On the Fluctuation of the Glass Eel (*Anguilla japonica*) Catch at the Kinokawa River

Toru Takai and kei Takizawa*

1. Preface

The anadromous movement of Japanese eel (*Anguilla japonica*) at the Kinokawa River occurs in early spring. The temporary stock of the glass eel often develops around the flood gate area of the Shin-rokkai-zeki dam which is located at ca. 6.8 km upstream from the river mouth. These glass eels seem to grow into the elver stage there but some of them are captured for the aquaculture seeds from February to April every year. In order to assess the eel abundance around the gate, we managed an investigation on the catch fluctuation from 1986 to 1988. Here we reported some characteristics on the temporal change of the catch and estimated the occasional recruitment size of 1986 year class.

2. Materials and Methods

We monitored not only the temporal chage in the catch of ten licensed catcher but also several ambient factors of the fishing ground such as water temperature, dissolved oxygen, chlorinity, tide level on April 10, 17, 18, 24 and 25, 1986. The catch records of the licensed catcher from February 15 to April 30, 1986 were analyzed to study the characteristics on the fluctuation and to assess the recruitment size after DeLury (1951).[1]

*Shimonoseki Univ. of Fisheries

3. Results

3.1 Diurnal Change in Catch

3.1.1 Fishing Ground

The catches of grass eel are shown in Fig. 1. The difference among these catches seems to be related to the flux which is under the operation of sluices; the catches are almost even when the sluicing through one or two gates is done, whereas the catch is concentrated in the riversides when the sluicing through three gates.

Table 1. Results of the ambient observation. AT, Air temperature (℃); WT, water temperature (℃); DO, dissolved oxygen in water; Cl, chlorinity (mg/l); HL, tide level (cm); THW, time at high water.

Date	Time	AT	WT	DO(mg/l)		Cl(mg/l)		HL	Note
		(℃)	(℃)	upper (S)	lower (B)	S	B	(cm)	THW
4/10 (3/2)	18:00	21.6	13.8	10	9.4	350	340	200	19:18
	20:00		15.2	9.5	9.7	950	1000	192	
	22:00	15.9	15.4	10	7.6	3500	4300	144	
	23:05							118	
4/17-18 (3/9)	19:45	16.8						70	
	20:00		14.8	10	9.2	1200	1300	84	
	21:20	16.1						95	
	22:00		14.8	9.4	9.7	1600	1900	104	
	22:25	15.1						111	
	23:25	14.8						128	
	24:00		15.1	9.2	8.9	3000	3600	135	
	24:15	15.0						144	
									02:36
4/24-25 (3/16)	20:00		16.9	9.4	9.4	1200	2100	205	18:39
	20:25	18.9						174	
	22:00		16.9	9.0	9.3	2000	2100	143	
	22:15	16.0						100	
	23:30	15.5						74	
	24:00	15.2	16.9	9.0	9.3	630	640	72	
	01:35	14.5						79	
	02:00	14.8	16.8	9.1	8.7	170	170	100	
	04:00		17.1	9.1	9.1	1300	1400	137	
	04:40							167	
									06:29

3.1.2 Diurnal Change

The fluctuation of catch per unit effort (CPUE : kg/hour/person) are shown in Fig. 2 and Table 2. The peak in CPUE seems to occur before midnight and during 3 to 4 AM in April 24 and 25 a temporary peak was observed.

