Chapter 18
Fisheries

Kazuki Yokouchi and Mari Kuroki

Contents

The relationship between freshwater eels and humans has a long history, dating back thousands of years. Eels have flexible ecological traits specific to the situation in which each individual is placed at each life history event, and they inherently have a relatively high adaptive capacity. Each continental developmental stage of this remarkable life cycle is the target of various forms of fisheries. In estuaries of Asia, glass eels are collected as seedlings for aquaculture in areas influenced by the Kuroshio Current and its extension in the Pacific. In Europe, along the Atlantic coast, there was once a tradition of frying glass eels in olive oil for consumption; however, nowadays, substitutes are often used. Yellow- and silver-stage eels are caught in waters close to human living areas such as streams, rivers, ponds, lakes, estuaries, and inner bays, mainly for direct consumption. The diversity of capture methods used for yellow and silver eels is substantial compared to other fish species. Depending on the developmental stage and habitat, eel fisheries exhibit a variety of ingenuity. Several different fishing gears and methods have been devised for each developmental stage. However, some traditional eel fishing methods have become obsolete because of declining stocks and a decrease in the number of fishers. This chapter introduces the main fishing gear and methods, mainly in Japan, devised for eels with their life history stages over the years.

K. Yokouchi (✉)
Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Kanagawa, Japan
e-mail: yokouchi_kazuki56@fra.go.jp

M. Kuroki
Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan

K. Tsukamoto et al. (eds.), *Eel Science*, Fisheries Science Series,
https://doi.org/10.1007/978-981-99-5692-0_18

18.1 Glass Eel Fisheries

Glass eels migrate ashore to estuaries and coastal areas from early winter to late spring in the temperate zone. The timing of their arrival varies depending on their location from the spawning grounds in the ocean. In Europe, *Anguilla anguilla* glass eels arrive in estuaries along the Atlantic Coast in winter (southwestern areas) and spring (eastern Mediterranean, western, and northwestern areas) (Dekker 2003). In East Asia, the fishing season for the *A. japonica* glass eel is early winter in the south and spring in the north (Kuroki and Tsukamoto 2012; Mochioka 2019). In subtropical Taiwan, facing the Philippine Sea located in the southern part of its distribution, glass eel fishing starts in October; in southern Japan, it starts in December; and in northeast Japan, the northern limit of the fishing area begins in February. In the Seto Inland Sea, these areas do not directly face the Kuroshio; thus, it takes time for the glass eel to reach the coast, resulting in a later fishing season than that in the estuarine areas along the Pacific coast. Recently, glass eels have also been reported in southern Hokkaido, which is the northern limit of its distribution (Morita and Kuroki 2021). In addition, the peak of the fishing season varies greatly from year to year, even at the same location (Aoyama et al. 2012; Yamamoto 2019).

In the glass eel fishery, transparent glass eels measuring ~50–70 mm in size gather at night in coastal estuarine waters during flood tide and are collected from the surf or riverbanks using hand nets or small set nets (Fig. 18.1) (see Chap. 6). When scooping glass eels from riverbanks, fishers use the small scoop net with lights to enable visualization while collecting. Large scoop nets have been used to catch eels in the sandy beach area near the mouth of the river (Mochioka 2019). In Europe, glass eels have been caught using handheld or ship-based nets, and a wide range of dipnet types have previously been applied, such as trawls, stow nets, and fyke nets (Dekker 2003). From these glass eel fisheries, catch per unit effort (CPUE) data

Fig. 18.1 Glass eel fishing using hand nets at river mouths in winter in Kochi prefecture (left) and Shizuoka prefecture (right), Japan. Photograph courtesy Mari Kuroki

could be obtained and used as important indices for stock assessment (see Chap. 19). In Asia, most of the collected glass eels are used as seedlings for aquaculture or stocking, depending on the country. In Japan, a special harvest permit is required for the harvest of glass eels. The use of boats or manpower to pull fishing gear and the use of secondary guiding fishing gear (commonly known as *kaki-ami* in Japanese) are prohibited in Japan (Mochioka 2019). In Taiwan, however, in addition to hand-scooping and set nets, small boats are used to catch fish by towing fine-mesh nets.

