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Author(s)	Araga, Chuichi; Tanase, Hidetomo
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FURTHER RECORD OF WINTER FISH STRANDING IN THE VICINITY OF SETO[1]

Chûichi ARAGA and Hidetomo TANASE

The Aquarium, Seto Marine Biological Laboratory

With 1 Text-Figure and 3 Tables

In January this year, this region was attacked by sudden drop of the atmospheric temperature continuously for about six days. Early morning of January 19, the junior author was awaked by Mr. Y. Makino, the head clerk of the laboratory, who found innumerable fishes stranded on the beach near the laboratory on the way of his daily walk. Immediately he went down to the beach with one of the aquarium members to examine those fishes, found that most of them were coral fishes, and began to collect them for further studies. The senior author made a dive in the shallow water around the laboratory in that afternoon and observed that such tropical fishes as *Apogon cyanosoma* Bleeker, *Abudefduf vaigiensis* (Quoy & Gaimard) and *Acanthurus bariene* Lesson were just losing the balance and dying.

The collecting of stranded fishes, in morning or sometimes at night, was continued by us together with some aquarium staff members till February 9. The collected fishes were cleaned, measured and sorted carefully every time. Most of collected specimens were nearly perfect in their appearance except for several specimens which were seemingly damaged by kites.

In this paper, the list of stranded fishes is given and some comparison with other cases of fish stranding by the cold is made. We are very grateful to Messrs. Y. Makino, S. Sakai, Y. Kashiyama and S. Moriyama of the laboratory and the laboratory aquarium who kindly helped us collect and measure fishes. We wish to express our hearty thanks to Mr. K. Nishi of the Disaster Prevention Research Institute of Kyoto University for his kind informations about the meteorological and hydrological conditions in the vicinity and also to Prof. H. Utinomi and Dr. T. Tokioka of the laboratory for their kindness in reading the manuscript.

Results of examination

Names, sizes and numbers of stranded fishes are shown in Table 1. In all, 3902 specimens belonging to 166 species were included in the collection. Of these, 116

1) Contributions from the Seto Marine Biological Laborotory, No. 493.

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Table 1. List of stranded fishes

No.	species	total length (mm)			number				%
		max.	min.	mean	1st week	2nd week	3rd week	total	
	Clupeida								
	Dussumieridae								
1	*Spratelloides japonicus* (HOUTTUYN) キビナゴ	—	—	35	1	—	—	1	
2	*Plecoglossus altivelis* TEMMINCK & SCHLEGEL アユ	32	62	51	8	1	—	9	
	Cyprinida								
	Plotosidae								
3	*Plotosus anguillaris* (LACÉPÈDE) ゴンズイ	57	216	124	10	4	3	17	0.4
	Anguillida								
	Ophichthidae								
4	*Leiuranus semicinctus* (LAY & BENNETT) ソラウミヘビ*	370	395	—	2	—	—	2	
5	*Pisoödonophis cancrivorous* (RICHARDSON) ミナミホタテウミヘビ	242	625	—	—	2	—	2	
6	*Myrichthys aki* TANAKA ゴイシウミヘビ	—	—	642	—	1	—	1	
	Dysommidae								
7	*Dysomma anguillare* BARNARD メクラアナゴ	—	—	326	1	—	—	1	
8	Leptocephallus of Apodes	64	92	76	3	—	—	3	
	Syngnathida								
	Aulostomidae								
9	*Aulostomus chinensis* (LINNÉ) ヘラヤガラ*	622	628	—	—	—	2	2	
	Fistulariidae								
10	*Fistularia villosa* KLUNZINGER アオヤガラ*	206	672	473	126	—	—	126	3.2
11	*Fistularia petimba* LACÉPÈDE アカヤガラ	310	567	455	2	2	—	4	
	Berycida								
	Holocentridae								
12	*Holotrachys lima* (VALENCIENNES) セトエビス*	—	—	98	—	1	—	1	
13	*Myripristis murdjan* (FORSKÅL) アカマツカサ*	58	110	78	16	1	—	17	0.4
14	*Flammeo sammara* (FORSKÅL) ウケグチイットウダイ*	—	—	60	1	—	—	1	
15	*Holocentrus spinosissimus* T. & S. イットウダイ	—	—	210	—	1	—	1	
16	*Holocentrus ruber* (FORSKÅL) アヤメエビス*	63	84	66	10	—	—	10	0.3
17	*Holocentrus ittodai* JORDAN & FOWLER テリエビス*	—	—	103	1	—	—	1	
	Gadida								
	Bregmacerotidae								
18	*Bregmaceros japonicus* TANAKA サイウオ	33	54	51	8	—	—	8	
	Percida								
	Mugilina								
	Atherinidae								
19	*Allanetta bleekeri* (GÜNTHER) トウゴロウイワシ	80	116	86	33	3	—	36	1.7
	Mugilidae								
20	*Mugil cephalus* LINNÉ ボラ	34	88	48	6	1	—	7	

