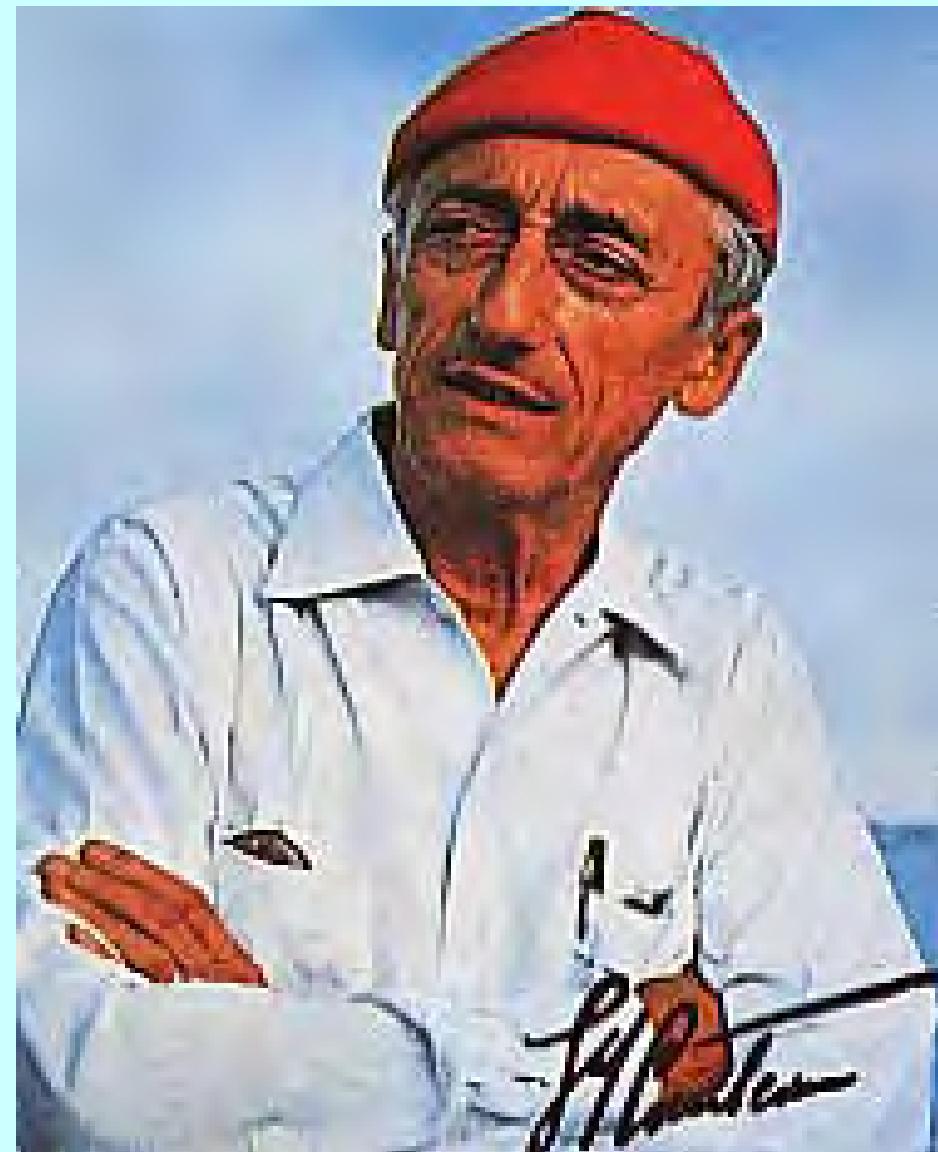


Underwater visual census as a tool to monitor coastal ecosystem: seasonal and interannual fluctuations, effect of thermal discharge from power stations, and recovery from the tsunami disaster

**Reiji Masuda
Maizuru Fisheries Research Station
Kyoto Univ.**

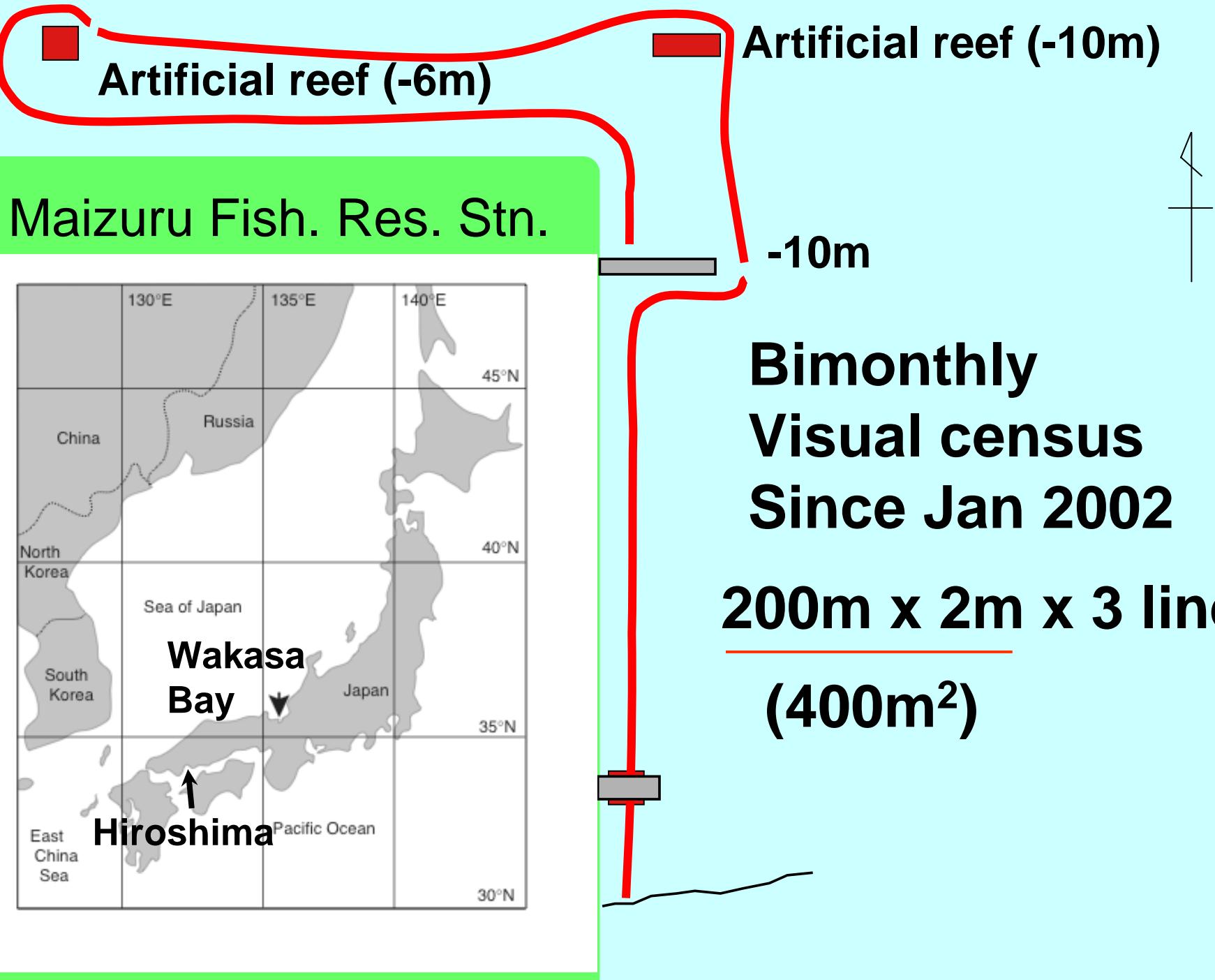


Jacques-Yves Cousteau (1910-1997)

