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Search for *Anguilla* Eels on the West Coast of North America and on the Aleutian and Hawaiian Islands

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In recent years, 19 *Anguilla* eels of several species have been caught in California. They are believed to be eels that had been imported by Japanese or Chinese restaurants, or by fish farms, which had escaped or been set free (Skinner, 1971; McCosker, 1989). The present study aimed to determine if any other *Anguilla* specimens have been caught on the west coast of North America from Alaska to California or on the Aleutian or Hawaiian Islands, and the likelihood of the Japanese eel *A. japonica* crossing the Pacific Ocean from west to east.

Method

We searched the literature and made enquiries of fish experts to discover if *Anguilla* eels have been caught in any of the States of USA and Provinces of Canada that border the Pacific Ocean.

Results and discussion

The following data were obtained from the biologists listed under acknowledgments and from literature records.

On the Aleutian Islands, Alaska mainland, British Columbia, Washington State and Hawaiian Islands, no *Anguilla* eels have ever been recorded, caught, seen or heard of. At the Ocean Weather Station P, 50°N, 145°W, 750 km west of British Columbia, in the long series of plankton samples taken, no *Anguilla* larvae have ever been caught. In Oregon, three *Anguilla* of undetermined species have been caught since 1981, one being still alive in an aquarium (J. L. Galbreath, pers. comm.). In California, 19 *Anguilla* have been caught since 1964 and further *Anguilla* have been seen but not caught (Skinner, 1971; McCosker, 1989).

The above 22 *Anguilla* eels have been identified on the basis of fin length and vertebral number (see Table 1) as:

A. rostrata (an eastern USA species: 13 specimens); *A. australis* (an Australasian species: 3 specimens); *A. japonica* or *A. anguilla* (from Japan or Europe: 2 specimens); unidentified (4 specimens).

The two specimens identified as *A. japonica* or *A. anguilla* both had 114 vertebrae, and are thus centrally within the vertebral number range of both species (*A. anguilla* 111–119, *A. japonica* 112–119; Ege, 1939; Tabeta et al., 1976). However, it was not possible to identify these eels more conclusively.

Since 1874, many consignments of *A. rostrata* have been brought from the eastern USA to California to stock rivers and to provide a basis for attempt to farm eels. Starting in the 1960's many live *Anguilla* from various parts of the world have been imported into California and Oregon by Japanese and Chinese restaurants. Imports of eels from New Zealand were particularly documented (Shebley, 1919; Skinner, 1971; McCosker, 1989). Since *A. japonica* is the eel species best known to Japanese and Chinese people, and is extensively cultured in Japan, Taiwan and mainland China, it is probable that many *A. japonica* have been imported into the USA. It is therefore likely that escaped or liberated *A. japonica* eels may be captured in future. In 1987, the State of California prohibited the further importing of live *Anguilla*. In British Columbia, the importing of live eel is also prohibited.

The known distribution of *A. japonica* is the Asian coast of the North Pacific from northern Luzon, Philippines and southern China to northern China, northern Korea and Hokkaido, Japan (Ege, 1939; Matsui, 1955; Okada, 1959–1960; Tabeta et al., 1975). In the Atlantic Ocean, *A. rostrata* has a similar west-side-of-the-ocean distribution, and is also found in Greenland (Boëtius, 1985).

From the supposed spawning area of *A. japonica*, west of the Mariana Islands (Kajihara, 1988; Tabeta and Mochioka, 1988; Ozawa et al., 1989), sea currents reach the following places (approximate distance from spawning area in parentheses): Taiwan (2,500 km); Tokyo, Japan (4,800 km); Hokkaido, Japan (5,800 km); Oregon, USA (14,000 km); easternmost Aleutian Island (15,000 km); and westernmost Aleutian Island (17,000 km).