	Sphyraenidae								
21	*Sphyraena pinguis* Günther アカカマス	134	300	213	24	—	—	24	0.6
	Carangina								
	Carangidae								
22	*Trachurus japonicus* (T. & S.) マアジ	—	—	202	1	—	—	1	
23	*Alectis cilialis* (Bloch) イトヒキアジ	—	—	250	1	—	—	1	
24	*Tranchinotus baillonii* (Lacépède) コバンアジ	67	200	115	4	—	—	4	
	Leiognathidae								
25	*Leiognathus rivulatus* (T. & S.) オキヒイラギ	42	88	53	1	2	—	3	
	Percina								
	Pempheridae								
26	*Pempheris xanthopterus* Tominaga ミナミハタンポ*	54	137	78	15	—	—	15	0.4
	Oplegnathidae								
27	*Oplegnathus fasciatus* (T. & S.) イシダイ	—	—	302	1	—	—	1	
	Mullidae								
28	*Pseudupeneus spilurus* (Bleeker) オキナヒメジ*	149	230	188	7	—	—	7	
	Apogonidae								
29	*Apogon niger* Döderlein クロイシモチ	52	66	—	2	—	—	2	
30	*Apogon marginatus* Döderlein ツマグロイシモチ	48	110	85	2	1	—	3	
31	*Apogon taeniatus* Cuvier ヨコスジイシモチ*	32	150	67	89	13	—	102	2.6
32	*Apogon cyanosoma* Bleeker キンセンイシモチ*	32	78	58	1052	24	—	1049	26.7
33	*Apogon endekataenia* Bleeker コスジイシモチ	90	112	—	2	—	—	2	
34	*Apogon novemfasciatus* Cuvier タスジイシモチ*	68	77	72	9	—	—	9	
35	*Apogon doederleini* Jordan & Snyder オオスジイシモチ*	50	115	87	10	—	1	11	0.3
36	*Apogon kiensis* J. & S. テッポウイシモチ	49	68	56	18	—	—	18	0.5
37	*Apogon semilineatus* T. & S. ネンブツダイ	52	114	77	3	—	—	3	
38	*Apogon notatus* (Houttuyn) クロホシイシモチ*	34	104	83	54	11	1	66	1.7
39	*Apogon erythrinus kominatoensis* Ebina コミナトテンジクダイ	32	64	41	25	—	1	26	0.7
40	*Apogon* sp.*	30	48	39	3	—	—	3	
41	*Apogon* sp.*	35	46	38	15	—	—	15	0.4
42	*Cheilodipterus macrodon* (Lacépède) リュウキュウヤライイシモチ*	—	—	105	1	—	—	1	
	Priacanthidae								
43	*Priacanthus macracanthus* Cuvier キントキダイ	165	180	—	2	—	—	2	
44	*Priacanthus hamrur* (Forskål) ホウセキキントキ*	170	230	201	4	—	—	4	
45	*Priacanthus cruentatus* (Lacépède)*	159	204	167	8	—	—	8	
	Serranidae								
46	*Cephalopholis miniatus* (Forskål) ユカタハタ*	34	140	78	13	3	—	16	0.4
47	*Cephalopholis* sp.*	61	68	—	2	—	—	2	
48	*Epinephelus merra* Bloch カンモンハタ*	10	165	—	1	1	—	2	
49	*Grammistes sexlineatus sexlineatus* (Thunberg) ヌノサラシ*	22	134	—	28	9	3	40	1.0
50	Grammistinae sp.	—	—	37	1	—	—	1	
51	*Sacura margaritacea* (Hilgendorf) サクラダイ	—	—	62	—	1	—	1	

Table 1. (Continued)