Invented Aqualung in 1944

Purchased Calypso in 1950

Photo from <http://www2.divers.ne.jp/vintage/sub8.htm>



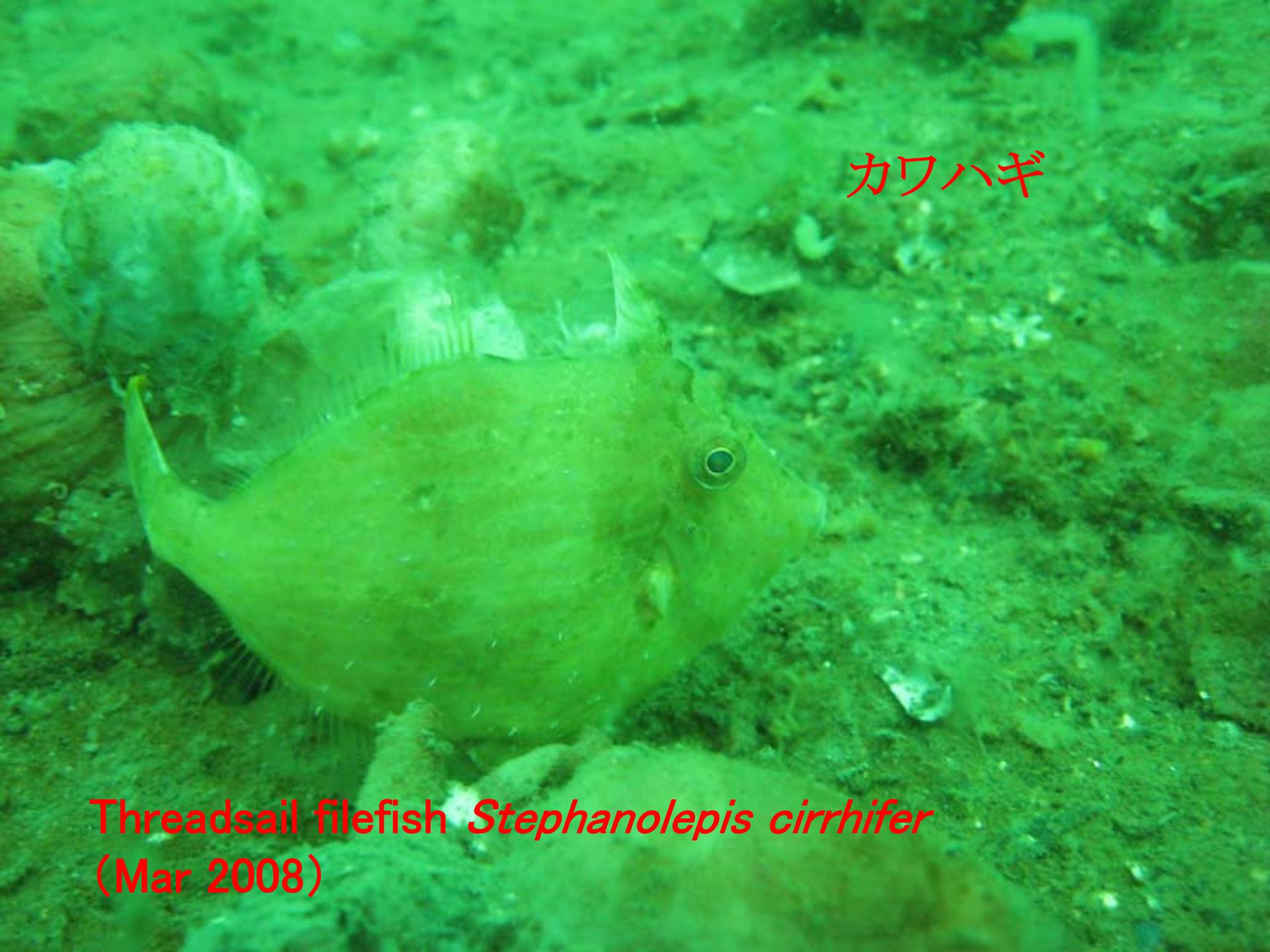
Underwater slate

1/528

07/11/08 長遠 明九

1.658-	<u>3.1107</u>	<u>3.3x3.2x3.4</u>	<u>7.230</u>
2.6	<u>L6</u>	<u>7.114</u>	<u>14.982</u>
3.3x5.4.5x2.0x2	<u>13.54.92</u>	<u>木=9x2</u>	<u>x4x20.7</u>
4.4x1.0x2	<u>2.7x2</u>	<u>7.2</u>	<u>7.214</u>
5.6x3.4x5	<u>3.22.5x6x2.7x1.1</u>		<u>11.74</u>
6.5x6.6x3	<u>7.32</u>		<u>7.32x6</u>
7.木=7x2	<u>7.1</u>	<u>7.347</u>	<u>7.3x3.4</u>
8.5x20.8.6	<u>7.27.26</u>	<u>2x3</u>	<u>15.01.32</u>
9.2x2x2.2.1	<u>7.96</u>	<u>7.3.2.5</u>	<u>イ.7.2.3</u>
10.	<u>*6.43</u>	<u>5x2</u>	<u>x4x2.6.8x2</u>
11.	<u>L7</u>	<u>9.04</u>	<u>7.215</u>
12.	<u>3.4.2.2x2.2</u>	<u>~14.44</u>	<u>7.22x4</u>
13.	<u>7.4.3x2</u>	<u>21.29</u>	<u>15.06.11.2</u>
14.	<u>7.2.6</u>	<u>14.452</u>	<u>7.7.6.12</u>
15.	<u>L8</u>	<u>7.7.6</u>	<u>7.22x14.7.3</u>
16.	<u>7.2.2x2.2</u>	<u>7.3x3.2.4</u>	<u>7.22.5.1</u>
17.	<u>7.2</u>	<u>11.024</u>	<u>7.5.0.2.3</u>
18.	<u>14.02.0.3</u>	<u>木.2.7</u>	<u>7.7.9</u>
19.	<u>L9</u>		<u>7.0.20</u>
20.	<u>7.9.7x20</u>	<u>14.4921</u>	<u>7.4.6</u>
21.	<u>x8x8.6x2.9</u>	<u>x4x35.5</u>	<u>7.0.1.2.2.8</u>
22.	<u>7.4</u>	<u>7.2.2x2.4x2</u>	<u>7.2.5</u>
23.	<u>13.50.12.1</u>	<u>7.7.7.1.0</u>	<u>7.4.2</u>
24.	<u>L5</u>		<u>7.5.14.2.3</u>
25.	<u>7.0.3.2</u>	<u>7.7.0.2x3</u>	<u>7.4x6.7</u>
26.	<u>7.1.7.8</u>	<u>14.53.11.1</u>	<u>7.0.3.0</u>
27.	<u>2.13x10.0</u>	<u>7.1.8.12.4x2</u>	<u>7.3x3</u>
28.	<u>21.5.0</u>	<u>7.1.7.4x2</u>	<u>7.2.2.5</u>
29.	<u>7.7.4</u>	<u>7.4</u>	<u>7.1.6</u>
30.	<u>木.7.3</u>	<u>7.3x3.2.2</u>	<u>7.2.2.2</u>
31.		<u>7.3.5.1</u>	

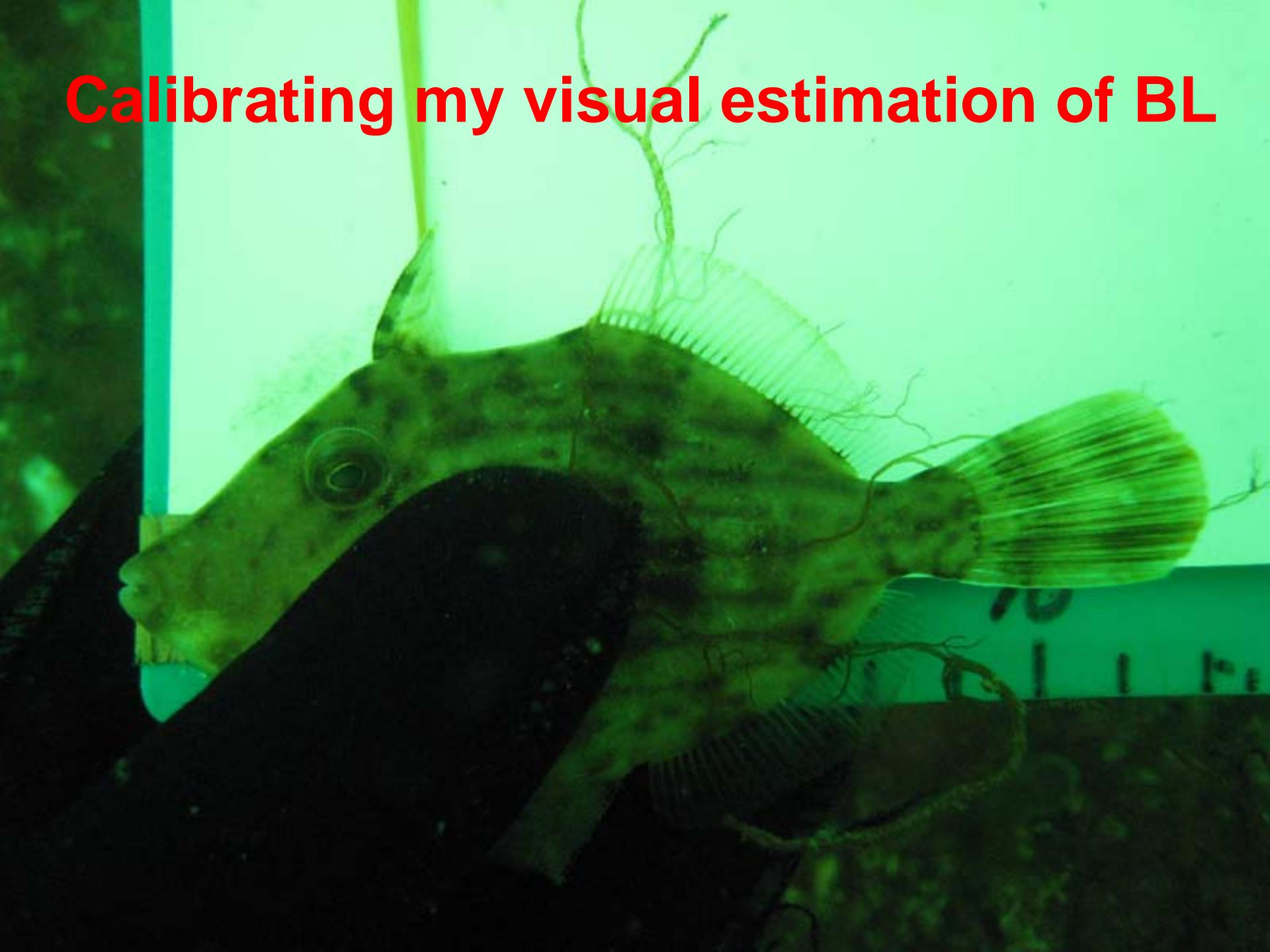




カワハギ

Threadsail filefish *Stephanolepis cirrifer*
(Mar 2008)

Calibrating my visual estimation of BL



A photograph of an underwater ecosystem. In the center, several dark-colored fish, identified as Black Rockfish, are swimming over a rocky seabed covered in green algae. The water is slightly murky, and sunlight filters down from the surface.

Black Rockfish *Sebastodes inermis* (Dec. 2006)