There are 2 types of eel cultivation cycles in Japan: single-year cultivation and year-round cultivation (Shiraishi and Crook 2015; Yokouchi 2019). In the single-year culture cycle, glass eels are placed in culture ponds from December to January and cultured for ~6 months until the traditional day of *Doyou-no-Ushi* in summer (late July to early August) of the same year. This Japanese custom of eating highly nutritious eels at the hottest times of the year has continued since the Edo era. Therefore, ~30–40% of the annual consumption in Japan occurs during this season. In the year-round cultivation method, glass eels are placed in ponds from February to April and cultivated for shipment from September to July. As a result of the large consumption of cultured eels in Japan on the day of *Doyou-no-Ushi* in the summer, demand and prices are generally higher for glass eels caught earlier.

The glass eel fishery is affected not only by fluctuations in glass eel recruitment and stock status but also by the historical development of aquaculture techniques and special socioeconomic circumstances. Japanese eel aquaculture began in 1879, when all seedlings were natural juveniles caught by traditional fisheries (Tanaka 2014 and references therein). With the development of the eel industry in the Tokai region of central Japan, around 1960, a large number of elver eels were introduced to the aquaculture industry from the large Tone River system near Tokyo. During the fishing season from mid-March to late October, seedlings collected from the lower reaches of the Tone River contained elvers and yellow eels, of which 60% were supplied to the Tokai region as seedlings for eel farming (Matsui 1972). As a result, the statistics of glass eels caught around 1960 include more elver eels and small yellow eels (young-of-the-year) than recent catches (see Chap. 19). The rate of decrease in the glass eel catch is likely to be less than that shown in the total seed catch in the sea and inland waters in Japan. Furthermore, estimating the annual demand for glass eels by converting the aquaculture production of commercial-sized eels to a certain survival and growth rate indicated that Japanese statistics may have overreported the catch during that period (Kishida and Kanto 2013) (see Chap. 19).

In the early 1990s, East Asia experienced a severe shortage of *A. japonica* glass eel seedlings for aquaculture, causing a rapid increase in imports of *A. anguilla* glass eels from Spain, France, and the Netherlands to replace the *A. japonica* glass eels. In the mid-1990s, a huge number of glass eels recruited annually in Europe were caught by fisheries, most of which were sent to aquaculture ponds in Asia (see Chap. 20). Thus, the glass eel fishery and aquaculture industries are socioeconomically linked on a global scale. The situation for glass eel fisheries has changed since the export of European eel became regulated by the Washington Convention (CITES: Convention on International Trade of Endangered Species of Wild Fauna) and conservation measures are being implemented in EU countries (see Chap. 23). As a result, part of the recent demand has shifted to other anguillid eel species.

18.2 Yellow Eel Fisheries

The yellow eel stage is the longest in the life history stages of eels, typically lasting ~5–15 years until the onset of maturity for *A. japonica* (see Chap. 3). Yellow eels inhabit environments familiar to humans, such as small rivers, ponds, lakes, estuaries, tidal flats, and inner bays (Yokouchi et al. 2012), with anthropogenic impacts (Righton et al. 2021; Yokouchi et al. 2022). Fishing methods targeting yellow eels are diverse and have a long history of use. Yellow eels are highly sedentary and feed on a variety of organisms, depending on their body size and habitat (e.g., Nishimoto et al. 2023) (see Chap. 8). In addition, yellow eels have a habit of hiding in structures such as stone piles, stone crevices, and vegetation roots. Therefore, as a fishing method, eels are captured using these habits to attract them by hiding places and bait. In estuarine areas and tidal flats, eels build burrows to spend the daytime in (Aoyama et al. 2005), and thus, there are also methods of capturing eels without attracting them, such as eel scraping.

