawling. Trawling was conducted by the training ship 'Nagasaki Maru', Nagasaki University, Japan, an 842 ton stern trawler. A bottom trawl net, with a 50 mm main trawl and a 30 mm cod end mesh, was towed for 90 minutes at approximately 2.3 knots (towing distance estimated was approximately 6.4 km). The net mouth was approximately 17 m wide and 10 m high. Prior to the trawl,

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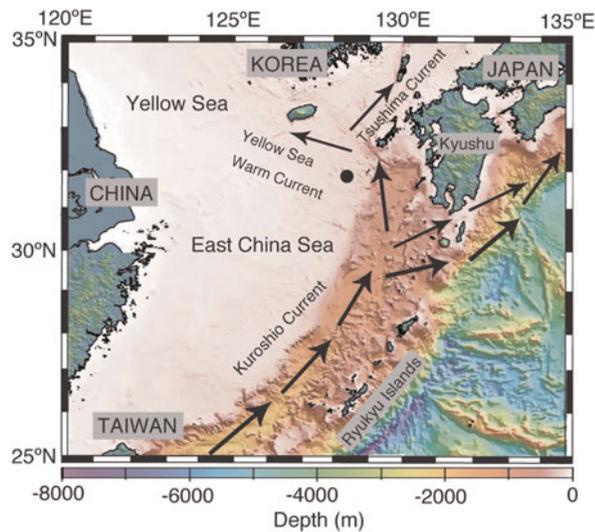


Fig. 1. Sample location (●) of the beach conger *Conger japonicus*. A conductivity–temperature–depth profile was also made for measurements at the same location. Bathymetry and ocean currents are shown.

a conductivity–temperature–depth (CTD; Sea-Bird Electronics) profile was made at the same sampling point with the trawl sample (Figure 1). Additionally, dissolved oxygen and concentration of chlorophyll-*a* were also measured.

After the trawl catch was sorted, total catch for each species were weighed to the nearest kilogram, except for the beach conger. Biomass of each species was expressed by catch (kg) per hour. For the beach conger, morphometric measurements and meristic counts were performed to the nearest millimetre using digital Vernier calipers and a ruler. The beach conger was also weighed to the nearest gram. External and internal appearances were photographed. Gonad was also observed under a microscope to identify sex according to Nemoto *et al.* (2004), which is based on *C. myriaster*.

Identification of the beach conger was made based on the description of Hatooka (2013), on the extended body; large pectoral fin among conger family; eye is behind posterior nares; no segment on dorsal and anal fins; pre-anal length is 30–45% of total length; in-line dentition on the premaxilla; no white spots on the head and trunk; dorsal fin origin is behind the pectoral fin insertion; lateral line pores 35–39 in front of anal opening; head length is approximately 14% of total length; 15–16 pectoral fin rays and 142–145 vertebrae.

RESULTS AND DISCUSSION

External appearance of the beach conger is shown in Figure 2. The body colour was completely black just after capture. The

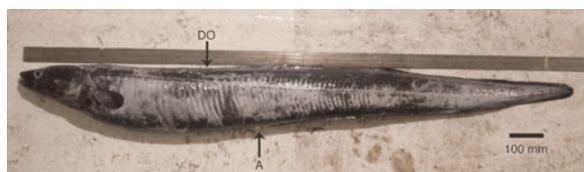


Fig. 2. External appearance of the beach conger *Conger japonicus* caught in the East China Sea. Note that the body colour was completely black just after capture. Arrows indicate: A, level of anus; DO, dorsal fin origin.

Table 1. Morphometric measurements (in mm and % of total length (TL)) and meristic counts of the beach conger *Conger japonicus* (female) caught in the East China Sea.

Characteristics	Specimen	(% of TL)
Morphometric		
Total length	1505	(100.0)
Standard length	1485	(98.7)
Head length	218	(14.5)
Head width	126	(8.4)
Eye horizontal diameter	28.5	(1.9)
Eye vertical diameter	27.4	(1.8)
Interorbital length	52	(3.5)
Upper jaw length	61	(4.1)
Snout length	47.7	(3.2)
Width of gill opening	43.2	(2.9)
Dorsal fin length	30	(2.0)
Pre-dorsal length	320	(21.3)
Pre-anal length	630	(41.9)
Anal fin length	27	(1.8)
Pectoral fin length	72.5	(4.8)
Body thickness	161	(10.7)
Body height	154.6	(10.3)
Girth length	420	(27.9)
Nostril largest diameter	3.1	(0.2)
Nostril smallest diameter	3.0	(0.2)
Weight	12,600 g	
Meristic		
Pectoral fin rays	15	
Pre-anal pores of the lateral line	35	
Vertebrae	144	
Gill rakers	0	