No.	species	total length (mm)			number				%
		max.	min.	mean	1st week	2nd week	3rd week	total	
	Gerridae								
52	*Gerres oyena* (Forskål) クロサギ	56	244	—	—	2	—	2	
	Girellidae								
53	*Girella melanichthys* (Richardson) クロメジナ	32	—	—	1	—	—	1	
	Pseudogrammidae								
54	*Pseudogramma polyacantha* (Bleeker) トゲメギス*	26	32	27	5	—	—	5	
	Lethrinidae								
55	*Lethrinus nematacanthus* Bleeker イトフエフキ*	—	—	170	1	—	—	1	
56	*Lethrinus haematopterus* T. & S. フエフキダイ*	130	176	—	2	—	—	2	
57	*Lethrinus choerorhynchus* (Schneider) ハマフエフキ*	—	—	90	1	—	—	1	
58	*Lethrinus variegatus* (C. & V.) シマクチビ*	95	110	102	3	—	—	3	
	Lutjanidae								
59	*Lutjanus kasmira* (Forskål) ヨスジフエダイ*	56	212	87	33	—	—	33	0.8
60	*Aprion virescens* C. & V. アオチビキ*	284	296	—	2	—	—	2	
	Caesionidae								
61	*Caesio chrysozonus* C. & V. タカサゴ*	—	—	106	1	—	—	1	
	Pomadasyidae								
62	*Plectorhynchus diagrammus* (Linné) ムスジコショウダイ*	109	114	—	2	—	—	2	
63	*Scolopsis* sp.	53	89	69	7	—	—	7	
64	*Leptoscolopsis nagasakiensis* Tanaka イトタマガシラ	80	100	86	5	2	—	7	
	Cirrhitidae								
65	*Isobuna japonica* (Steindachner & Döderlein) イソブナ	—	—	38	1	—	—	1	
	Champsodontidae								
66	*Champsodon snyderi* Franz ワニギス	29	36	—	2	—	—	2	
	Blenniina								
	Blenniidae								
67	*Aspidontus taeniatus* Quoy & Gaimard*	83	100	90	3	—	—	3	
68	*Aspidontus tapeinosoma* (Bleeker) テンクロスジギンポ*	—	—	71	1	—	—	1	
69	*Meiacanthus kamoharai* Tomiyama カモハラギンポ*	57	62	—	2	—	—	2	
	Gobiina								
	Eleotridae								
70	*Amblyeleotris japonicus* Takagi ダテハゼ	—	—	102	1	—	—	1	
71	*Parioglossus dotui* Tomiyama サツキハゼ	—	—	59	1	—	—	1	
72	*Vireosa hanae* J. & S. ハナハゼ*	33	111	67	59	5	2	66	1.7
73	*Zonogobius boreus* Snyder ミサキイレズミハゼ	30	33	32	4	—	—	4	
74	Eleotridae sp.	—	—	29	1	—	—	1	
75	Eleotridae sp.	39	65	53	3	—	—	3	