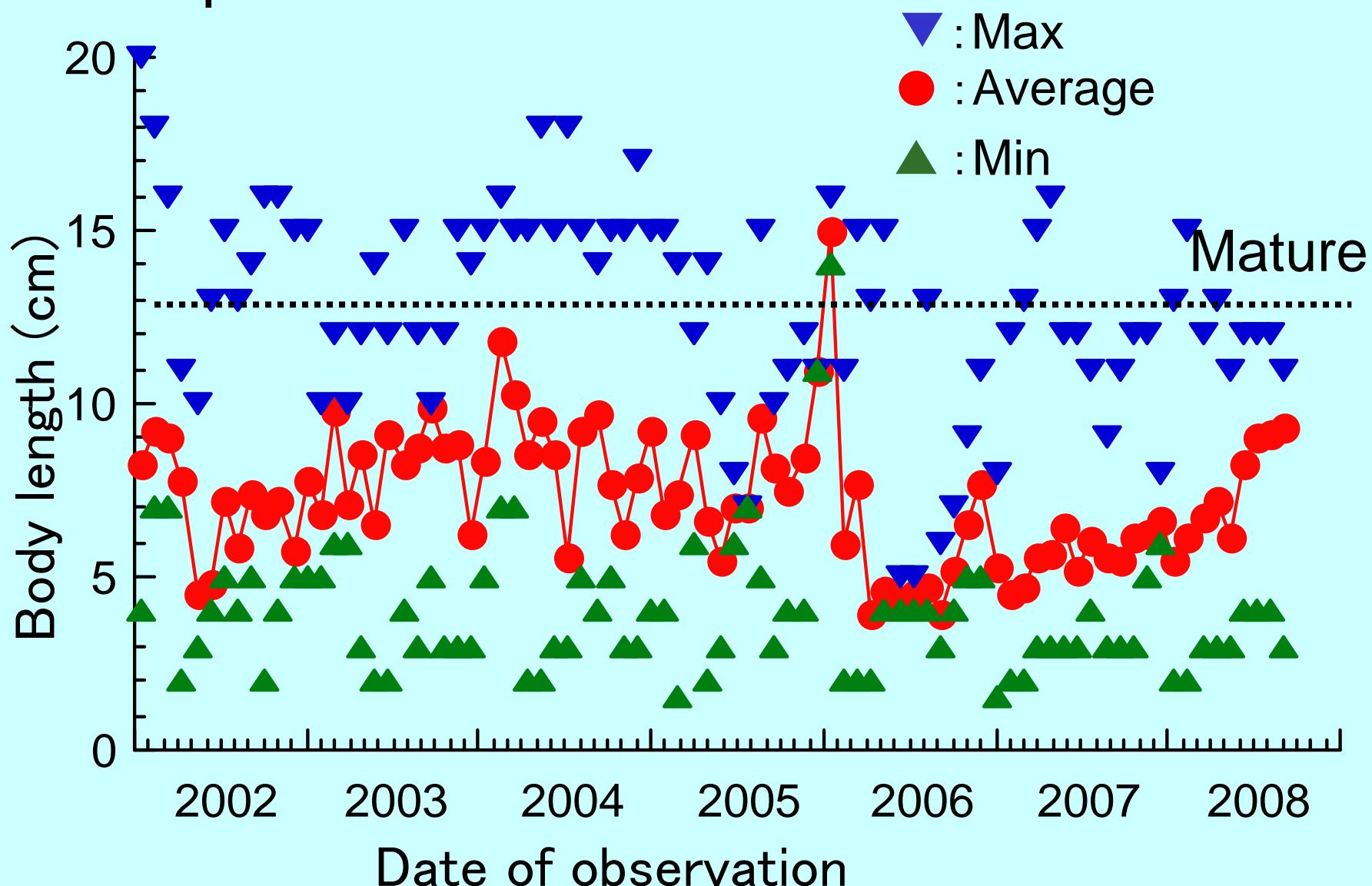
メバル

Black rockfish *Sebastes inermis*
(Jan 2005, Nagahama, Maizuru)

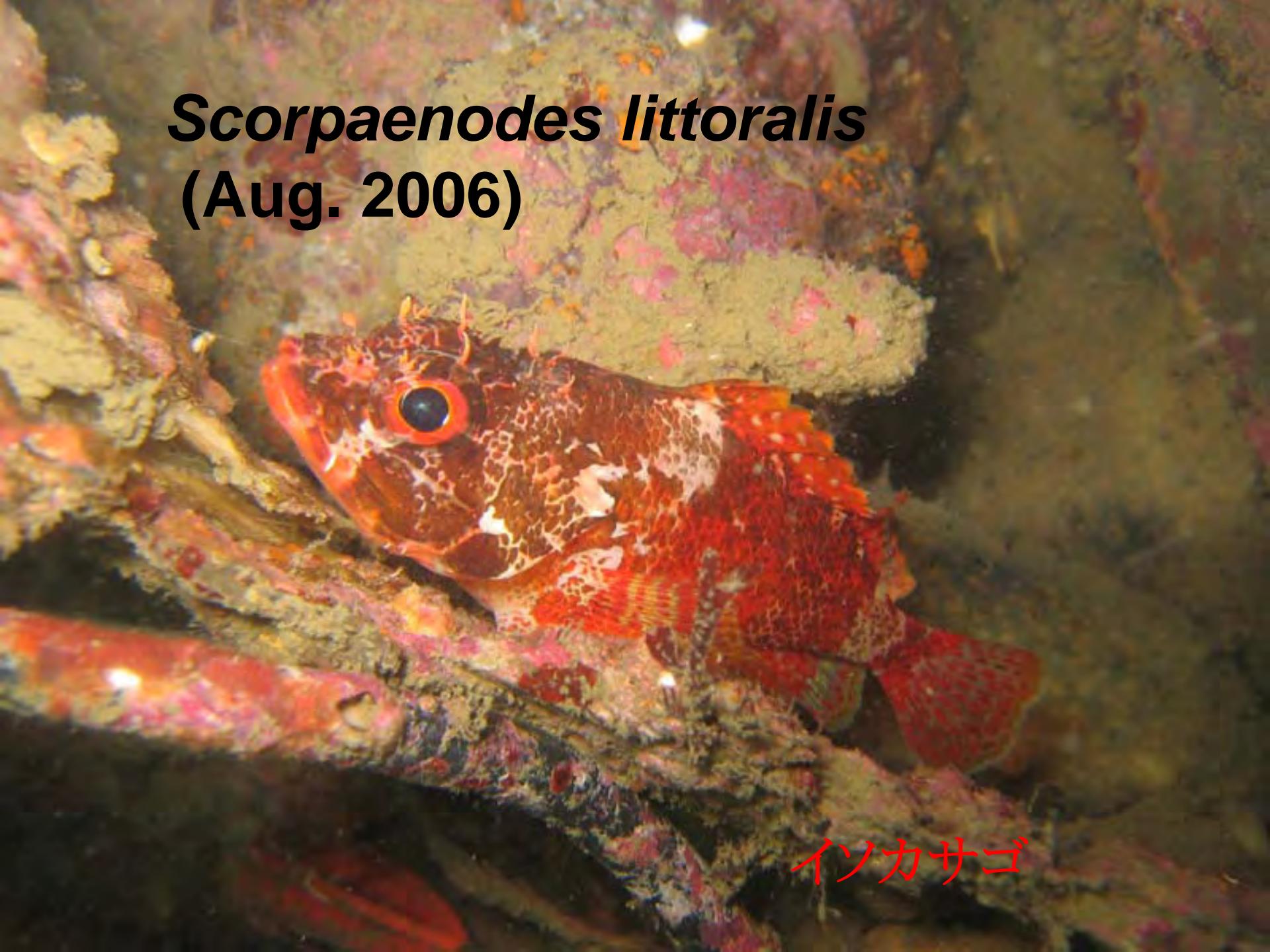


Black rockfish

Reproduces in a coastal reef habitat.



Scorpaenodes littoralis
(Aug. 2006)



イソカサゴ

Snapper *Lutjanus russellii*
(Sep. 2005)

クロホシフエダイ

Brownbanded butterflyfish
Chaetodon modestus
(Sep. 2012)



ゲンロクダイ



タツノオトシゴ

Seahorse *Hippocampus coronatus*
(Nov. 2002, Nagahama)



ヨウジウオ

Pipefish *Syngnathus schlegeli*
(May. 2004, Nagahama)

アカオビシマハゼ



Goby *Tridentiger trigonocephalus*
capturing anchovy
(Nov. 2002, Nagahama)

Who did this?



Bitten anchovy (Dec 2007)

Spanish mackerel

サワラ

Scomberomorus niphonius



(May 2008)

A large school of Jack mackerel, Trachurus japonicus, swimming in clear blue water. The fish are silvery-blue with a distinct yellow stripe along their sides and a yellow-tipped dorsal fin. They are swimming in various directions, creating a dense, dynamic scene.

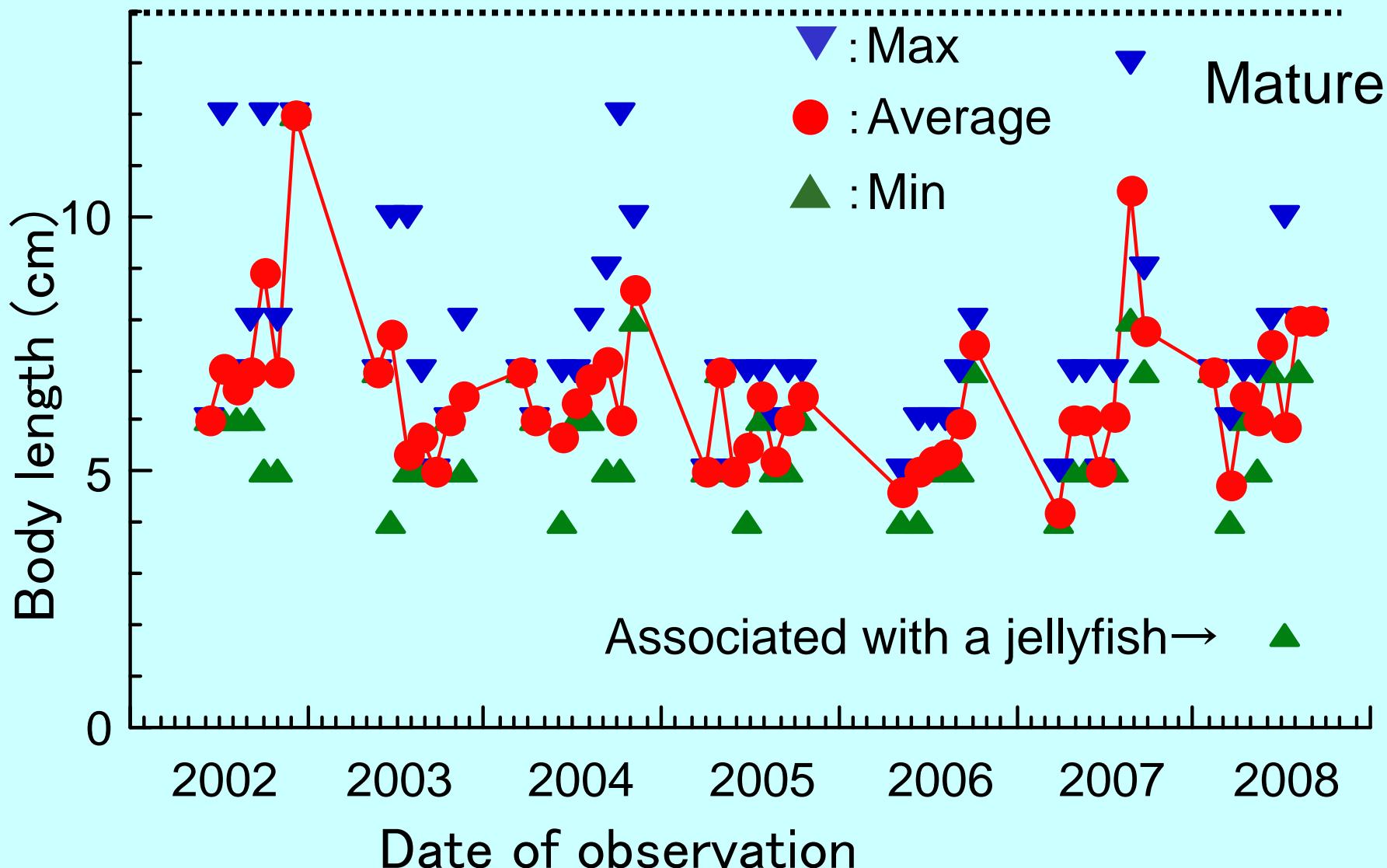
Jack mackerel *Trachurusu japonicus*
is the most common fish.

