# Chapter 2-3
## Submerged Macrophytes

**Abstract**
Thirty-five species of submerged macrophyte have been recorded recently in Lake Biwa, the largest lake in Japan (Table 2-3-1). Table 2-3-1 includes two kinds of endemic species, *Vallisneria asiatica* var. *biwaensis* (Fig. 2-3-1) and *Potamogeton biwaensis* (Fig. 2-3-2) and 4 kinds of alien species, *Elodea nuttallii*, *Egeria densa*, *Cabomba caroliniana* and *Myriophyllum aquaticum*. *Potamogeton dentatus* is thought to be extinct now, with no evidence of collection over the last 60 years. Changes in growth conditions have engendered changes in the species composition and the status of submerged macrophytes.
**Keywords:** Species composition, Endemic, Alien, Eutrophication, Regime shift

### 1. Changes in Conditions of Growth

In Lake Biwa, conditions for growth of submerged macrophytes in recent years can be divided into three stages: The period up to the 1960s, the period from the 1960s to 1993 and the period from 1994 onwards. During the first stage, the North Basin was oligotrophic and the South Basin was mesotrophic, and the dominant species of submerged macrophytes was the endemic species, *Vallisneria asiatica* var. *biwaensis*. Submerged macrophytes were used as fertilizer during this stage, and records of such usage date back to books written 200-300 years ago (Edo period). During the second stage, the lake eutrophicated, and the invasive species, *Elodea nuttallii* and *Egeria densa* invaded and proliferated, resulting in the decline of native species. In the South Basin, where marked eutrophication occurred, any underwater plants could hardly be found. During the most recent stage, after serious water shortages (the water level dropped to -1.23 m of the standard level) in the summer of 1994, the native submerged macrophyte bed in the South Basin began to recover and there was an improvement in the transparency of the water and its quality. This so-called "regime shift" of the ecosystem took place mainly around the South Basin.

### 2. Proper Control of Aquatic Weeds

The areas surrounding the South Basin are densely populated, and water weed which washes up on the lakeshore is considered a nuisance by many of the residents. As a result, submerged macrophytes have become excluded from lake management activities.

Since a single mistake at this point could once again worsen water quality, we must carefully consider how best to manage submerged macrophyte beds.

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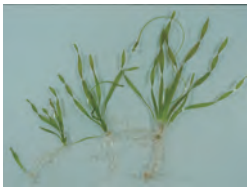