	Pomacentrina								
	Pomacentridae								
76	*Amphiprion xanthurus* C. & V. クマノミ*	44	126	85	33	1	2	36	0.9
77	*Amphiprion chrysogaster* C. & V. モンツキクマノミ*	—	—	35	1	—	—	1	
78	*Chromis isharai* (Schmidt) アマミスズメダイ*	80	96	87	9	—	—	9	
79	*Chromis notatus* (T. & S.) スズメダイ	60	90	73	25	—	—	25	0.6
80	*Chromis weberi* Fowler & Bean*	65	95	81	33	—	—	33	0.8
81	*Chromis xanthochir* (Bleeker) コガネスズメダイ*	—	—	58	—	1	—	1	
82	*Chromis* sp.*	74	83	78	—	3	—	3	
83	*Tetradrachmum aruanum* (Lenné) ミスジリュウキュウスズメ*	—	—	30	1	—	—	1	
84	*Tetradrachmum trimaculatum* (Rüppell) ミツボシクロスズメ*	34	94	51	89	—	—	89	2.3
85	*Parapomacentrus nigricans* (Lacépède) クロソラスズメ*	32	110	77	29	3	2	34	0.9
86	*Parapomacentrus marginatus* (Jenkins) セダカスズメダイ*	116	120	118	4	—	—	4	
87	*Pomacentrus coelestis* Jordan & Starks ソラスズメダイ*	34	86	52	53	—	1	54	1.4
88	*Pomacenturs dorsalis* Gill セホシスズメダイ*	—	—	35	—	—	1	1	
89	*Abudefduf notatus* (Day) イソスズメダイ*	—	—	80	1	—	—	1	
90	*Abudefduf vaigiensis* (Quoy & Gaimard) オヤビッチャ*	60	130	86	87	—	—	87	2.2
91	*Abadefduf sexfasciatus* (Lacépdèd) ロクセンスズメダイ*	111	115	—	2	—	—	2	
	Labrina								
	Labridae								
92	*Cheilio inermis* (Forskål) カマスベラ*	—	—	392	1	—	—	1	
93	*Labroides dimidiatus* (C. & V.) ホンソメワケベラ*	—	—	66	1	—	—	1	
94	*Stethojulis kalosoma* (Bleeker) カミナリベラ*	90	95	93	3	—	—	3	
95	*Cheilinus bimaculatus* (C. & V.) タコベラ*	44	111	76	16	3	—	19	0.5
96	*Iniistius pavo* (C. & V.) ホシテンス*	—	—	122	1	—	—	1	
97	Labridae sp.*	—	—	32	1	—	—	1	
	Scaridae								
98	*Scarus ghobban* Forskål ヒブダイ*	104	256	170	4	—	—	4	
99	*Scarus* sp.*	53	80	—	2	—	—	2	
100	*Scarus* sp.*	72	80	75	3	—	—	3	
	Chaetodontina								
	Chaetodontidae								
101	*Pomacanthus imperator* (Bloch) タテジマキンチャクダイ*	32	129	54	37	—	—	37	0.9
102	*Pomacanthus semicirculatus* (C. & V.) サザナミヤッコ*	40	76	59	42	—	—	42	1.1
103	*Holacanthus trimaculatus* Lacépède シテンヤッコ*	52	97	73	—	3	—	3	
104	*Centropyge tibicen* (C. & V.) アブラヤッコ*	50	80	62	10	1	—	11	0.3
105	*Centropyge croliki* (Bleeker) ナメラヤッコ*	54	58	—	2	—	—	2	
106	*Centropyge flavicauda* Fraser-Beunner*	48	62	56	4	—	—	4	
107	*Forcipiger longirostris* (Broussonet) フエヤッコダイ*	104	116	111	5	—	—	5	
108	*Chaetodon plebeius* C. & V. スミツキトノサマダイ*	51	54	—	2	—	—	2	
109	*Chaetodon auriga* Forskål トゲチョウチョウウオ*	48	94	65	95	—	—	95	2.4
110	*Chaetodon vagabundus* Linné フウライチョウチョウウオ*	64	76	68	7	—	—	7	
111	*Chaetodon collaris* Bloch チョウチョウウオ*	59	115	81	2	1	—	3	
112	*Chaetodon lienolatus* C. & V. ニセフウライチョウチョウウオ*	—	—	263	1	—	—	1	

Table 1. (Continued)

No.	species	total length (mm)			number				%
		max.	min.	mean	1st week	2nd week	3rd week	total	
113	*Chaetodon citrinellus* C. & V. ゴマチョウチョウウオ*	72	102	78	7	—	—	7	
114	*Chaetodon kleini* BLOCH ミゾレチョウチョウウオ*	64	80	73	29	—	—	29	0.7
115	*Chaetodon trifasciatus* MONG PARK ミスジチョウチョウウオ*	—	—	43	1	—	—	1	
116	*Chaetodon speculum* C. & V. トノサマダイ*	—	—	54	1	—	—	1	
117	*Heniochus acuminatus* (LINNÉ) ハタタテダイ*	49	112	85	31	—	—	31	0.8
118	*Heniochus monoceros* C. & V. オニハタタテダイ*	72	85	—	2	—	—	2	
119	*Zanclus cornutus* (LINNÉ) ツノダシ*	110	185	122	14	—	—	14	0.4
	Acanthuridae								
120	*Acanthurus olivaceus* BLOCH & SCHNEIDER モンツキハギ*	—	—	129	1	—	—	1	
121	*Acanthurus bariene* LESSON カンランハギ*	56	182	124	276	—	—	276	7.0
122	*Acanthurus lineolatus* C. & V. ナガニザ*	84	132	108	11	—	—	11	0.3
123	*Ctenochaetus strigosus* (BENNETT) サザナミハギ*	88	124	100	3	—	—	3	
124	*Callicanthus hexacanthus* (BLEEKER) テングハギモドキ*	96	148	127	15	—	—	15	0.5
125	*Naso unicornis* (FORSKÅL) テングハギ*	118	476	168	21	—	—	21	0.5
126	*Brionurus microlepidotus* LACÉPÈDE ニザダイ	—	—	393	—	—	1	1	
	Siganina								
	Siganidae								
127	*Siganus fuscescens* (HOUTTUYN) アイゴ*	66	374	142	40	76	4	120	3.1
	Tetraodontida								
	Balistidae								
128	*Balistes vidua* SOLANDER クロモンガラ*	128	145	139	6	—	—	6	
129	*Balistes capistratus* SHAW メガネハギ*	64	96	76	20	—	—	20	0.5
130	*Balistes chrysopterus* BLOCH & SCHNEIDER ツマジロモンガラ*	40	154	82	251	3	—	254	6.5
131	*Balistes bursa* LACÉPÈDE ムスメハギ*	60	100	82	11	—	—	11	0.3
132	*Abalistes stellatus* (LACÉPÈDE) オキハギ*	—	—	152	—	1	—	1	
	Aluteridae								
133	*Prevagor melanocephalus* (BLEEKER) ニシキカワハギ*	—	—	78	1	—	—	1	
134	*Stephanolepis cirrhifer* (T. & S.) カワハギ	60	73	—	—	2	—	2	
135	*Rudarius ercodes* JORDAN & FOWLER アミメハギ	—	—	42	1	—	—	1	
136	*Amanses pardalis* (RÜPPELL) アミメウマヅラ *	120	170	154	12	—	—	12	0.3
137	*Aluteres monoceros* (LINNÉ) ウスバハギ*	480	585	529	9	—	—	9	
	Ostraciontidae								
138	*Ostracion tuberculatus* LINNÉ ハコフグ*	25	230	56	27	1	—	28	0.7
139	*Lactoria cornutus* (LINNÉ) コンゴウフグ*	45	97	67	4	—	—	4	
140	*Lactoria diaphanus* (BLOCH & SCHNEIDER) ウミスズメ*	128	256	181	11	10	15	36	0.9
141	*Lactoria fornasini* (BIANCONI) シマウミスズメ*	36	108	77	3	2	6	11	0.3