The accurate monitoring of yellow eel catches requires certain considerations. In Japan, because the main method of stocking eels is to release small yellow eels (originating from eel farms) into rivers and lakes, farmed and stocked individuals are common in inland waters (Kaifu et al. 2014, 2018). As a result, it is difficult to collect accurate data on yellow and silver eel fisheries in Japan's inland waters; however, relatively accurate information on the dynamics of wild Japanese eel stocks can be obtained from coastal and estuarine areas where wild eels are dominant (Kaifu and Yokouchi 2019).

Fishing methods that use bait to attract eels include hook-and-line fishing, longline, hole fishing, and eel pots. There is also a traditionally specialized way of fishing eels known as bobbing or *juzu-tsuri* in Japanese or *la pêche à la vermée* in French (Kuroki and Tsukamoto 2012; Kuroki et al. 2014a; Feunteun and Robinet 2014). Among these, the longline method is still used locally. Longlining is a common fishing method that is used in many areas. The bait used varies depending on the fishing area and season, and may include pond snails, earthworms, shrimp, mud shrimp, hornet larva, and cultured worms. Hole fishing is performed with a hook tied to the end of a bamboo rod approximately 1-m long with a bait attached. The hook is inserted into a crevice where eels are likely to hide. After the bait is fully chewed and swallowed by the eel, the hook is gradually pulled out. In Japan, the bait should be earthworms, ayu, or loach (Mochioka 2019). Fishing methods using bamboo traps exist in many areas of the world. Bamboo strips woven into a tube or basket are used as traditional fishing gear; this method also utilizes the elongated shape of eels to hide in narrow places (Righton and Roberts 2014; McCarthy 2014; Tzeng 2014; Jellyman 2014) (Figs. 18.2 and 18.3). They can be submerged in the

Fig. 18.2 Photo of an eel pot woven with wicker at the Eel Festival in Ely, England. Photograph courtesy Mari Kuroki

water alone, connected together in a long line, or guided to the gear by a weir built into the riverbed.

Even if quite specific, traditional fishing methods can have similar plans between distant locations. In Japan, *Juzu-tsuri* (beads fishing in Japanese) is a fishing method that does not use hooks. It was popular in parts of the Chugoku region of western Japan in the 1950s; however, this method is rarely seen today. A 5-m long string of bait was made by threading dozens of polychaetes (bristle worms) and earthworms vertically with a sewing needle, winding it into a 3–5 cm loop and tying it with a weight in the center of the loop to form a spherical mass of bait. *Juzu-tsuri* is done in brackish water at night during flood tide, and when a fish strikes, it is taken into the boat. Although large fish are caught, most of the catch consists of juveniles weighing less than 20 g (Mochioka 2019). A similar fishing method was found in some countries, known as bobbing or *la pêche à la vermée* in French (Feunteun and Robinet 2014). In France, "*la pêche à la vermée*" was commonly used to hold an

Fig. 18.3 Traditional eel fishing gears, Japan. Bamboo tubes with return trap (top left), bamboo tubes without return (bottom left), and eel sickles in the possession of Shunsuke Sanda (right). Kuroki and Tsukamoto (2012) reproduced with permission

umbrella upside down under the bait, enabling the eel dropped off from the bait to be captured (Feunteun and Robinet 2014).

Methods of luring eels by providing artificial shelters without bait allow them to come and go at night, including several techniques such as baitless eel tubes, bush dip, *shibazuke* in Japanese, and a traditional Japanese method using stones known as *ishikura*. Fishing methods still in use today include baitless eel tubes and Japan's *ishikura* fisheries. The baitless eel tubes are traditionally made of bamboo; however, PVC tubes are currently used often (5–15 cm in diameter, 2–3 tubes bundled together) with knots cut out and ropes attached to both ends and submerged in water (Fig. 18.3). The tube can be gradually raised to the surface horizontally during the day to collect eels hiding in the tubes by tilting the tube inside the hand net. In the bush dip method, bundles of bamboo, chinquapin, oak, or other twigs are immersed in water for at least one night, then slowly pulled out of the water; small eels that have entered it are collected using a large scoop net at the water surface.