3.1.3 Tide Level

The relation between CPUE and tide level is plotted in Fig. 3. The peaks in CPUE

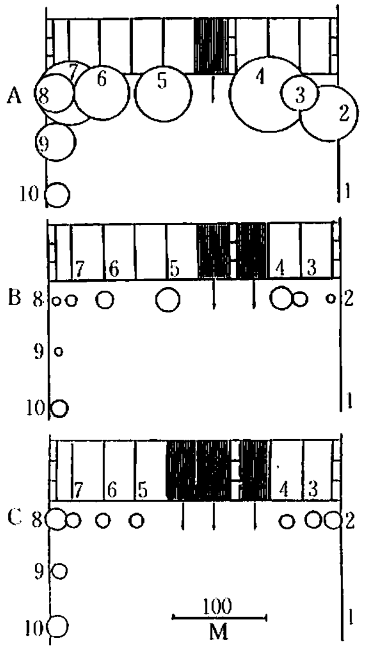

Fig. 1 Catches (H kg) in glass eel of ten fishing grounds. Numbers are for the fishing ground. ← shows the gate in sluicing. Open circle shows catch (kg). Diameters (d mm) of circles are indicated by $d=\sqrt[3]{H/4.19}$. A: April 10, 1986; B: Aprill 17-18, 1986; C: April 24-25, 1986.

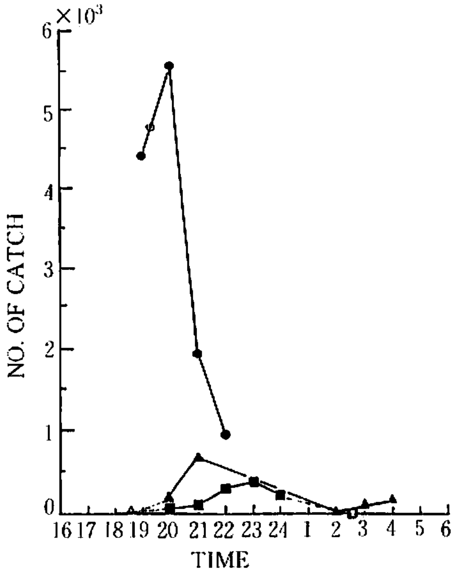

Fig. 2 Diurnal change in eel catch. ●: April 10, 1986; ■: April 17-18, 1986; ▲: April 24-25, 1986; ○, □, △: Time at high tide.

Table 2. Diurnal change in CPUE (No./hour/person) values of glass eel.

Date \ Time	CPUE; catch per unit effort								
	19:00	20:00	21:00	22:00	23:00	24:00	2:00	3:00	4:00
4.10	4400	5554	1937	931					
4.17~18		74	110	300	380	220			
4.24~25		206	677				30	117	160

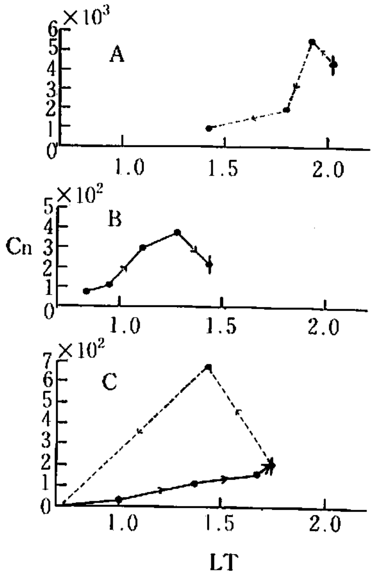

Fig. 3 Relationship between tide level (LT) and catch (Cn).
A: April 10, 1986; B: April 17-18, 1986; C: April 24-25, 1986. ←: flood tide; ←-: ebb tide.

often occurred during the end of flood tide and the onset of ebb tide. This indicates that high water levels conditioned eels to move upward, and hence the increase in catch.

3.2 Daily Fluctuation and Estimation of the Temporary Recruitment Size

3.2.1 Periodicity

Daily fluctuation in catch and its moving average within 15 days are plotted in Figs. 4 and 5, respectively. These indicate three recruitments on February 9, March 10, and April 10, which corresponded to the new moon periods. Namely, the occurrence of recruitment almost synchronized to lunar calendar.

3.2.2 Estimation of the Temporary Recruitment Size

On applying the method of DeLury (1951), three recruitment sizes mentioned above were evaluated[1]. Table 4 shows the first recruitment was $9\sim10\times10^4$ and the second and third were $1.4\sim1.9\times10^5$ and $2.25\sim2.50\times10^6$, respectively. The total amount of the rectuitment in this season, therefore, was estimated at around $3.8\sim5.5\times10^6$.