	Tetraodontidae								
142	*Canthigaster valentini* (Bleeker) シマキンチャクフグ*	36	122	95	101	21	5	127	3.2
143	*Canthigaster cinctus* Richarsdon*	—	—	49	1	—	—	1	
144	*Canthigaster rivulatus* (T. & S.) キタマクラ*	80	162	117	21	5	2	28	0.7
145	*Lagocephalus sceleratus* (Gmelin) センニンフグ*	—	—	130	1	—	—	1	
146	*Fugu niphobles* (T. & S.) クサフグ	78	116	102	2	1	—	3	
147	*Fugu poecilonotus* (T. & S.) コモンフグ	—	—	160	1	—	—	1	
148	*Fugu pardalis* (T. & S.) ヒガンフグ	—	—	168	—	1	—	1	
149	*Arothron hispidus* (Linné) サザナミフグ*	74	210	111	23	—	—	23	0.6
	Diodontidae								
150	*Diodon holacanthus* Linné ハリセンボン*	111	130	120	—	8	—	8	
151	*Chilomycterus affinis* Günther イシガキフグ*	310	362	334	3	—	—	3	
	Cottida								
	Scorpaenidae								
152	*Scorpaenodes littoralis* (Tanaka) イソカサゴ	—	—	90	—	1	—	1	
153	*Pterois volitans* (Linné) ハナミノカサゴ*	48	222	91	2	19	—	21	0.5
154	*Pterois radiata* C. & V. キミオコゼ*	33	129	79	23	—	—	23	0.6
155	*Brachirus zebra* (Quoy & Gaimard) キリンミノ*	40	200	87	211	2	4	217	5.5
156	*Brachirus* sp.*	42	57	—	2	—	—	2	
157	Scorpaenidae sp.	—	—	32	1	—	—	1	
158	Scorpaenidae sp.	42	57	—	2	—	—	2	
	Cephalacanthidae								
159	*Dactyloptena orientalis* (C. & V.) セミホウボウ*	76	330	182	7	2	—	9	
	Pleuronectida								
	Bothidae								
160	*Bothus* sp.	—	—	40	1	—	—	1	
	Lophiida								
	Antennariidae								
161	*Phyrnelox nox* (Jordan) クロイザリウオ*	—	—	70	—	1	—	1	
162	*Phyrnelox tridens* (T. & S.) イザリウオ*	41	97	68	2	3	—	5	
163	*Antennarius nummifer* (Cuvier) ベニイザリウオ*	42	89	61	5	3	1	9	
164	*Antennarius* sp.	43	77	59	6	—	—	6	
165	*Antennarius* sp.	—	—	77	1	—	—	1	
166	*Lophiocharon horridus* (Bleeker) オオモンイザリウオ*	150	310	208	4	2	—	6	
	Grand total				3574	269	59	3902	

* : coral or tropical species

species with asterisk, 69.9% in number of species and 93.4% in number of individuals, are so-called coral fishes or tropical fishes. *Spratelloides japonicus* (HOUTTUYN), *Plecoglossus altivelis* TEMMINCH & SCHLEGEL and *Girella melanichthys* (RICHARDSON) listed in this table, all represented by young specimens, are found very abundantly and commonly in the shallow water of this vicinity in that season, and the minimum water temperature in that season, 10.1°C, seems a little above the critical low water temperature for these three species. Therefore, they were probably killed not by the cold but by another factor such as an attack of some predatory fishes.