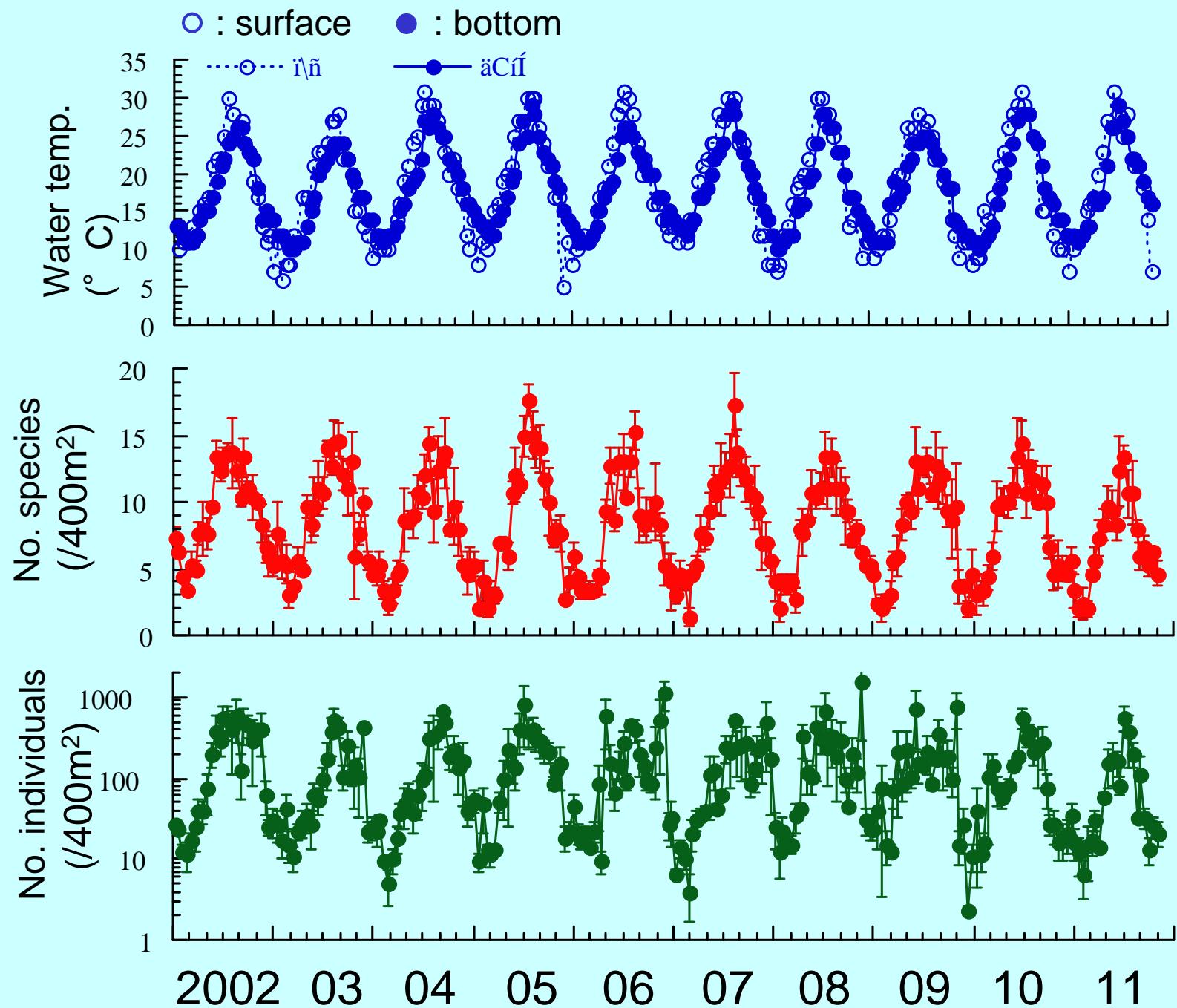
マアジ

(Sep. 2005, Nagahama)

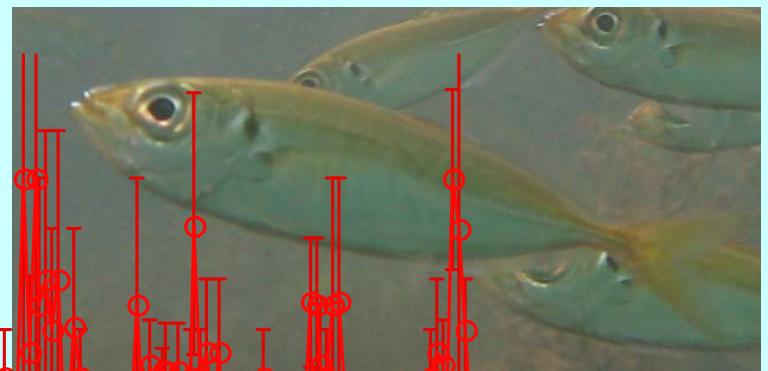
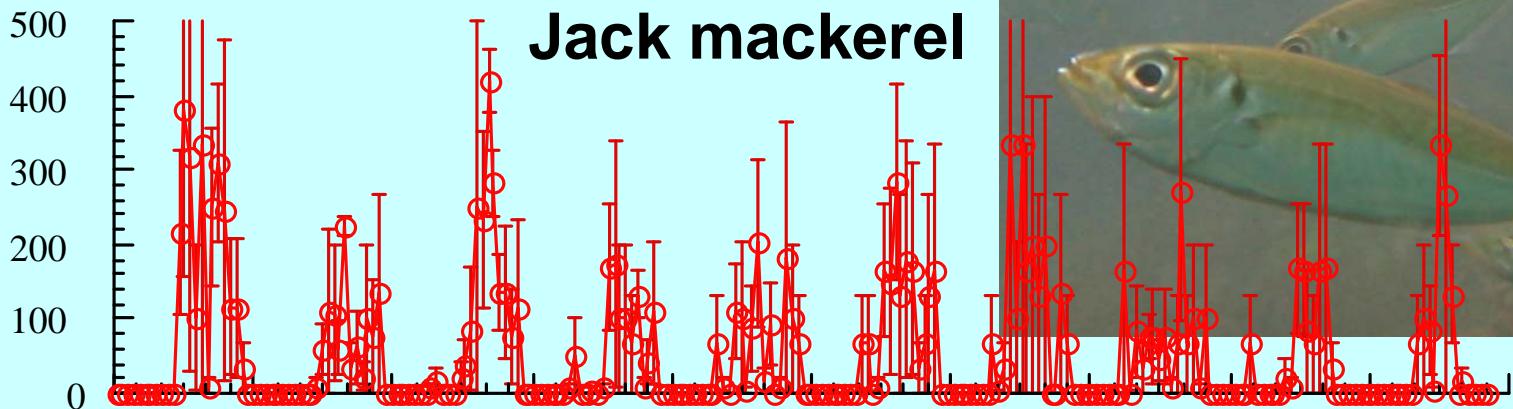
Jack mackerel

Utilizes coastal reef as a nursery habitat.

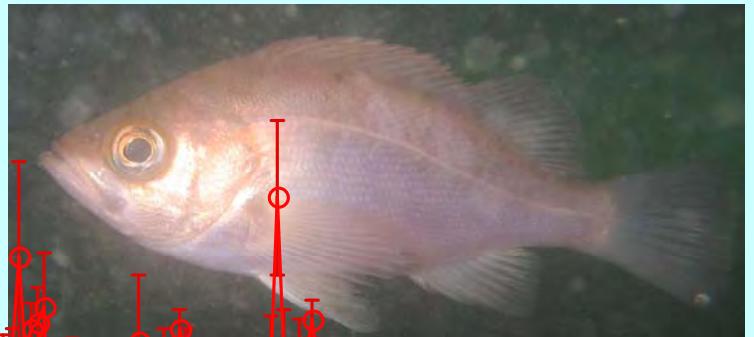
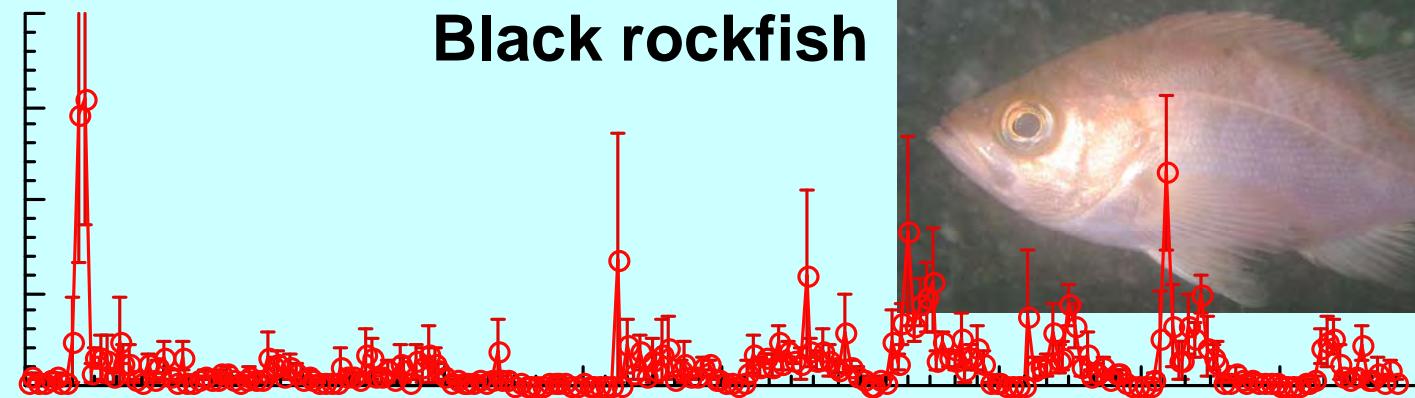