Ishikura fishing is a traditional fishing method with unique procedures for catching eels (Fig. 18.4) that still remains in the Kyushu and Shikoku regions in Japan. The *ishikura* fishing is done in the tidal zone near the river mouth, where stones of the size of a human head are piled up in the water to create a shelter for eels.

Fig. 18.4 Traditional *Ishikura* (rock pile) fishing for yellow eels (top) and migrating silver eel fishing with scoop-nets (bottom) from *Mie-ken Suisan Zukai*, published in 1883. Source, Mie Prefectural Museum

At low tide, the stone shelter is surrounded by a net, and eels that hide in the gaps between stones at high tide are caught by removing the rock pile and/or driving them into a fish-catching section of the net with a return. Some fishers do not use a net for

Fig. 18.5 Fyke net fishing in Lough Ennell, Ireland. Photograph courtesy Kazuki Yokouchi

the *ishikura* fishing, and instead use box glasses or other equipment to visualize the inside of the stone piles, pick up stones, and catch eels with eel shears or other tools.

Fishing methods that do not use attractants include fyke nets, scraping, poking, hand fishing, *kaibori* (drain-up), small-bottom trawling, push nets, and small-set nets. With the exception of some net fishing methods, including small set nets and fyke nets, scraping, poking, and hand fishing or *kaibori* methods are rarely used commercially today. Yellow eels are often caught using small set nets in brackish lakes and are sometimes caught as bycatch using small trawl nets in semi-closed bays in Japan. Fyke nets and draft nets are a type of fishing net commonly used in Europe (i.e., Ireland) for collecting yellow eels from estuaries and lakes (Fig. 18.5) (McCarthy 2014; Rindom et al. 2014). The Fyke net is a long cylindrical bag net with several inner returns that facilitates entry and makes escape difficult. It is also equipped with a wing or leader to guide the eels towards the entrance of the bag. Draft nets 80–100 m in length with a cod-end are deployed from boats in open water (Aprahamian et al. 2021).

Scraping and poking use special spears, forks, rakes, or sickles to catch eels. These fishing methods are used worldwide. Eel poking is a fishing method in which eels are poked using a fish spear with box glasses on a riverboat (Kuroki et al. 2014a; Righton and Roberts 2014; McCarthy 2014; Rindom et al. 2014; Jellyman 2014). For eel scraping, warped iron fishing gear with several claws on the tip is used to collect eels hidden in the mud (Fig. 18.3). At river mouths and tidal flats, eels hiding in the mud bottom are caught by inserting an eel scraper with a long handle into the bottom sediment from a boat. In the past, this method was actively used in small irrigation canals and reservoirs after water was drained in Japan. Hand fishing, or noodling, is a method of catching eels that hide in burrows on tidal flats or natural stone piles by inserting their hands into them. Eel grips and shears are often used. Unfortunately, scraping and hand fishing are no longer commercially viable.

Other Japanese traditional fishing methods in which all or part of a small swamp, pond, or river is partitioned using mud, stones, or wood, the water is drained out to collect the stranded fish (Kuroki and Tsukamoto 2012; Mochioka 2019). The ponds and swamps are then sun-dried, which is a traditional management method used during the off-season to maintain the reservoirs for agriculture in Japan. Similar fishing methods have also been used in Europe (Feunteun and Robinet 2014); however, these methods are not commonly employed.

18.3 Silver Eel Fisheries

It is known that the size at silvering and age at maturity vary widely among eels in the temperate zone, and that a certain minimum size must be achieved for eel silvering maturity (see Chap. 3). Since silver eels that have begun spawning migration rarely catch food, fishing methods that use bait are not used. They are caught mainly using fish weirs, waiting nets, and small set nets, or caught as bycatch using small trawl nets. Silver eels migrating towards the sea along the shoreline are collected using small set nets from late autumn to winter. However, recently in the inland waters of Japan, silver eel fisheries have stopped fishing to conserve eel resources.