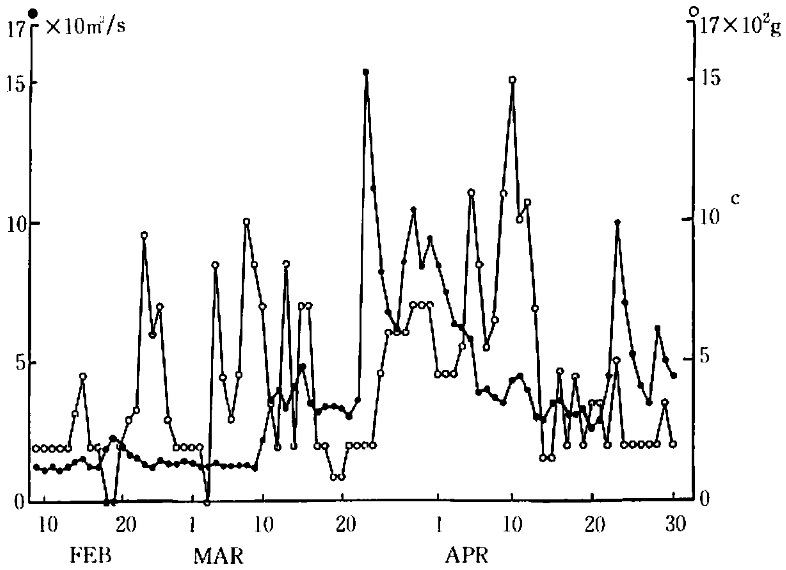

Fig. 4 Fluctuation of catch in glass eel and flux of the Shin-rokkai-zeki dam. ●: catch; ○: flux.

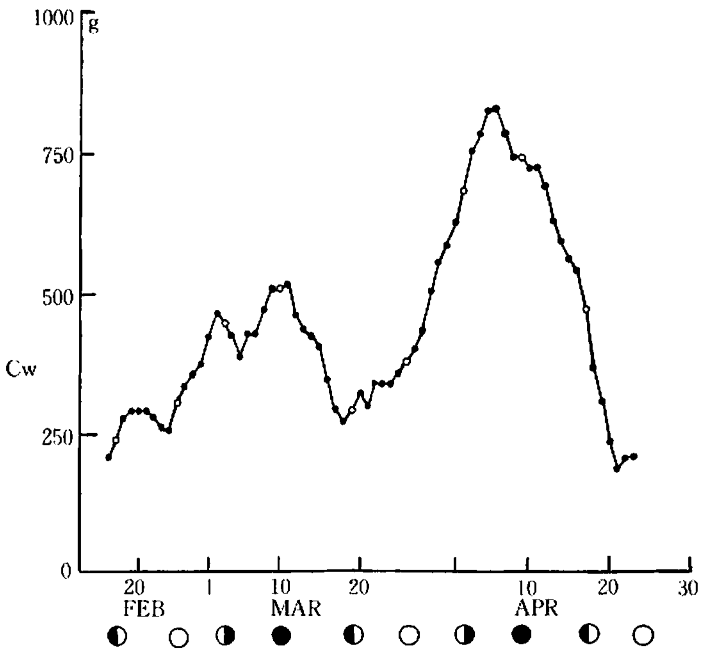

Fig. 5 Moving average within 15 days of catch in glass eel.

Table 3. Daily change in catch, effort, CPUE, log(CPUE), cumulative catch and cumulative effort. H(t) : catch (g) ; P(t) No. of catcher ; C(t) : CPUE (No./hour/person) ; K(t) : cumulative catch ; E(t) : cumulative effort.