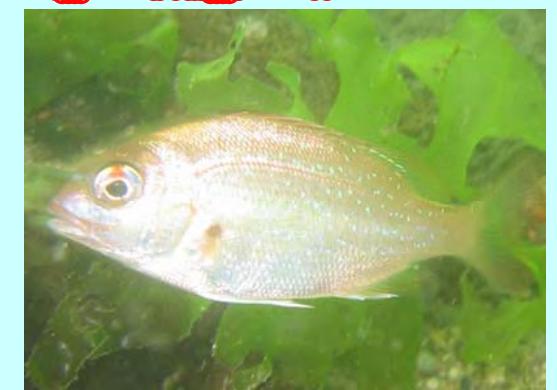
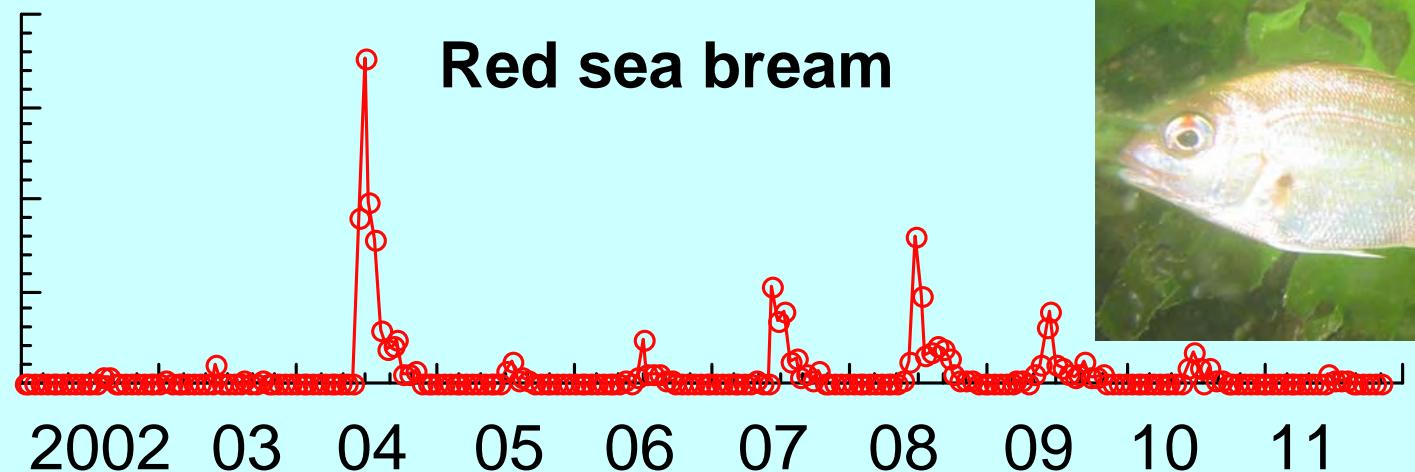
No. of individuals (/400m²)



Black rockfish

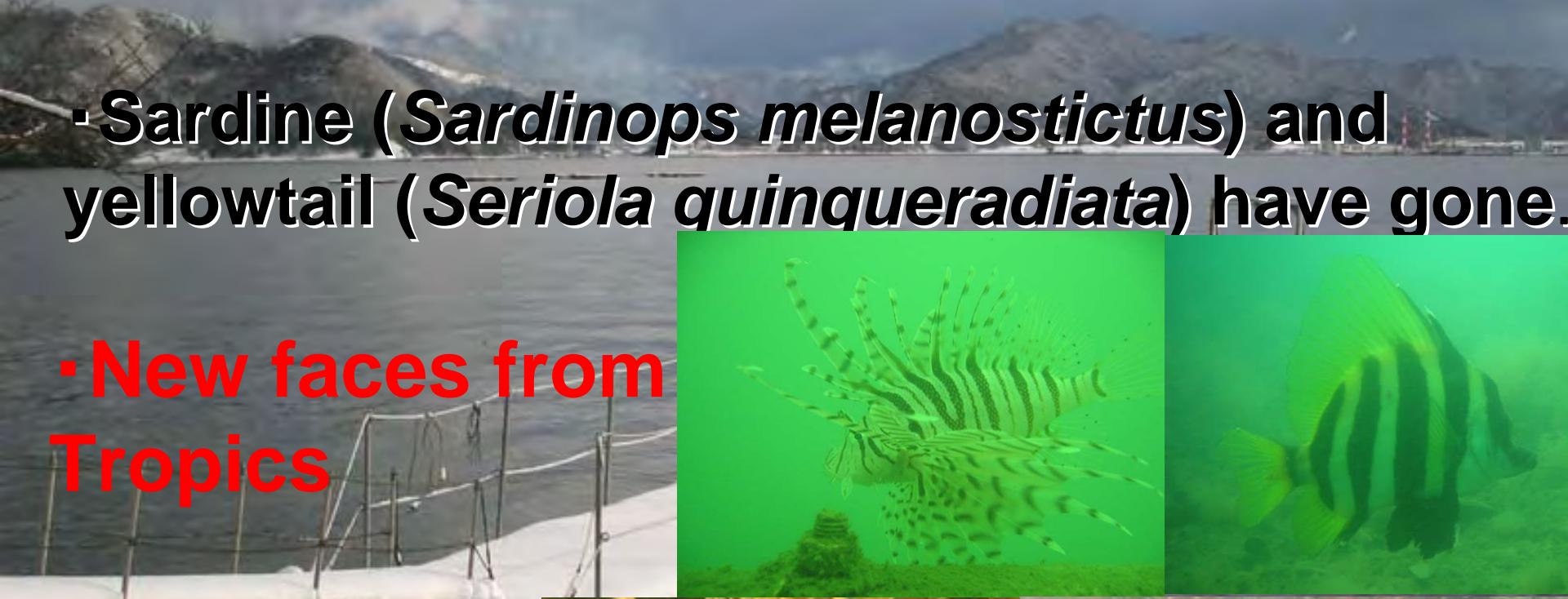


Red sea bream



Comparison with 1970-72 survey (Nishida et al. 1977) reporting 89 fish species

- Sardine (*Sardinops melanostictus*) and yellowtail (*Seriola quinqueradiata*) have gone.
- New faces from Tropics