Female eels tend to attain larger body sizes when growth conditions are sufficient to spend extra time in their growth habitats. When growth rates decline, the onset of maturation and spawning migration is triggered (Yokouchi et al. 2018). Eels caught by small set nets in coastal areas are often large females, while male silver eels are small and may be able to slip through the set nets (Mochioka 2019). Small set nets can be found in semi-closed or inner bays for eel fishing. Both male and female silver are typically successfully collected using small set nets (Yokouchi et al. 2009). Although silver eels tend to burrow in holes less often, they can also be captured by the aforementioned-eel scrapers and *ishikura*. In Europe, silver eels are often caught in set nets lowered into the water at eel weirs in several river systems, a long-established fishing method (McCarthy 2014; Aprahamian et al. 2021). In Indonesia, fish weirs catch silver-phase tropical eels of *A. marmorata* and *A. celebesensis* heading downstream to each spawning area (Hagihara et al. 2018).

Silver eels are collected from late autumn to early winter when the river water levels increase from autumn rains. To catch silver eels swimming down the river, stones are piled up to gather river water, with nets set at their ends, or large eel pots woven from bamboo are installed (McCarthy 2014; Jellyman 2014). Other silver eel fishing gear includes traditional scoop nets (Fig. 18.4) and beam nets that lined up two boats facing the current. The beam-net method was previously used in Japan when rainfall and runoff occurred. However, these methods are rarely used today.

Silver eel biology is essential for understanding eel life history and contributing to conservation and management efforts. To conserve eel resources effectively, it is crucial to monitor maturing silver eels in estuarine and marine areas, where it is possible to target all migratory types assumed to contribute to reproduction. In addition, accurate information on wild Japanese eels can be obtained from coastal and estuarine areas, where wild eels are dominant. Therefore, it is essential to accumulate knowledge on the habitat and ecology of yellow eels in brackish/marine habitats and migrating silver eels in the waters around the coast (Righton et al. 2021) (see Chap. 23). Furthermore, the use of several existing fishing methods to capture silver eels is important not only from a scientific point of view but also from a social perspective. For example, in Lake Hamana, a private-sector-led conservation initiative targeting silver eels has been implemented ahead of others to purchase and release wild silver eels, which involves stakeholders such as fishers, distributors, and restaurants in Japan (Iida et al. 2017).

As noted in this chapter, there is a great diversity of traditional eel fishing methods worldwide. Surprisingly, some traditional methods have high similarity among distant locations, even if the methods are quite specific. This case is an interesting case study of the cultural convergent development between eels and humans (Kuroki et al. 2014b; Righton and Roberts 2014). Various fishing methods are introduced in this section, each of which targets a different stage, size, or habitat. To accurately understand eels, research-based surveys alone, such as those conducted by recent electrofishing, bio-logging, and environmental DNA methods, are costly and limited in terms of technical requirements. As such, it is considered most effective to utilize the characteristics of various existing fishing methods and conduct monitoring of the current status of eel resources by combining these fishing methods and research-based surveys.

There is concern that without stable relationships between eels and humans through an interest in eels or fishing of eels, the environments they inhabit may decline. Without people's awareness and intervention, the decline of eel resources and the degradation of the surrounding ecosystem will unintentionally accelerate. Therefore, the various existing fishing methods are of cultural value and great value to natural science in maintaining a stable relationship between eels and humans. However, many of the traditional eel fisheries mentioned above have already disappeared because of declining stocks and a decrease in the number of fishers. Thus, learning and utilizing culturally distinctive, ecologically efficient traditional fishing methods in various activities, such as monitoring, research, education, and recreation, will become increasingly crucial for conserving ecosystem diversity and connectivity for eels and other species.