morphometric measurements with percentages of total length (% of TL) and meristic counts are shown in Table 1. The beach conger captured was 1520 mm long and 12,600 g weight, which is approximately an increase of 120 mm and 2600 g over previous records for the beach conger. Previously, the record body sizes of the beach conger were 1300 mm (5626 g) along the coast of the Boso Peninsula, Japan (Shouji, 2003), and 1400 mm along the Japanese coast (estimate of weight for female according to Shouji (2003) is approximately 10,000 g) (Masuda *et al.*, 1984; Hatooka, 2013), and 1260 mm (6200 g) in the northern Yellow Sea (Yongbo, 1996).

In other *Conger* species, 2100 mm (54,400 g) of *C. oceanicus* in Maine Bay, USA, and 2002 mm (54,100 g) of *C. conger*

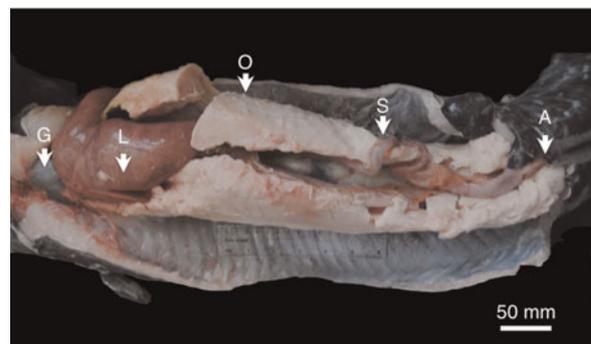


Fig. 3. Ventral view of ovary of the beach conger *Conger japonicus*. Arrows indicate: A, level of anus; G, gallbladder; L, liver; O, ovary; S, stomach.

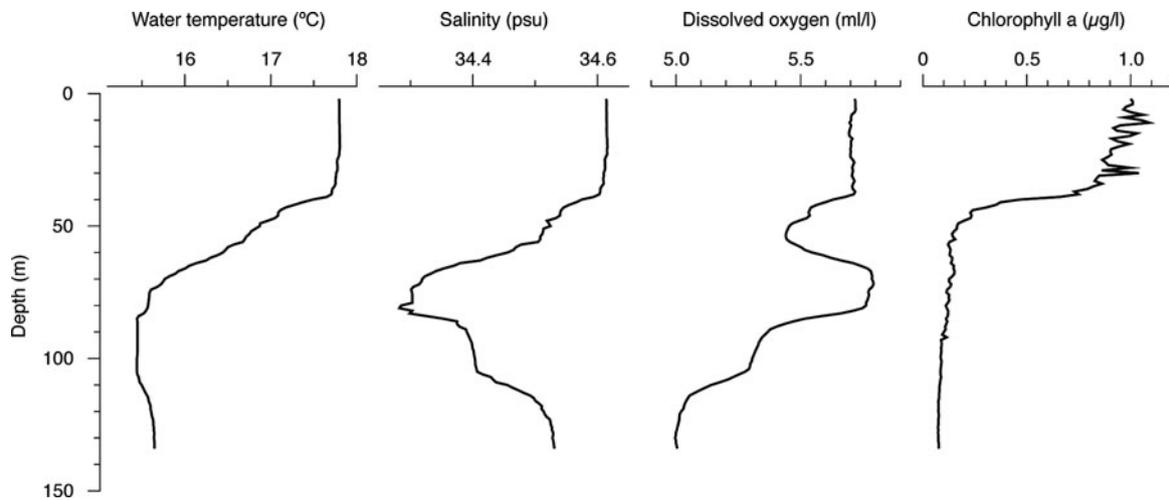


Fig. 4. Profiles of water temperature, salinity, dissolved oxygen and chlorophyll-*a* at the survey point in the East China Sea on 4 April 2013.

off the coast of Ireland were recorded (Bigelow & Schroede, 1953; Fannon *et al.*, 1990). A 1270 mm *C. myriaster* in Mekawa Bay, Japan, and a 1540 mm *C. orbignianus* from South Brazil were also recorded (Katayama & Kurogi, 2008; Figueroa *et al.*, 2010). Thus, these *Conger* species can reach quite large sizes of >2 m, which is probably larger than most other genera of the Congrinae.