In the Atlantic Ocean, from the Sargasso Sea spawning area of Atlantic *Anguilla* (Schmidt, 1925), currents reach the following places (approximate distance from spawning area in parentheses): North Carolina (2,800 km); Newfoundland (4,300 km); Greenland (8,000 km) for *A. rostrata*; Europe (France, 8,000 km) and Egypt (11,000 km) for *A.*

Table 1. *Anguilla* eels captured

Spec. nb.	Species	Vert. nb.	Dorsal fin length	Total length (cm)	State	Area
1–11	*A. rostrata*	108–109	long	13–33	California	San Francisco
12	*A. rostrata*	108	long	52	California	San Francisco
13	*A. rostrata*	108	long	72	California	San Francisco
14	*A. australis*	?	short	70	California	Los Angeles
15, 16	*A. australis*	111, 112	short	50, 68	California	Los Angeles
17	*A. japonica/anguilla*	114	long	74	California	San Francisco
18	*A. japonica/anguilla*	114	long	93	California	San Francisco
19	*A.* ?	?	?	76	California	San Francisco
20	*A.* ?	?	?	20	Oregon	Portland
21	*A.* ?	?	?	64	Oregon	Portland
22	*A.* ?	?	?	62	Oregon	Portland

* CAS=California Academy of Sciences, LACM=Los Angeles County Museum, SIO=Scripps Institute of

anguilla.

Recent studies on the microstructure of the otoliths of *A. japonica* elvers indicate that the duration of larval life in the sea may be four to five months (Tabeta et al., 1987; Umezawa and Tsukamoto, 1990; Tzeng, 1990). If any *A. japonica* larvae ever did survive the long drift across the Pacific Ocean, the current would have distributed the young eels along the North American coast from southern British Columbia to northern California. However, none have been found there.

At first sight the Aleutian Islands appeared to be a possible place where *A. japonica* might occur, as the westernmost island of Attu (173°E), for example, is in direct-distance only 8,000 km from the *A. japonica* spawning area. By current-distance, however, the Aleutian Islands are at a vast 15,000–17,000 km distance from the eel spawning area. The North Pacific Current flows completely across the North Pacific Ocean before it turns back to flow past the Aleutian Islands (Sverdrup et al., 1961). Thus these islands are very unlikely to receive any *A. japonica* eels and indeed none have been found there. This contrasts with the situation in the Atlantic Ocean where Greenland receives a mid-ocean northward branch of the North Atlantic Current and in current-distance is close enough to the *Anguilla* spawning area to receive a few eel larvae (Boëtius, 1985). In the Pacific Ocean, there is no equivalent to Greenland in respect of its location relative to ocean currents.

The current system on the American side of the Pacific Ocean does not have any "Sargasso Sea" area suitable for the spawning of *Anguilla* eels (i.e. where temperatures and salinities are consistently high). When and if escaped *Anguilla* in California and Oregon mature and migrate to sea they will become lost and not reproduce.

We conclude that all *Anguilla* caught on the Pacific coast of North America were introduced by man, that no *A. japonica* are likely to cross the Pacific Ocean and that the natural range of *A. japonica* is the Asian side of the Pacific Ocean only.

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on west coast of North America.

Locality (t.o. = tributary of)	Year	Source	Specimen number*
Stow Lake, Golden Gate Park	1978–79	McCosker 1989	CAS 41042–41045, 62246, 4405
Tracy, Sacramento River delta	1983	McCosker 1989	CAS 53928
Byron, t.o. San Joaquin River	1984	McCosker 1989	CAS 62206
Legg Lake, L.A. County	1985	McCosker 1989	LACM 44140
Puddingstone Reservoir, L.A. County	1983	McCosker 1989	LACM unnumbered, LACM 43527-
Antioch Bridge, San Pablo Bay	1976?	McCosker 1989	CAS 39012
Byron, t.o. San Joaquin River	1969	Skinner 1971	CAS 27136
Honker Cut, San Joaquin River	1964	Skinner 1971	SIO 64-219
Wilamette River	1981	J.L. Galbreath *pers. comm.*	alive in aquarium (1990)
Lake River, t.o. Willamette River	1982	J.L. Galbreath *pers. comm.*	was not preserved
Willamette River	1983	J.L. Galbreath *pers. comm.*	was not preserved

Oceanography.