Date	H(t)	P(t)	C(t)	ℓogC(t)	K(t)	E(t)	Date	H(t)	P(t)	C(t)	ℓogC(t)	K(t)	E(t)
2/15	4500	10	450	2.6532	0	0	3/27	5990	10	599	2.7774	10490	20
16	1950	10	195	2.2900	4500	10	28	5990	10	599	2.7774	16480	30
17	1950	10	195	2.2900	6450	20	29	6960	10	696	2.8426	22470	40
					8400	30	30	6960	10	696	2.8426	29430	50
23	9510	10	951	2.9782	0	0	31	6960	10	696	2.8426	36390	60
24	5990	10	599	1.7774	9510	10	4/ 1	4500	10	450	2.6532	43350	70
25	6960	10	696	2.8426	15500	20	2	4500	10	450	2.6532	47850	80
26	2920	10	292	2.4654	22460	30	3	4500	10	450	2.6532	52350	90
27	1950	10	195	2.2900	25380	40	4	5470	10	547	2.7380	56850	100
28	1950	10	195	2.2900	27330	50	5	11000	10	1100	3.0414	62320	110
3/ 1	1950	10	195	2.2900	29280	60	6	8450	10	845	2.9269	3320	120
2	1950	10	195	2.2900	31230	70	7	5470	10	547	2.7380	81770	130
3							8	6440	10	644	2.8089	87240	140
4	8450	10	845	2.9269	33180	80	9	11000	10	1100	3.0414	93680	150
5	4410	10	441	2.6444	41630	90	10	15040	10	1504	3.1772	104680	160
6	2920	10	292	2.4645	46040	100	11	10030	10	1003	3.0013	119720	170
7	4500	10	450	2.6532	48960	110	12	10640	10	1064	3.0269	129750	180
8	10030	10	1003	3.0013	53460	120	13	6870	10	687	2.8370	140390	190
9	8450	10	845	2.9269	63490	130	14	1500	10	150	2.1761	147260	200
10	6960	10	696	2.8426	71940	140	15	1540	10	154	2,1875	148760	210
11	3440	10	344	2.5366	78900	150	16	4600	10	460	2.6628	150300	220
12	1950	10	195	2.2900	82340	160	17	1950	10	195	2.2900	154900	230
13	3450	10	845	2.9269	84290	170	18	4400	10	440	2.6435	156850	240
14	1950	10	195	2.2900	92740	180	19	1950	10	195	2.2900	161250	250
15	6960	10	696	2.8426	94690	190	20	3440	10	344	2.5366	163200	260
16	6960	10	696	2.8426	101650	200	21	3440	10	344	2.5366	166640	270
17	1950	10	195	2.2900	108610	210	22	1950	10	195	2.2900	170080	280
18	1950	10	195	2.2900	110560	220	23	4930	10	493	2.6928	172030	290
19	870	10	87	1.9395	112510	230	24	1950	10	195	2.2900	176960	300
20	870	10	87	1.9395	113380	240	25	1950	10	195	2.2900	178910	310
21	1950	10	195	2.2900	114250	250	26	1950	10	195	2.2900	180860	320
22	1950	10	195	2.2900	116200	260	27	1950	10	195	2.2900	182810	330
23	1950	10	195	2.2900	118150	270	28	1950	10	195	2.2900	184760	340
24	1950	10	195	2.2900	120100	280	29	3440	10	344	2.5366	186710	350
					122050	290	30	1950	10	195	2.2900	190150	360
25	4500	10	450	2.6532	0	0						192100	370
26	5990	10	599	2.7774	4500	10							

Table 4. Results and the estimating processes of the recruitment size (No). No estimated on the assumption that an individual is weighted as 0.1g. Refer to Table 3 for C(t), K(t) and E(t). k; slope in Fig. 6.