**Fig. 2-3-1** *Vallisneria asiatica* var. *biwaensis*

**Fig. 2-3-2** *Potamogeton biwaensis*

**Table 2-3-1** List of the submerged macrophytes recorded in Lake Biwa

| Year of survey | -1910 | 1935-43 | | 1953 | 1962-65 | 1974 | 1982-83 | | 1986-87 | 1997-98 | 2002 | 2007 | 2006-09 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reference number | 1 | 2 | | 3 | 4 | 5 | 6 | | 7 | 8 | 8 | 8 | 9 | |
| Surveyed site (L: Lake Biwa; N: Naikos (lagoon)) | L | L | N | L | L | L | L | N | L | L | L | L | L | N |
| Species name (Japanese name) | | | | | | | | | | | | | | |
| 1 *Chara* spp. (Shajikumo spp.) | ○ | ○ | | ○ | | | | | | | | | | |
| 2 *C. braunii* (Shajikumo) | | | | | | | | | | ○ | ○ | ○ | | |
| 3 *C. corallina* var. *corallina* (Oushajikumo) | | | | | | | | | | | ○ | ○ | | |
| 4 *Nitella* spp. (Furasukomo spp.) | | ○ | | ○ | | | | | ○ | | | ○ | | |
| 5 *N. flexilis* var. *flexilis* (Himefurasukomo) | | | | | | | | | | | | ○ | | |
| 6 *N. hyalina* (Otomefurasukomo) | | | | | | | | | | ○ | ○ | ○ | | |
| 7 *N. gracillima* var. *robusta* (Onihimafurasukomo) | | | | | | | | | | | ○ | | | |
| 8 *N. mucronata* (Sakibosofurasukomo) | | | | | | | | | | ○ | | | | |
| 9 *N. nigida* var. *nigida* (Onifurasukomo) | | | | | | | | | | | ○ | ○ | | |
| 10 *Potamogeton natans* (Ohirumushiro) | | | | | | | | | | | | | | ○ |
| 11 *P. fryeri* (Futohirumushiro) | | | ○ | | | | | | | | | | | |
| 12 *P. distinctus* (Hirumushiro) | ○ | | ○ | | | | ○ | | | | | | ○ | |
| 13 *P. malainoides* (Ainokohirumushiro) | | ○ | | | | | | | | | | | | |
| 14 *P. nipponicus* (Sasaebimo) | | ○ | ○ | | | ○ | | | | | | | | |
| 15 *P. octandrus* (Hosobamizuhikimo) | | | ○ | | | | | | ○ | ○ | ○ | ○ | | |
| 16 *P. octandrus* var. *miduhikimo* (Mizuhikimo) | | | ○ | | | | | | | | | | | |
| 17 *P. perfoliatus* (Hirohanoebimo) | ○ | ○ | ○ | ○ | ○ | ○ | | | ○ | ○ | ○ | ○ | | |
| 18 *P. dentatus* (Gashamoku) | | | ○ | ○ | | | | | | | | | | |
| 19 *P. malaianus* (Sasabamo) | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | |
| 20 *P. crispus* (Ebimo) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | |
| 21 *P. oxyphyllus* (Yanagimo) | ○ | | ○ | | | | ○ | | | ○ | ○ | ○ | | |
| 22 *P. maackianus* (Senninmo) | | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | | |
| 23 *P. oxyphyllus*× *P. maackianus* (Yanagimo×Senninmo) | | | | | | | | | ○ | | | | | |
| 24 *P. leptocephalus* (Hirohanosenninmo) | | | | | | | | | ○ | ○ | ○ | ○ | | |
| 25 *P. biwaensis* (Sanmenmo) | | ○ | | ○ | ○ | | | | ○ | ○ | ○ | ○ | | |
| 26 *P. panormitanus* (Tsutsuitomo) | | | | | | | | | | | | | ○ | |
| 27 *P. pectinatus* (Ryunohigemo) | | | ○ | | | | | | | | | | | |
| 28 *P. anguillanus* (Oosasaebimo) | | ○ | | | | | ○ | | ○ | ○ | ○ | ○ | | |
| 29 *Najas marina* (Ibaramo) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | | |
| 30 *N. oguraensis* (Ootorigemo) | | | ○ | | | | | | ○ | ○ | ○ | ○ | | |
| 31 *N. minor* (Torigemo) | ○ | ○ | ○ | | ○ | | | | | | | | | |
| 32 *N. foveolata* (Hirohatorigemo) | | | ○ | | | | | | | | | | | |
| 33 *N. graminea* (Hossumo) | | ○ | ○ | ○ | | | | | | | | | | |
| 34 *Blyxa japonica* (Yariagisubuta) | | | | | | ○ | | | | | | | | |
| 35 *B. ceratosperma* (Subuta) | ○ | | | | | | | | | | | | | |
| 36 *Vallisneria denseserrulata* (Kougaimo) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | |
| 37 *V. asiatica* (Sekishoumo) | ○ | | ○ | ○ | | ○ | | | | | | | | |
| 38 *V. asiatica* var. *biwaensis* (Nejiremo) | | ○ | | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | | |
| 39 *Hydrilla verticillata* (Kuromo) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | | |
| 40 *Elodea nuttallii* (Kokanadamo) | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | |
| 41 *Egeria densa* (Ookanadamo) | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | |
| 42 *Ottelia alismoides* (Mizuoobako) | ○ | | | | | | | | | ○ | ○ | | | |
| 43 *Schoenoplectus lineolatus* (Himehotarui) | | | | | | | | | | ○ | ○ | ○ | | |
| 44 *Cabomba caroliniana* (Hagoromomo) | | | | | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | |
| 45 *Ceratophyllum demersum* (Matsumo) | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | |
| 46 *C. demersum* var. *quadrispinum* (Goharimatsumo) | | ○ | ○ | | | | | | | | | | ○ | |
| 47 *Ranunculus nipponicus* var. *submersus* (Baikamo) | ○ | | ○ | | | | | | | | | | | |
| 48 *Elatine triandra* (Mizuhakobe) | | | ○ | | | | | | | | | | | |
| 49 *Myriophyllum verticillatum* (Fusamo) | ○ | ○ | ○ | ○ | | ○ | | | | | | | | |
| 50 *M. spicatum* (Hozakinofusamo) | ○ | ○ | ○ | ○ | ○ | | ○ | | ○ | ○ | ○ | ○ | | |
| 51 *M. oguraense* (Oguranofusamo) | | | ○ | | | | | | | | | | | |
| 52 *M. ussuriense* (Tachimo) | | | ○ | | | | | | | | | | | |
| 53 *M. aquaticum* (Ootusamo) | | ○ | | | | ○ | ○ | ○ | | | | | | |
| Total number of species | 16 | 21 | 29 | 17 | 13 | 17 | 16 | 8 | 20 | 24 | 26 | 26 | 3 | 1 |
| | | 36 | | | | | 35 | | | | | | | |

1) Maeda (1910); 2) Yamaguchi (1943); 3) Ikusima et al. (1962); 4) Ikusima (1966); 5) Nagai (1975); 6) Kunii et al. (1985); 7) Hamabata (1991); 8) Japan Water Agency (2009); 9) Hamabata & Yabuuchi (2012).