In this study, the specimen was female with an empty stomach (Figure 3). Its ovary was yellowish-white with a rough texture, paired structures which run the length of the body cavity and extend past the anus (Figure 3). They were attached to the peritoneum on either side of the swim bladder, and approximate percentage of space occupied by the ovary into the abdominal cavity was 80%. Tiny oocytes were visible through the ovary wall.

The ovary was partway developed, because this specimen had the highest gonadosomatic index level (GSI = gonad weight/body weight \times 100) of this species (GSI = 9.5, M. Yagi and Y. Morita; unpublished data), compared with previous eels captured along the coast of the Boso Peninsula, Japan that had GSI values ranging from 0.2 to 8.3 (Shouji, 2003). The GSI levels appear generally to be directly related to the degree of gonad development. In *C. myriaster*, GSI < 1 female individuals were immature, whereas individuals (GSI: 2–4) were relatively mature with the oocytes at the oil droplet or the primary yolk globule stages (Okamura *et al.*, 2000). Therefore, according to these values, the sampled ovary could be maturing in preparation for spawning.

The specimen was collected at 140 m depth on the slope of the continental shelf and near the northern branch of

Table 2. Total biomass (in kg/h) and its percentage (% of total biomass) of the catch by otter trawling in the East China Sea, except for the beach conger.

Group (class)	Common name	Species	Family	Biomass (kg/h)	% of total biomass
Osteichthyes	Yellowback seabream	<i>Evynnis tumifrons</i> (Temminck & Schlegel, 1843)	Sparidae	32.3	44.1
	John dory	<i>Zeus faber</i> (Linnaeus, 1758)	Zeidae	6.1	8.4
	Ukkari-kasago	<i>Sebastes tertius</i> (Barsukov & Chen, 1978)	Scorpaenidae	5.3	7.3
	Japanese thread-sail fish	<i>Aulopus japonicus</i> (Günther, 1877)	Aulopodidae	3.3	4.5
	Redwing searobin	<i>Lepidotrigla microptera</i> (Günther, 1873)	Triglidae	2.8	3.8
	Yellow goosfish	<i>Lophius litulon</i> (Jordan, 1902)	Lophiidae	2.7	3.6
	Whitefin trevally	<i>Kaiwarinus equula</i> (Temminck & Schlegel, 1844)	Carangidae	2.3	3.2
		<i>Pseudorhombus</i> sp.	Paralichthyidae	1.9	2.5
	Red seabream	<i>Pagrus major</i> (Temminck & Schlegel, 1843)	Sparidae	1.7	2.3
	Stripey	<i>Microcanthus strigatus</i> (Cuvier, 1831)	Scorpididae	1.5	2.0
	Black scraper	<i>Thamnaconus modestus</i> (Günther, 1877)	Monacanthidae	1.2	1.6
	Armoured cusk	<i>Hoplobrotula armata</i> (Temminck & Schlegel, 1846)	Ophidiidae	0.8	1.1
	Batfish	<i>Halieutaea stellate</i> (Vahl, 1797)	Ogcocephalidae	0.5	0.7
		<i>Repomucenus</i> sp.	Callionymidae	0.4	0.5
	Japanese jack mackerel	<i>Trachurus japonicus</i> (Temminck & Schlegel, 1844)	Carangidae	0.3	0.5
	Bluespotted stargazer	<i>Gnathagnus elongatus</i> (Temminck & Schlegel, 1843)	Uranoscopidae	0.1	0.2
	Dragonet	<i>Foetorepus ativelis</i> (Temminck & Schlegel, 1845)	Callionymidae	0.1	0.2
Chondrichthyes	Common skate	<i>Raja kenoeji</i> (Müller & Henle, 1841)	Rajidae	4.9	6.6
Cephalopoda	Cuttlefish	<i>Sepia</i> sp.	Sepiidae	1.1	1.5
	Japanese common squid	<i>Todarodes pacificus</i> (Steenstrup, 1880)	Ommastrephidae	0.7	1.0
	Swordtip squid	<i>Loligo edulis</i> (Hoyle, 1885)	Loliginidae	0.4	0.5
Crustacea	Slipper lobster	<i>Ibacus novemdentatus</i> (Gibbes, 1850)	Scyllaridae	2.8	3.8