February 8-17, 1986	
$C(t)=435.2313-0.04255K(t)$	$\ell ogC(t)=2.5927-0.0182E(t)$
$C(t)=\kappa No-\kappa K(t)$	$\ell ogC(t)=\ell og\kappa No-0.4343\kappa E(t)$
$\kappa=0.0425$	$\kappa=0.0182\div0.4343$
$\therefore No=435.23130\div0.425$	$=0.0419$
$=10240.7365(g)$	$\ell og\kappa No=2.5927$
	$\therefore \kappa No=10^{2.0027}$
	$\therefore No=9342.9920(g)$
No. ; 93,430～102,407	
February 23-March 24, 1986	
$C(t)=614.1419-0.0028K(t)$	$\ell ogC(t)=2.7418-0.0016E(t)$
$C(t)=\kappa No-\kappa K(t)$	$\ell ogC(t)=\ell og\kappa No-0.4343\kappa E(t)$
$\kappa=0.0028$	$\kappa=0.0016\div0.4343$
$\therefore No=614.14190\div0.0028$	$=0.0037$
$=219336.3929(g)$	$\ell og\kappa No=2.7418$
	$\therefore \kappa No=10^{2.7418}$
	$\therefore No=149141.4207(g)$
No. ; 1,491,414～2,193,364	
March 25-April 30, 1986	
$C(t)=782.0263-0.0024K(t)$	$\ell ogC(t)=2.9210-0.0016E(t)$
$C(t)=\kappa No-\kappa K(t)$	$\ell ogC(t)=\ell og\kappa No-0.4343\kappa E(t)$
$\kappa=0.0024$	$\kappa=0.0016\div0.4343$
$\therefore No=782.02630\div0.0024$	$=0.0037$
$=325844.2917(g)$	$\ell og\kappa No=2.9210$
	$\therefore \kappa No=10^{2.0210}$
	$\therefore No=225319.2391(g)$
No. ; 2,253,192～3,258,443	
Total No. 3,838,036～5,554,214	

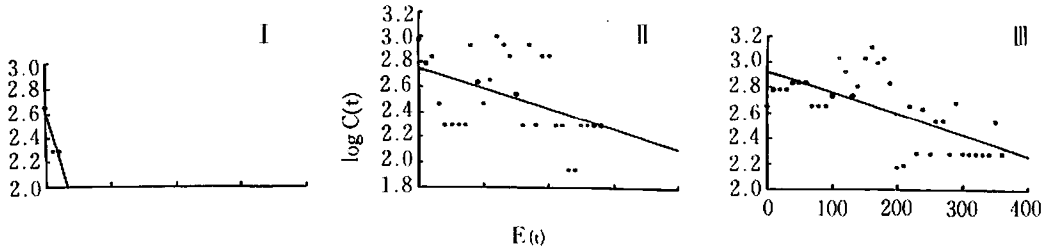

Fig. 6 Relationship between cumulative effort E (t) and catch C (t). I : April 10, 1986; II : April 17-18, 1986; III : April 24-25, 1986.

4. Discussion

There are some reports that indicate tidal change induces the anadromous movement of eel[2-4]. Inaba and Yamamoto (1938) showed the anadromous movement of eel in the Hamanako Lake frequently occurred at high waters except the neap tides[2]. This is supported by Matsui (1972) who showed the anadromous movement of this species rarely occurs at the neap tides and the catch is large at high water in the spring tides, especially within the time zone of 1 or 1.5 hours after sunset[3]. Higashi and Sakurai (1975) showed the peak in catch at the spring tides occurred both within the time zones of three hours after sunset and those of four hours before sunrise at Hikijigawa River[4]. Also, they indicated the relationship between the catch fluctuation and the tidal calendar; the peak in daily catch of eel occurred correspondingly to the new moon period, having the bottom at young moon. Our research shows the accordance with them in the point that the anadromous movement of glass eel is conditioned by tide.

References

1) DeLury: *J. Fish. Res. Bd. Can.*, 8, 281-307. (1951)

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3) Matsui: Science of Eel; Cultivatable Technic. Koseisha-Koseikaku, Tokyo. pp. 318-333. (1972)

4) Higashi and Sakurai: *Bull. Lab. Fishery Resources, Coll. Agr. & Vet. Med., Nihon Univ.* 32. 257-261. (1975)