Literature cited

Boëtius, J. 1985. Greenland eels, *Anguilla rostrata* LeSueur. Dana, 4: 41–48.

Ege, V. H. 1939. A revision of the genus *Anguilla* Shaw, a systematic, phylogenetic and geographical study. Dana-Rep., (16): 1–256, pls. 1–6.

Kajihara, T. 1988. Distribution of *Anguilla japonica* in western Pacific during September 1986. Nippon Suisan Gakkaishi, 54(6): 929–933.

Matsui, I. 1955. On the species and distribution of Japanese eels collected in the Pacific region and its adjacent waters. Bull. Biogeogr. Soc., 16–19: 282–292.

McCosker, J. E. 1989. Freshwater eels (Family Anguillidae) in California: current conditions and future scenarios. Calif. Fish and Game, 75(1): 4–10.

Okada, Y. 1959–1960. Studies on the freshwater fishes of Japan. J. Fac. Fish., Pref. Univ. Mie, 4: 1–860, pls. 1–61.

Ozawa, T., O. Tabeta and N. Mochioka. 1989. Anguillid leptocephali from the western North Pacific east of Luzon, 1988. Nippon Suisan Gakkaishi, 55(4): 627–632.

Schmidt, J. 1925. The breeding places of the eel. Ann. Rep. Smithsonian Inst., (1924): 279–316.

Shebley, W. H. 1919. History of the introduction of food and game fishes into the waters of California. Calif. Fish and Game, 3(1): 4–6.

Skinner, J. E. 1971. *Anguilla* recorded from California. Calif. Fish and Game, 57(1): 76–79.

Sverdrup, H. U., M. W. Johnson and R. H. Fleming. 1961. The oceans, their physics, chemistry and general biology. Modern Asian Editions, Charles E. Company, Tokyo, 1087 pp.

Tabeta, O. and N. Mochioka. 1988. Anguillid leptocephali from the waters south of Okinawa and east of Taiwan and Luzon, western North Pacific, in 1986. Nippon Suisan Gakkaishi, 54(6): 935–940.

Tabeta, O., T. Takai and I. Matsui. 1975. Record of the Japanese eel from the Philippines. Nippon Suisan Gakkaishi, 41(6): 641–644.

Tabeta, O., T. Takai and I. Matsui. 1976. The sectional counts of vertebrae in the anguillid elvers. Japan. J. Ichthyol., 22(4): 195–200.

Tabeta, O., K. Tanaka, J. Yamada and W.-N. Tzeng. 1987. Aspects of the early life history of the Japanese eel *Anguilla japonica* determined from otolith microstructure. Nippon Suisan Gakkaishi, 53(10): 1727–1734.

Tzeng, W.-N. 1990. Relationship between growth rate and age at recruitment of *Anguilla japonica* elvers in a Taiwan estuary as inferred from otolith growth increments. Mar. Biol., (107): 75–81.

Umezawa, A. and K. Tsukamoto. 1990. Age and birth date of the glass eel, *Anguilla japonica*, collected in Taiwan. Nippon Suisan Gakkaishi, 56(8): 1199–1202.

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北米大陸西岸域とハワイにおけるウナギ属魚類の聞取り調査

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北米大陸西岸域とアリューシャン列島，アラスカ，カナダからカリフォルニア及びハワイ諸島の魚類研究者にウナギ属魚類の分布について聞取り調査を行ない，併せて文献を調べた．カリフォルニア州(19 個体)とオレゴン州(3 個体)から，これまでに計 22 個体のウナギ属魚類 *Anguilla* spp. が記録されているが，その他には確認されなかった．これらは全て料理用または飼育用に移入されたもの等に由来すると見られている．ウナギ *Anguilla japonica* は太平洋のアジア側にのみ分布することが再確認された．

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