Chromis weberi FOWLER & BEAN, *Centropyge flavicauda* FRASER-BRUNNER, *Canthigaster cinctus* RICHARDSON and most of 18 unidentified species seem to be new to the Japanese ichthyofauna; their descriptions will be given in another paper. Fifteen species (Nos. 14. 42, 54, 48, 62, 69, 70, 78, 83, 98, 103, 124, 130, 133 and 165 in Table 1) are newly recorded from the coast of Wakayama Prefecture including this vicinity.

Hydrological conditions of the period

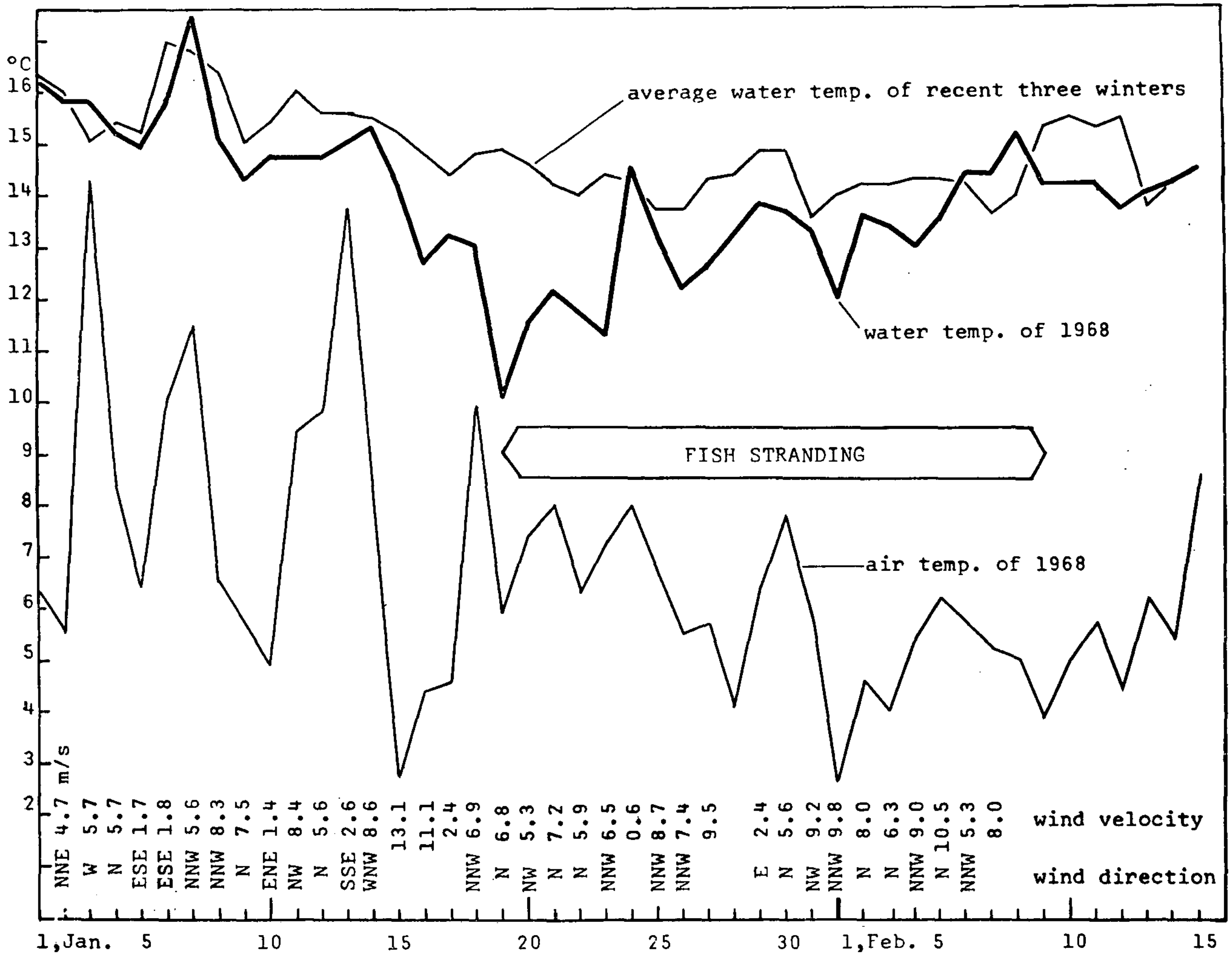
Daily changes of the air temperature, sea water temperature and the wind direction and velocity from January 1 to Feburary 15, recorded at 9:00 every morning near the laboratory, are shown in Text-figure 1. Of these, the air temperature, wind direction and wind velocity were recorded at the Shirahama Oceanographic Tower Station of Kyoto University in Tanabe Bay; Some vacancies in the wind data were caused by the trouble of the automatic recorder.