References

Aoyama J, Shinoda A, Sasai S, Miller MJ, Tsukamoto K (2005) First observations of the burrows of *Anguilla japonica*. J Fish Biol 67:1534–1543. https://doi.org/10.1111/j.1095-8649.2005.00860.x

Aoyama J, Shinoda A, Yoshinaga T, Tsukamoto K (2012) Late arrival of *Anguilla japonica* glass eels at the Sagami River estuary in two recent consecutive year classes: ecology and socio-economic impacts. Fish Sci 78:1195–1204. https://doi.org/10.1007/s12562-012-0544-y

Aprahamian MW, Evans DW, Briand C, Walker AM, McElarney Y, Allen M (2021) The changing times of Europe's largest remaining commercially harvested population of eel *Anguilla anguilla* L. J Fish Biol 99:1201–1221. https://doi.org/10.1111/jfb.14820

Dekker W (2003) Status of the European eel stock and fisheries. In: Aida K, Tsukamoto K, Yamauchi K (eds) Eel biology. Springer, Tokyo, pp 237–254

Feunteun E, Robinet T (2014) Freshwater eels and people in France. In: Tsukamoto K, Kuroki M (eds) Eels and humans. Springer, Tokyo, pp 75–89

Hagihara S, Aoyama J, Limbong D, Tsukamoto K (2018) Interspecific difference in downstream migratory season between two tropical eels, *Anguilla celebesensis* and *Anguilla marmorata*. J Fish Biol 93:729–732. https://doi.org/10.1111/jfb.13750

Iida M, Tanaka T, Nishimoto A, Yokouchi K (2017) Biological characteristics and conservation of Japanese eel *Anguilla japonica* inhabiting seawater habitats - based on survey in the Miyakoda River system. KAIYOU Monthly 49:556–559; in Japanese

Jellyman DJ (2014) Freshwater eels and people in New Zealand: a love/hate relationship. In: Tsukamoto K, Kuroki M (eds) Eels and humans. Springer, Tokyo, pp 143–154

Kaifu K, Yokouchi K (2019) Increasing or decreasing? - current status of the Japanese eel stock. Fish Res 220:105348. https://doi.org/10.1016/j.fishres.2019.105348

Kaifu K, Maeda H, Yokouchi K, Sudo R, Miller MJ, Aoyama J, Yoshida T, Tsukamoto K, Washitani I (2014) Do Japanese eels recruit into the Japan Sea coast?: a case study in the Hayase River system, Fukui, Japan. Environ Biol Fish 97:921–928. https://doi.org/10.1007/s10641-013-0193-8

Kaifu K, Yokouchi K, Higuchi T, Itakura H, Shirai K (2018) Depletion of naturally recruited wild Japanese eels in Okayama, Japan, revealed by otolith stable isotope ratios and abundance indices. Fish Sci 84:757–763. https://doi.org/10.1007/s12562-018-1225-2

Kishida T, Kanto I (2013) Reconsideration on the catch of glass eel in Japan. Bull Japan Soc Fish Oceanogr 77:164–166; in Japanese with English abstract

Kuroki M, Tsukamoto K (2012) Eels on the move—mysterious creatures over millions of years. Tokai University Press, Hadano

Kuroki M, van Oijen MJP, Tsukamoto K (2014a) Eels and the Japanese: an inseparable, long-standing relationship. In: Tsukamoto K, Kuroki M (eds) Eels and humans. Springer, Tokyo, pp 91–108

Kuroki M, Righton D, Walker AM (2014b) The importance of Anguillids: a cultural and historical perspective introducing papers from the World Fisheries Congress. Ecol Freshw Fish 23:2–6. https://doi.org/10.1111/eff.12089

Matsui I (1972) Mangaku. An eel science. Kouseisha-Kouseikaku, Tokyo; in Japanese

McCarthy KT (2014) Eels and people in Ireland: from mythology to international eel stock conservation. In: Tsukamoto K, Kuroki M (eds) Eels and humans. Springer, Tokyo, pp 13–40