Center of distribution in northern hemisphere

Distribution data based on Nakabo (2000) and FishBase



Seriola quinqueradiata

Southern limit: 30

Northern limit: 45

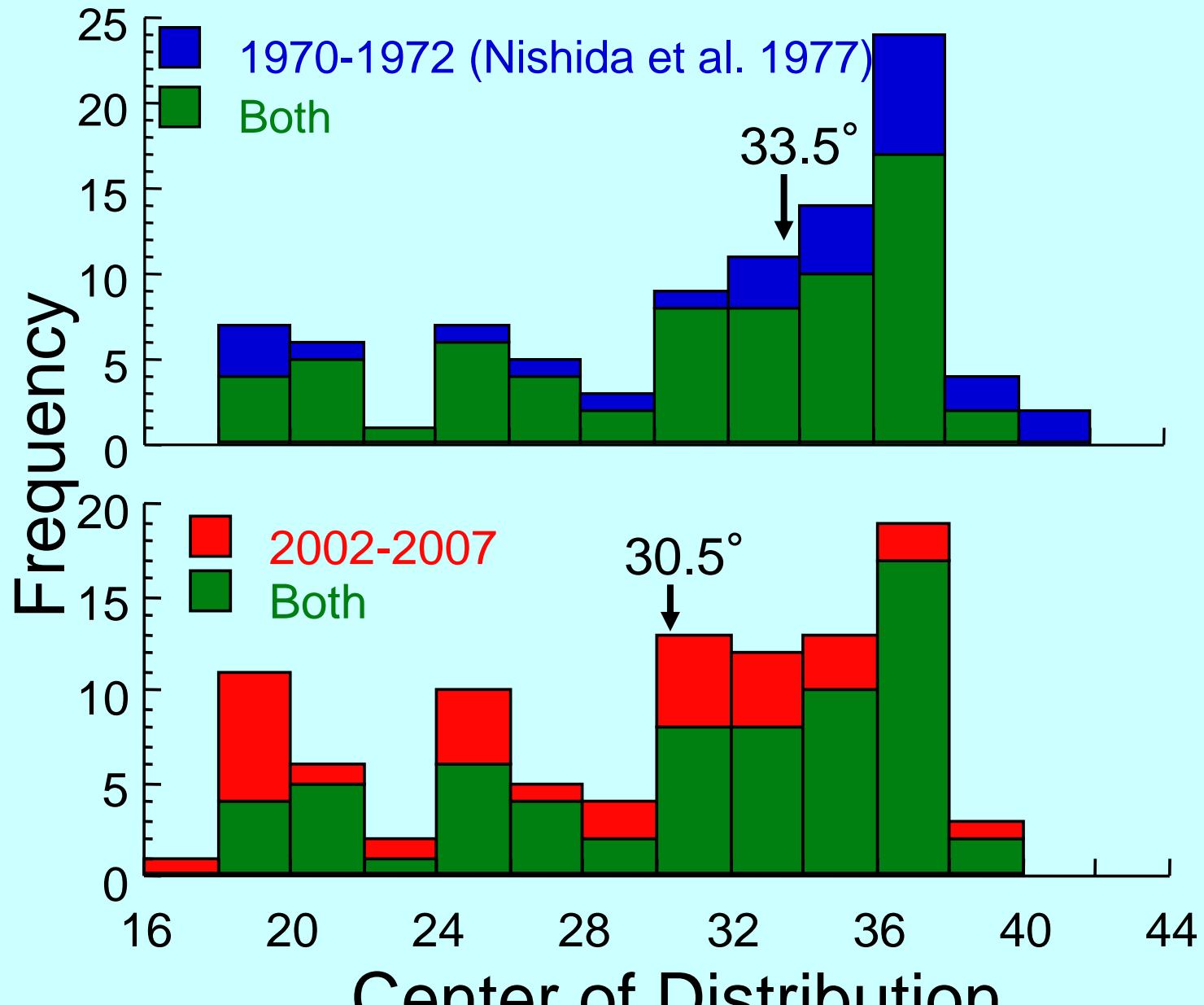
Center of distribution: 37.5

Lutjanus russelli

Southern limit: 0

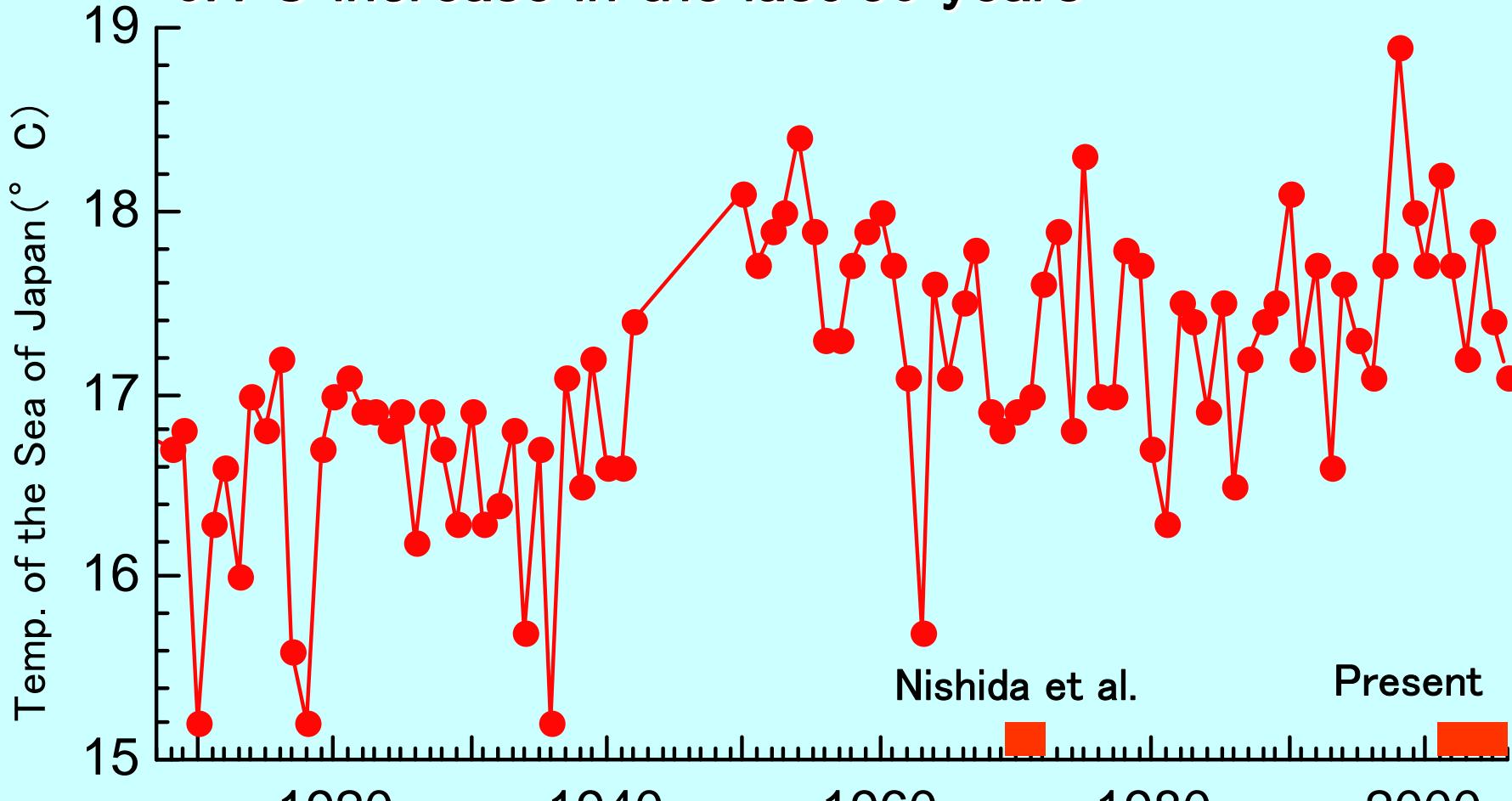
Northern limit: 38

Center of distribution: 19



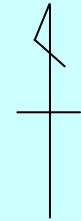
1.0°C increase in the last 100 years

0.4°C increase in the last 30 years



(From the HP of Japan Meteorology Agency)

Diving along thermal discharge from power stations



10km

Sezaki

River flow:
 $42 \text{ m}^3/\text{s}$

Yura
River

Coal-fired
Power Station
 $73 \text{ m}^3/\text{s}$

Nagahama
FRS, Kyoto
Univ.

Four times of uw visual census from Jan to Mar
since 2004

Otomi

Nuclear
Power Station

Thermal
discharge:
 $230 \text{ m}^3/\text{s}$

Sezaki (Feb. 2008)





Greenling *Vellitor centropomus*
(Mar. 2004, Sezaki)

スイ



Rockfish *Sebastes pachycephalus*
(Mar. 2004, Sezaki)

ムラソイ

Porcupinefish *Diodon holocanthus*
(Feb. 2007, Sezaki)



ハリセンボン

Pinecornfish *Monocentris japonica*
(Feb. 2008, Sezaki)



マツカサウオ

Otomi where a nuclear power station had been running since 1974 (Jan 2004, Otomi)



A close-up photograph of a blue damselfish, *Pomacentrus coelestis*, swimming in an underwater environment. The fish has a vibrant blue body with a slightly darker dorsal side and a lighter ventral side. It is positioned in the center-right of the frame, facing towards the left. The background is a blurred, greenish-blue color, suggesting a coral reef or rocky seabed.

ソラスズメダイ

Damsel fish *Pomacentrus coelestis*
(Feb. 2004, Otomi, Fukui)

A photograph of an underwater environment. The bottom is covered in light-colored, textured rocks and patches of green and brown algae. Several small, vibrant blue fish, likely Pomacentrus coelestis, are scattered across the scene. One fish is positioned near the center, another is lower left, one is on the right, and others are partially visible in the background. The water is clear, allowing sunlight to illuminate the scene.

Pomacentrus coelestis with
Diadema (Feb. 2005, Otomi)

Brocade perch

Ostichthys japonicus

(Mar. 2005, Otomi)

エビスダイ



Blue-speckled rubble goby

Asterropteryx semipunctata

(Jan. 2005, Otomi)

ホシハゼ



Cutribbon wrasse

カミナリベラ

Stethojulis interrupta dominating
(Mar. 2005, Otomi)

Common wrasse,
Halichoeres tenuispinnis

The nuclear power station was suspended from Feb 20, 2012

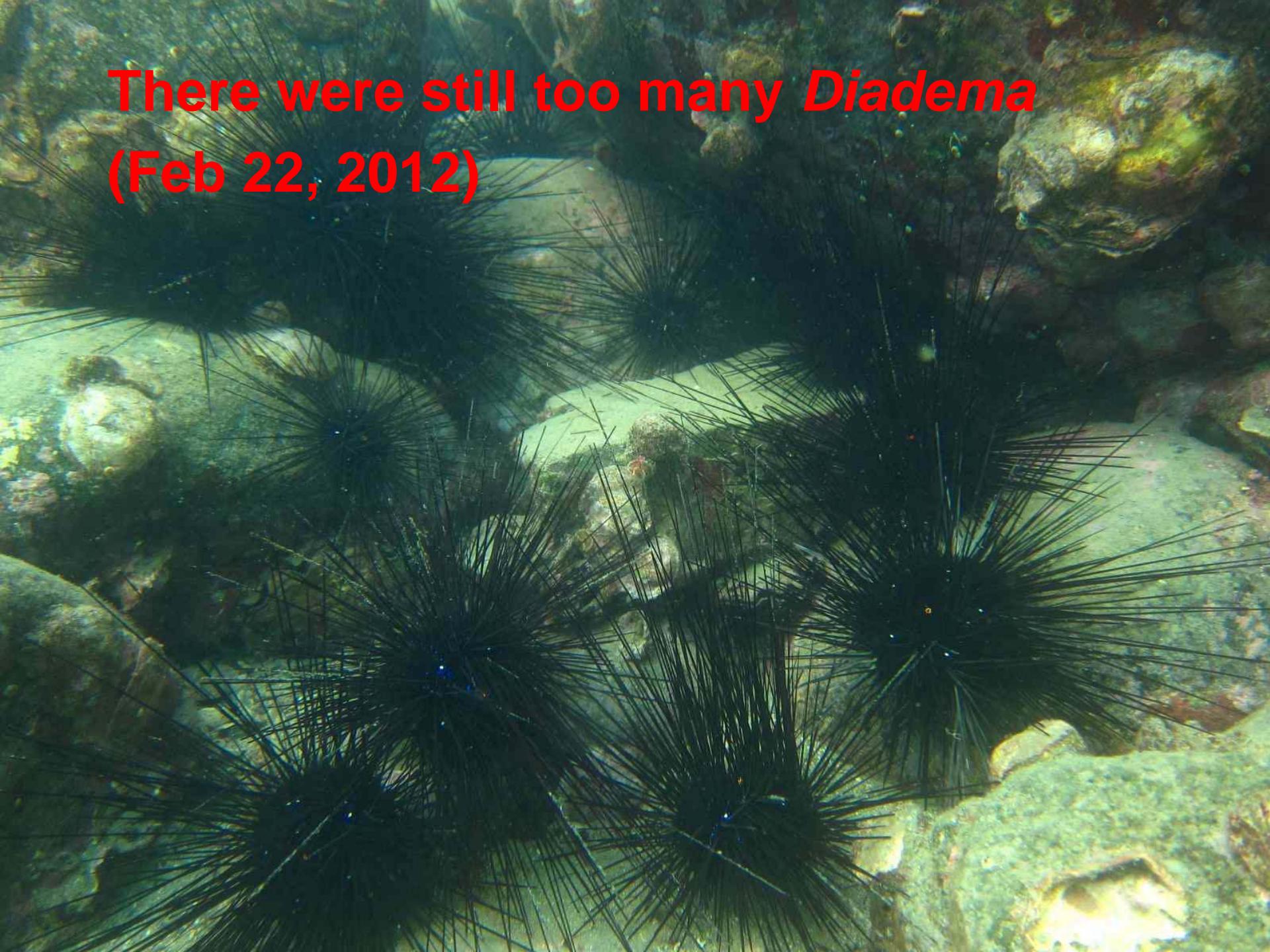
And silversides

Hypoatherina tsurugae died off
(Feb 22, 2012)