As seen clearly by comparing the water temperature curve of last winter with that averaging three foregoing winters, the most noticeable in the figure is that the water temperature went down sharply from 15.3°C (Jan. 14) to 10.1°C (Jan. 19) prior to fish stranding. The mass mortality of tropical fishes must be caused by this sudden drop of water temperature. After January 20, the water temperature went up gradually. At present, it is uncertain how the local air temperature in the early weeks of January showing prominent fluctuations was correlated with the above-mentioned drop of the water temperature.

The winds during the period were mostly northerly and with a considerable velocity. On the other hand, the beach where the fishes were stranded faces the north. As the fishes affected or killed by the cold usually go up to the surface (DOUDOROFF 1945, TAMURA 1944), killing by the cold and accumulation by the wind must be the main mechanism of the fish stranding on that beach. The effect of the tidal phase seems to be rather insignificant about this phenomenon.

Considerations

Many cases of mass mortality of fish by the cold have been reported in this and other countries. Among those in these years, two cases on the Pacific coast of middle Japan (KIMURA 1948, AMEMIYA et al. 1957) and some cases on the Texas coast of the



Text-fig. 1. Daily changes of the air temperature, sea water temperature, and the wind direction and velocity from January 1 to Feburary 15.

United States (GUNTER 1941, GUNTER & HILDEBRAND 1951) are to be noted. These cases are common in that most of the stranded fishes were the species adapted to the temperate region and they were killed by unusual long-term cold. In the case reported here, most of stranded fishes were coral or tropical fishes.

As seen in Table 2, high percentage of coral fish specimens to total number of specimens was maintained similarly for three weeks of observation.

To see the successive changes of the composition of stranded fishes during the

Table 2. Percentage of coral fishes to total number of specimens.

	1st week	2nd week	3rd week	total
number of coral fish specimens	3349	242	54	3645
number of total specimens	3574	264	59	3902
percentage of coral fish	93.8	90.0	91.5	93.4

Table 3. Dominant species and their numbers, with percentages to the total number of specimens for each week.

species	1st week	2nd week	3rd week
Plotosus anguillaris (LACÉPÈDE)		4 (1.5)	3 (5.1)
Fistularia villosa KLUNZINGER	126 (3.5)		
Allanetta bleekeri (GÜNTHER)		3 (1.1)	
Apogon taeniatus CUVIER	89 (2.5)	13 (4.8)	
Apogon cyanosoma BLEEKER	1025 (28.7)	24 (8.9)	
Apogon notatus (HOUTTUYN)	54 (1.5)	11 (4.1)	
Cephalopholis miniatus (FORSKÅL)		3 (1.1)	
Grammistes sexlineatus (THUNBERG)		9 (3.3)	3 (5.1)
Vireosa hanae JORDAN & STARKS	59 (1.7)	5 (1.9)	2 (3.4)
Chromis sp.		3 (1.1)	
Tetradrachmum trimaculatum (RÜPPEL)	89 (2.5)		
Parapomacentrus nigricans (LACÉPÈDE)		3 (1.1)	2 (3.4)
Pomacentrus coelestis J. & S.	53 (1.5)		
Abudefduf vaigienses (QUOY & GAIMARD)	87 (2.4)		
Cheilinus bimaculatus (C. & V.)		3 (1.1)	
Pomacanthus imperator (BLOCH)	37 (1.0)		
Pomacanthus semicirculatus (C. & V.)	42 (1.2)		
Holacanthus trimaculatus LACÉPÈDE		3 (1.1)	
Chaetodon auriga FORSKÅL	95 (2.7)		
Acanthurus bariene LESSON	276 (7.7)		
Siganus fuscescens (HOUTTUYN)	40 (1.1)	76 (28.3)	4 (6.8)
Balistes chrysopterus B. & S.	251 (7.0)		
Canthigaster rivulatus (T. & S.)		5 (1.9)	
Canthigaster valentini (BLEEKER)	101 (2.8)	21 (7.8)	
Diodon holacanthus LINNÉ		8 (3.0)	
Pterois volitans (LINNÉ)		19 (7.1)	
Brachirus zebra (Q. & G.)	211 (5.9)		
Phyrnelox tridens (T. & S.)		3 (1.1)	
Antennarius numifer (CUVIER)		3 (1.1)	