Kuroshio in the East China Sea. Shouji (2003) found that the beach congers larger than 1000 mm were only female, and maximum size of males was 920 mm (1705 g). He also reported that the sex-ratio of females is higher than males at depths less than 276 m along the coast of the Boso Peninsula, Japan (female is 77.7%, male 10.8% and unidentified 11.5%) (Shouji, 2003). Although the reason for these differences in body size and sex-ratio between male and female is currently unknown, it may be due to differences of growth rate and/or habit use among the sexes. It is known that the growth rate of females is faster than that of males in *C. myriaster* (Nabeshima, 2001). Furthermore, in *Conger* species such as *C. myriaster*, *C. conger* and *C. oceanicus* only females are found in continental shelf areas, whereas males and females occur in shallow coastal areas (Cau & Manconi, 1984; Hood *et al.*, 1988; Ishida *et al.*, 2003; Gorie *et al.*, 2004). Sexual maturation of *Conger* species is thought to occur during their migration towards their deep-sea spawning areas (Sbaihi *et al.*, 2001; Figueroa *et al.*, 2010). Therefore, females of the beach conger may also have a higher growth rate and migrate to deeper waters to spawn. Further surveys on reproductive ecology, growth and migration of this eel species are clearly required in the future.

The CTD profiles are shown in Figure 4. Thermocline appeared from 40 to 75 m in depth. From 40 to 70 m, salinity decreased, but it increased from more than 80 m depth. Dissolved oxygen tended to gradually decrease; finally, chlorophyll-*a* dramatically decreased at 50 m depth. Bottom trawling was conducted at 140 m depth. Thus, the beach conger and other species caught by trawling inhabited at approximately 15.8°C, 34.5 psu, 5.0 ml/l in dissolved oxygen and nearly zero chlorophyll-*a*.

The species composition of catch by the trawling is also shown in Table 2. Abundant species by assorted group, Osteichthyes, Chondrichthyes, Cephalopoda and Crustacea were yellowback seabream *Eynniss tumifrons* (Temminck & Schlegel, 1843), common skate *Raja kenoei* (Müller & Henle, 1841), cuttlefish *Sepia* sp. and slipper lobster *Ibacus novemdentatus* (Gibbes, 1850), respectively. No food was found in the stomach of the beach conger, but the diet of this eel species might include some of the small fish or crustaceans that were collected (Table 2) by the trawl. In this study the beach conger had the largest body size among the catch. Body size and feeding habit of fish are fundamental determinants of the ecological niche in the marine environment (Woodward & Hildrew, 2002). The beach conger may play a key role as one of the top predators among demersal marine species in the East China Sea.