ギンイソイワシ



There were still too many *Diadema*
(Feb 22, 2012)



**Diadema started to die
(Mar 7, 2012)**



Dead flatfish

タマガンゾウビラメ

Pseudorhombus pentophthalmus

(Mar 7, 2012)



Other dead fish (Mar 7, 2012)



Spines of *Diadema*
(April 13, 2012)



Purple sea urchin recovering
(April 13, 2012)



Common wrasse returned
(June 5, 2012, Otomi)

ホンベラ

Juvenile St. Peter's fish
recruiting to *Sargassum* bed
(April 13, 2012)



マトウダイ

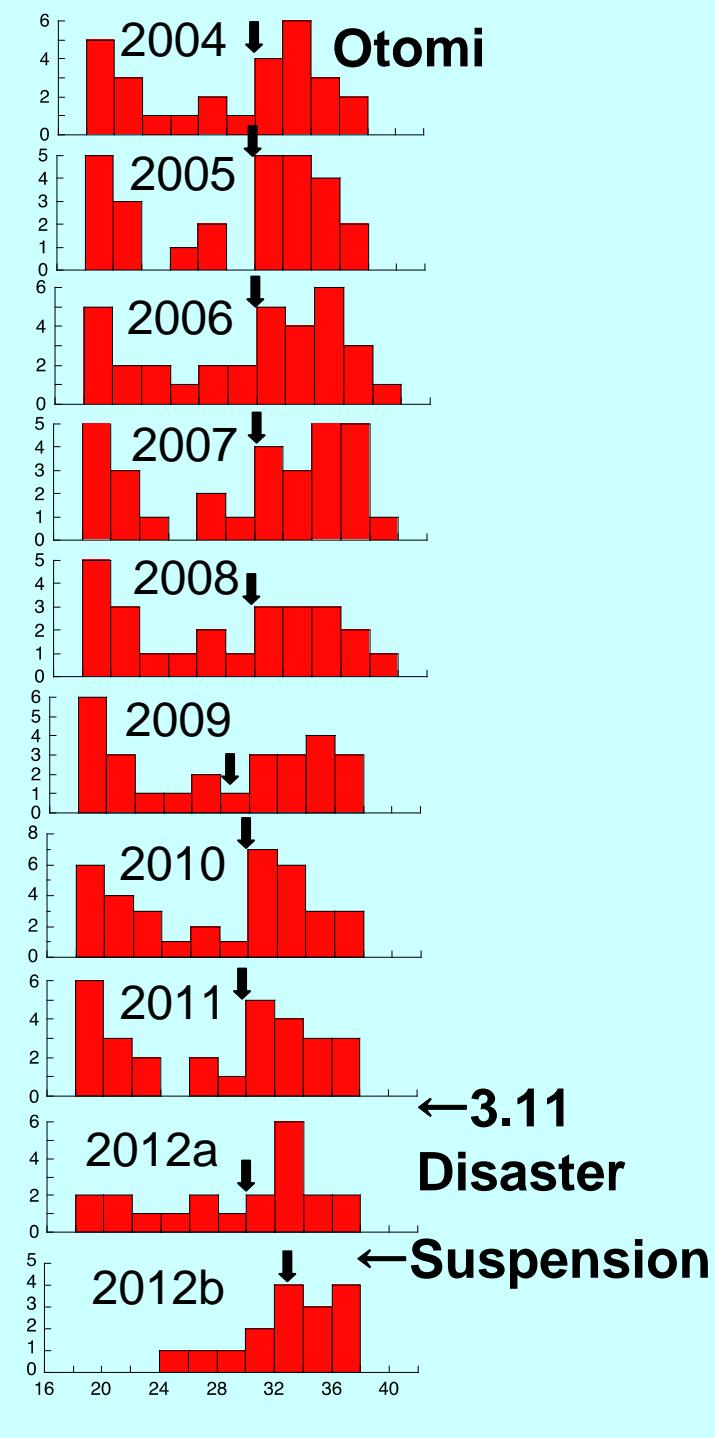
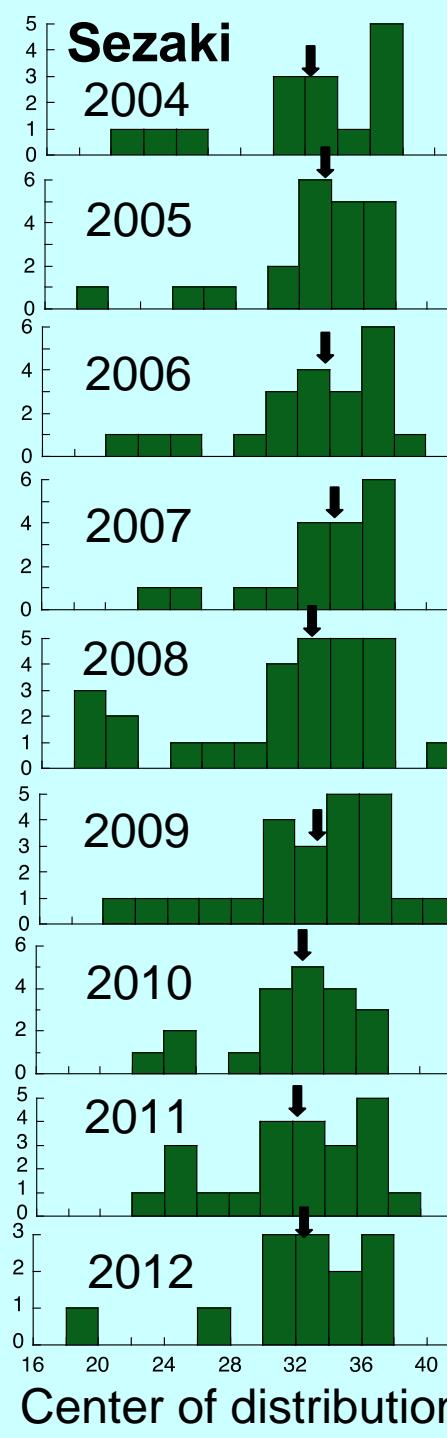
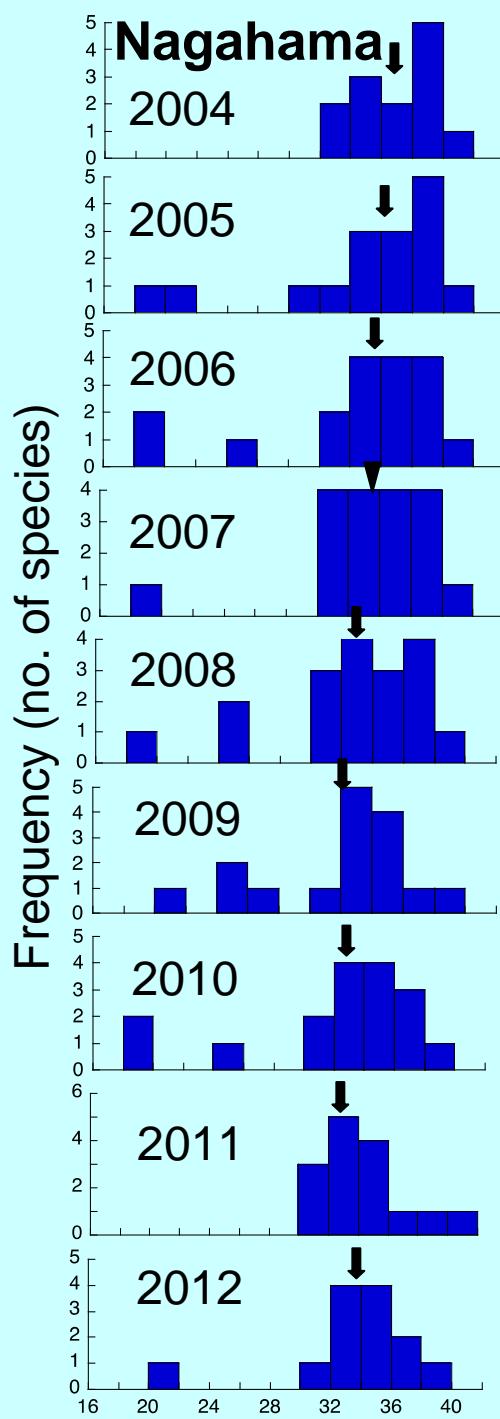
Center of latitudinal distribution in the northern hemisphere



Yellowtail
Seriola quinqueradiata
is distributed 30–45 ° N
Center of distribution: 37.5



Spotted snapper
Lutjanus russelli
is distributed 0–38 ° N
Center of distribution: 19



A photograph of the Takahama Nuclear Power Station in Japan. The station is built on a hillside overlooking a body of water. In the foreground, there's a concrete wall and some greenery. On the hillside, several large white cylindrical structures, likely storage tanks or cooling towers, are visible. In the background, more industrial buildings and power lines are seen against a blue sky with white clouds.