period, dominant species occupying more than 1% of the total specimens are listed up for each week (Table 3).

Most of fishes in this table are coral or tropical fishes, except for two species, *Allanetta bleekeri* (GÜNTHER) (1.1% in the first week) and *Vireosa hanae* JORDAN & STARKS (1.7% in the first week, 1.9% in the second week) which are ranging mainly in the temperate region. Five species, *Plotosus anguillaris*, *Apogon notatus*, *Pomacentrus coelestis*, *Siganus fuscescens* and *Phrynelox tridens*, are originally tropical ones but also adapted to the temperate region as their breeding has been confirmed in this vicinity. The total percentage of these five species was 4.1% in the first week, increased to 34.9% in the second week, and decreased to 11.9% in the last week in which much fewer fishes were stranded. This change seems to reflect the gradual rise of water temperature after January 19 (10.1°C to 15.2°C) in the vicinity. If the cold water has continued longer, much more individuals of such fishes adapted to the temperate region would be killed and stranded. Though in the first week stranded fishes were collected solely by us, in the second week and thereafter many people in the vicinity walked around the beach for edible fishes such as *Siganus fuscescens* and *Stephanolepis cirrhifer*, thus the decrease of such fishes might be artificial.

The mass mortality of marine fishes by the cold in this vicinity was reported first by YAMANOUCHI in 1936. All of the warm-water fishes kept in the laboratory aquarium were killed at that time and the minimum temperature of the sea water was 7.0°C.

TOKIOKA also reported the fish stranding on the same beach in the mid-winter of 1961. Though the minimum temperature at that time was somewhat higher (11.5°C) than in this case, the number of tropical fishes was rather few (29/51: 56.9% in number of species, and 488/1906: 30.3% in number of specimens) and a half of dominant species were the fishes well adapted to the temperate region. The possible reason for such a difference in the composition of stranded fishes might be the difference of the time of that stranding that occurred in the middle of February when the water climate might be more advanced than in the present case.

The cold attacked this vicinity in 1963 too, and native shore fishes such as *Gerres oyena* (FORSKÅL), *Plectropomus leopardus* (LACÉPÈDE), *Epinephelus fasciatus* (FORSKÅL) and *Callyodon ovifrons* T. & S. were killed and stranded from Januray to February. The minimum temperature was 9.8°C on January 31 in that year. Although no detailed data in this vicinity is available, the fishes inhabiting the southern coasts of Japan were seemingly damaged very widely by the cold wave of that year (Kondo 1963).

It was rather warm in next four winters as shown in Text-figure 1. Though such tropical fishes as *Solenostomus paradoxus* (PALLAS) and *Prevagor melanocephalus* (BLEEKER) were found stranded on the same beach by the junior author, the number of specimens were very few. The influence of the warm-water current *Kuroshio* was so strong in this district in these four years that unusually many kinds and individuals of coral fishes seemingly transported by *Kuroshio* in juvenile stages were found in the shallow water of this vicinity in the autumn of 1967 as observed directly by SCUBA. Further, the unusually higher water temperature was maintained from the end of 1967 to the beginning of 1968 and a considerable amount of tropical fishes were found still staying there as confirmed by the senior author on January 4. Thus, it is clear that the above-mentioned tropical fishes were killed at a stretch by the sudden drop of the water temperature that started on January 14.

At the time of our observations, it was reported that a big scale of mass mortality of common inshore fishes occurred along the coast of the northwestern part of Kii Peninsula facing the Kii Channel adjacent to Osaka Bay. Some opinions were expressed to attribute this to the winter cold, although we could not agree to them, for the reason that those inshore fishes are distributed much northerly and of course stand much lower temperature. Much later, illegal discharge of the industrial wastes by an outlaw boat in that area was reported by papers, and inevitably this must be responsible for that mass mortality.

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