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REFERENCES

- Bell G.W., Witting D.A. and Able K.W. (2003) Aspects of metamorphosis and habitat use in the conger eel, *Conger oceanicus*. *Copeia* 2003, 544–552.
- Bigelow H.B. and Schroede W.C. (1953) Fishes of the Gulf of Maine. *Fisheries Bulletin. USA* 52, 154–157.
- Cau A. and Manconi P. (1984) Relationship of feeding, reproductive cycle and bathymetric distribution in *Conger conger*. *Marine Biology* 81, 147–151.
- Correia A.T., Antunes C., Wilson J.M. and Coimbra J. (2006) An evaluation of the otolith characteristics of *Conger conger* during metamorphosis. *Journal of Fish Biology* 68, 99–119.
- Fannon E., Fahy E. and O'Reilly R. (1990) Maturation in female conger eel, *Conger conger* (L.). *Journal of Fish Biology* 36, 275–276.
- Figueroa D.E., Macchi G. and Haimovici M. (2010) News about the reproductive ecology of the southern conger eel *Conger orbignianus*. *Journal of the Marine Biological Association of the United Kingdom* 90, 461–465.
- Gorie K., Tanda M. and Katayama S. (2004) Age and growth of white-spotted conger *Conger myriaster* collected in northeast Harima Nada, Seto Inland Sea. *Suisanzoshoku* 52, 407–411.
- Hatooka K. (2001) Taxonomy and distribution of conger eel. *Nippon Suisan Gakkaishi* 67, 109–110. [In Japanese.]
- Hatooka K. (2013) Congridae. In Nakabo T. (ed.) *Fishes of Japan with pictorial keys to the species*. 3rd edition. Tokyo: Tokai University Press, pp. 279–287.
- Hood P.B., Able K.W. and Grimes C.B. (1988) Biology of the conger eel *Conger oceanicus*. 1. Distribution, age, growth and reproduction. *Marine Biology* 98, 587–596.
- Ichikawa H. and Beardsley R.C. (2002) The current system in the Yellow and East China Seas. *Journal of Oceanography* 58, 77–92.
- Ishida T., Yamanobe A., Goto K., Katayama S. and Mochioka N. (2003) Study on the white-spotted conger *Conger myriaster* (Brevoort) caught in the coast of Joban. *Bulletin of the Fukushima Prefectural Fisheries Experimental Station* 11, 65–79. [In Japanese.]
- Kanazawa R.H. (1958) A revision of the eels of the genus *Conger* with descriptions of four new species. *Proceedings of the United States National Museum* 108, 219–267.
- Katayama S. and Kurogi H. (2008) Review on the life history of conger fishes in the Atlantic Ocean. *Bulletin of the Fisheries Research Agency* 24, 15–21. [In Japanese with English abstract.]
- Katayama S., Ishida T., Shimizu Y. and Yamanobe A. (2004) Seasonal change in distribution of conger eel *Conger myriaster* off the Pacific coast south of Tohoku, north-eastern Japan. *Fisheries Science* 70, 1–6.
- Kurogi H., Mochioka N., Okazaki M., Takahashi M., Miller M.J., Tsukamoto K., Ambe D., Katayama S. and Chow S. (2012) Discovery of a spawning area of the common Japanese conger *Conger myriaster* along Kyushu-Palau Ridge in the western North Pacific. *Fisheries Science* 78, 525–532.
- Masuda H., Amaoka K., Araga C., Uyeno T. and Yoshino T. (1984) *The fishes of the Japanese Archipelago. Volume 1*. Tokyo: Tokai University Press.
- Miller M.J., Yoshinaga T., Aoyama J., Otake T., Mochioka N., Kurogi H. and Tsukamoto K. (2011) Offshore spawning of *Conger myriaster* in the western North Pacific: evidence for convergent migration strategies of anguilliform eels in the Atlantic and Pacific. *Naturwissenschaften* 98, 537–543.
- Nabeshima Y. (2001) Growth and feeding behavior of *Conger myriaster*. *Nippon Suisan Gakkaishi* 67, 113–114. [In Japanese.]

- Nelson J.S.** (2006) *Fishes of the world*. 4th edition. New York: John Wiley & Sons.
- Nemoto Y., Kawai T. and Ishida T.** (2004) Survival rate, growth and sex ratio of reared juvenile conger eel, *Conger myriaster*. *Bulletin of the Fukushima Prefectural Fisheries Experimental Station* 12, 7–12. [In Japanese.]
- Okamura A., Utoh T., Zhang H., Yamada Y., Horie N., Mikawa N., Tanaka S., Motonobu T. and Oka H.P.** (2000) Seasonal changes in maturity in the conger eel *Conger myriaster* at the Pacific coast of Atsumi Peninsula, central Japan. *Nippon Suisan Gakkaishi* 66, 412–416. [In Japanese with English abstract.]
- O’Sullivan S., Moriarty C., FitzGerald R.D., Davenport J. and Mulcahy M.F.** (2003) Age, growth and reproductive status of the European conger eel, *Conger conger* (L.) in Irish coastal waters. *Fisheries Research* 64, 55–69.
- Richard R.C., Ray G.C. and Douglass J.** (1986) *A field guide to Atlantic coast fishes of the North America*. New York: Houghton Mifflin Company.
- Sbaihi M., Fouchereau-Peron M., Meunier F., Elie P., Mayer I., Burzawa-Gerard E., Vidal B. and Dufour S.** (2001) Reproductive biology of the conger eel from the south coast of Brittany, France and comparison with the European eel. *Journal of Fish Biology* 59, 302–318.
- Shouji Y.** (2003) Studies on the sex ratio and gonad index of beach conger, *Conger japonicus*. *Bulletin of the Chiba Prefectural Fisheries Research Center* 2, 71–74. [In Japanese.]
- Smith D.G.** (1989) Family Congridae. In Böhlke E.B. (ed.) *Fishes of the western North Atlantic*. New Haven: Sears Foundation for Marine Research, pp. 460–567.
- Woodward G. and Hildrew A.G.** (2002) Body-size determinants of niche overlap and intraguild predation within a complex food web. *Journal of Animal Ecology* 71, 1063–1074.
- and
- Yongbo Z.** (1996) A new record of fish in the Northern Yellow Sea (Lianoning)—*Conger japonicus* Bleeker. *Journal of Dalian Fishery College* 11, 54–56. [In Chinese with English abstract.]

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