Mochioka N (2019) Fishing gear and fishing methods. In: Tsukamoto K (ed) Science of eels. Asakura Publishing, Tokyo, pp 120–125. (in Japanese)

Morita K, Kuroki M (2021) Japanese eel at the northern edge: glass eel migration into a river on Hokkaido, Japan. Ichthyol Res 68:217–221. https://doi.org/10.1007/s10228-020-00771-5

Nishimoto A, Iida M, Yokouchi K, Fukuda N, Yamamoto T (2023) Eels as natural samplers highlight spatial heterogeneity in energy flow in an estuary. Estuar Coast Shelf Sci 281: 108215. https://doi.org/10.1016/j.ecss.2023.108215

Righton D, Roberts M (2014) Eels and people in the United Kingdom. In: Tsukamoto K, Kuroki M (eds) Eels and humans. Springer, Tokyo, pp 1–12

Righton D, Piper A, Aarestrup K, Amilhat E, Belpaire C, Casselman J, Castonguay M, Diaz E, Doerner H, Faliex B, Feunteun E, Fukuda N, Hanel R, Hanzen C, Jellyman D, Kaifu K, McCarthy K, Miller MJ, Pratt T, Sasal P, Schabetsberger R, Shiraishi H, Simon G, Sjoberg N, Steele K, Tsukamoto K, Walker A, Westerberg H, Yokouchi K, Gollock M (2021) Important questions to progress science and sustainable management of Anguillid eels. Fish Fish 22:762–788. https://doi.org/10.1111/faf.12549

Rindom S, Tomkiewicz J, Munk P, Aarestrup K, Als TD, Pedersen MI, Graver C, Anderberg A (2014) Eels in culture, fisheries and science in Denmark. In: Tsukamoto K, Kuroki M (eds) Eels and humans. Springer, Tokyo, pp 41–60

Shiraishi H, Crook V (2015) Eel market dynamics: *Anguilla* production, trade and consumption in East Asia. TRAFFIC, Tokyo

Tanaka E (2014) Stock assessment of Japanese eels using Japanese abundance indices. Fish Sci 80: 1129–1144. https://doi.org/10.1007/s12562-014-0807-x

Tzeng W-N (2014) Freshwater eels and humans in Taiwan. In: Tsukamoto K, Kuroki M (eds) Eels and Humans. Springer, Tokyo, pp 129–142

Yamamoto T (2019) 4.4. Stock dynamics of the glass eel. In: Tsukamoto K (ed) Unagi no kagaku. Asakura Publishing, Tokyo, pp 132–137; in Japanese

Yokouchi K (2019) 2.6. Growth. In: Tsukamoto K (ed) Unagi no Kagaku. Asakura Publishing, Tokyo, pp 37–41; in Japanese

Yokouchi K, Sudo R, Kaifu K, Aoyama J, Tsukamoto K (2009) Biological characteristics of silver-phase Japanese eels, *Anguilla japonica*, collected from Hamana Lake, Japan. Coast Mar Sci 33: 54–63. https://doi.org/10.15083/00040704

Yokouchi K, Fukuda N, Miller MJ, Aoyama J, Daverat F, Tsukamoto K (2012) Influences of early habitat use on the migratory plasticity and demography of Japanese eels in central Japan. Estuar Coast Shelf Sci 107:132–140. https://doi.org/10.1016/j.ecss.2012.05.009

Yokouchi K, Daverat F, Miller MJ, Fukuda N, Sudo R, Tsukamoto K, Elie P, Poole WR (2018) Growth potential can affect timing of maturity in a long-lived semelparous fish. Biol Lett 14: 20180269. https://doi.org/10.1098/rsbl.2018.0269

Yokouchi K, Itakura H, Wakiya R, Yoshinaga T, Mochioka N, Kimura S, Kaifu K (2022) Cumulative effects of low-height barriers on distributions of catadromous Japanese eels in Japan. Anim Conserv 25:137–149. https://doi.org/10.1111/acv.12725