Risk of running a nuclear power station

Catastrophic risk of earthquake & tsunami

Radioactive waste

Thermal discharge
(7° C warmer than the ocean; 230 m³/s)

Takahama Nuclear Power Station
(Otomi, Fukui; May. 2010)

Diving in Tohoku After the *Tsunami* Disaster

QuickTime® Ç²
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(May 2011, Kesennuma)

Every two-month visual survey



Inner bay



**Rocky
shore**



Mouth of bay



Outreef

Redrawn from Google Map

Fin-kick transect

2 m

50 m

Line transect

QuickTime® Ç²
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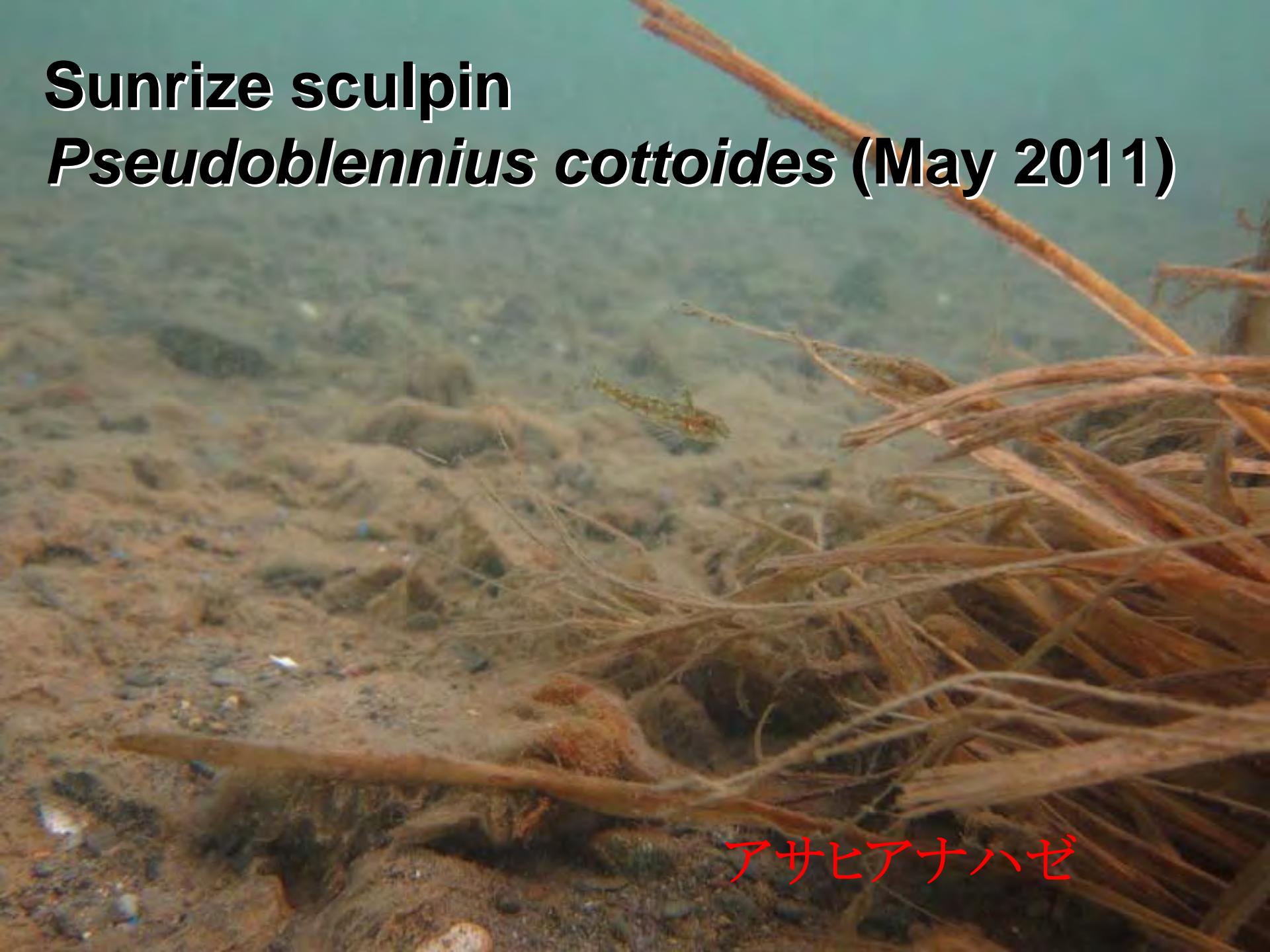
(May 2011)

QuickTime®'y Ç²
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Wooden debris (May 2011)

Sunrise sculpin

Pseudoblennius cottooides (May 2011)



アサヒアナハゼ

Prickleback

***Pholis crassispina* (May 2011)**



タケギンポ

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Sculpin *Alcichthys elongatus* (May 2011)

ニジカジカ

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Goby *Pterogobius elapoides* (July 2011)

キヌバリ

QuickTime®'y C²
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Greenling *Hexagrammos otakii* (July 2011)

アイナメ

Goby (Sep 2011)

QuickTime® 2

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Goatfish *Upeneus japonicus* (Sep 2011)

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ヒメジ

Jack mackerel (Sep 2011)

QuickTime® \mathbb{C}^2

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Mullet *Mugil cephalus* (Sep 2011)

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ボラ

Goby (Nov 2011)

QuickTime® \mathcal{C}^2
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Greenling (Nov 2011)

QuickTime® 2

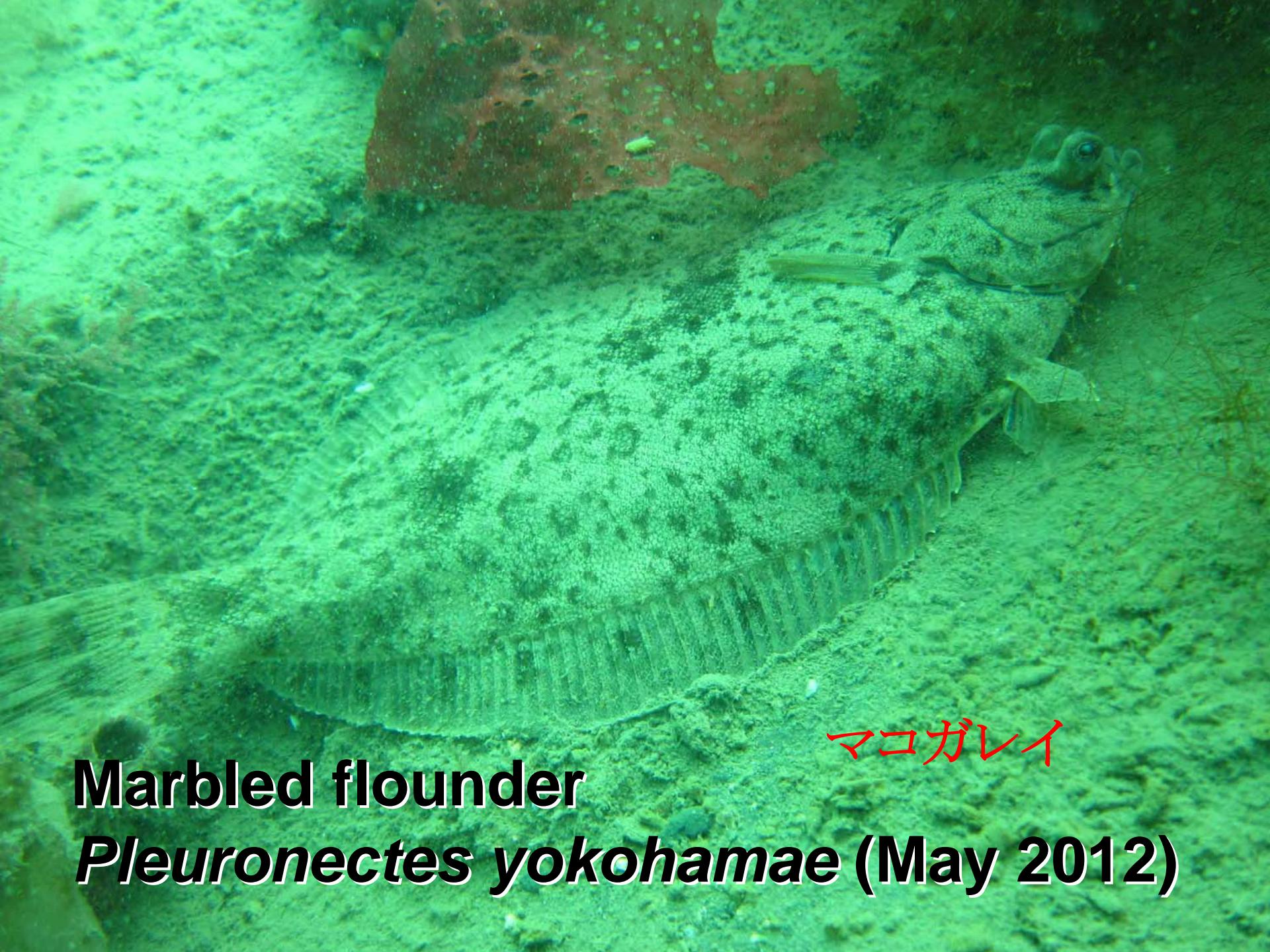
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Prickleback
Opisthocentrus ocellatus (May 2012)

ガジ



Marbled flounder

***Pleuronectes yokohamae* (May 2012)**

マコガレイ

**Fox jacopever *Sebastes vulpes*
(Sep 2012)**

キツネメバル



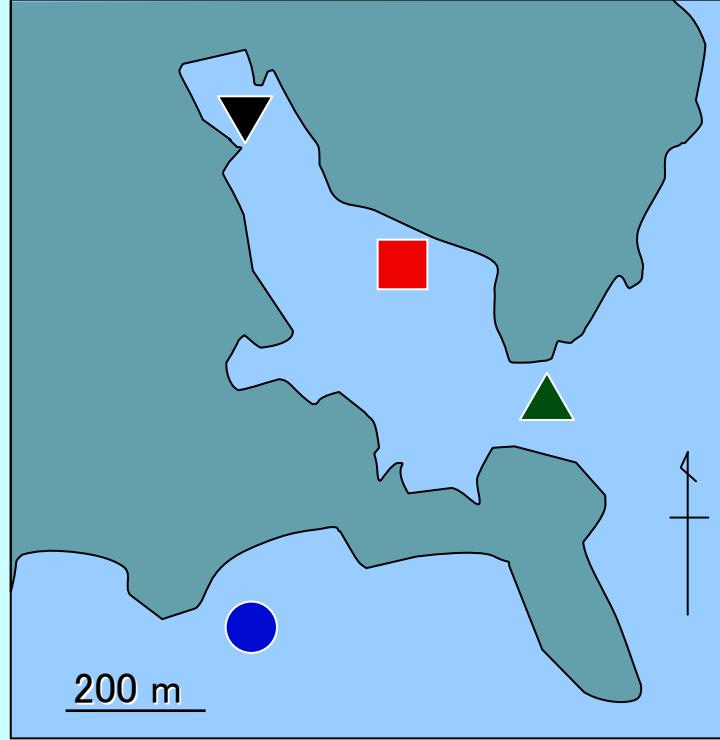
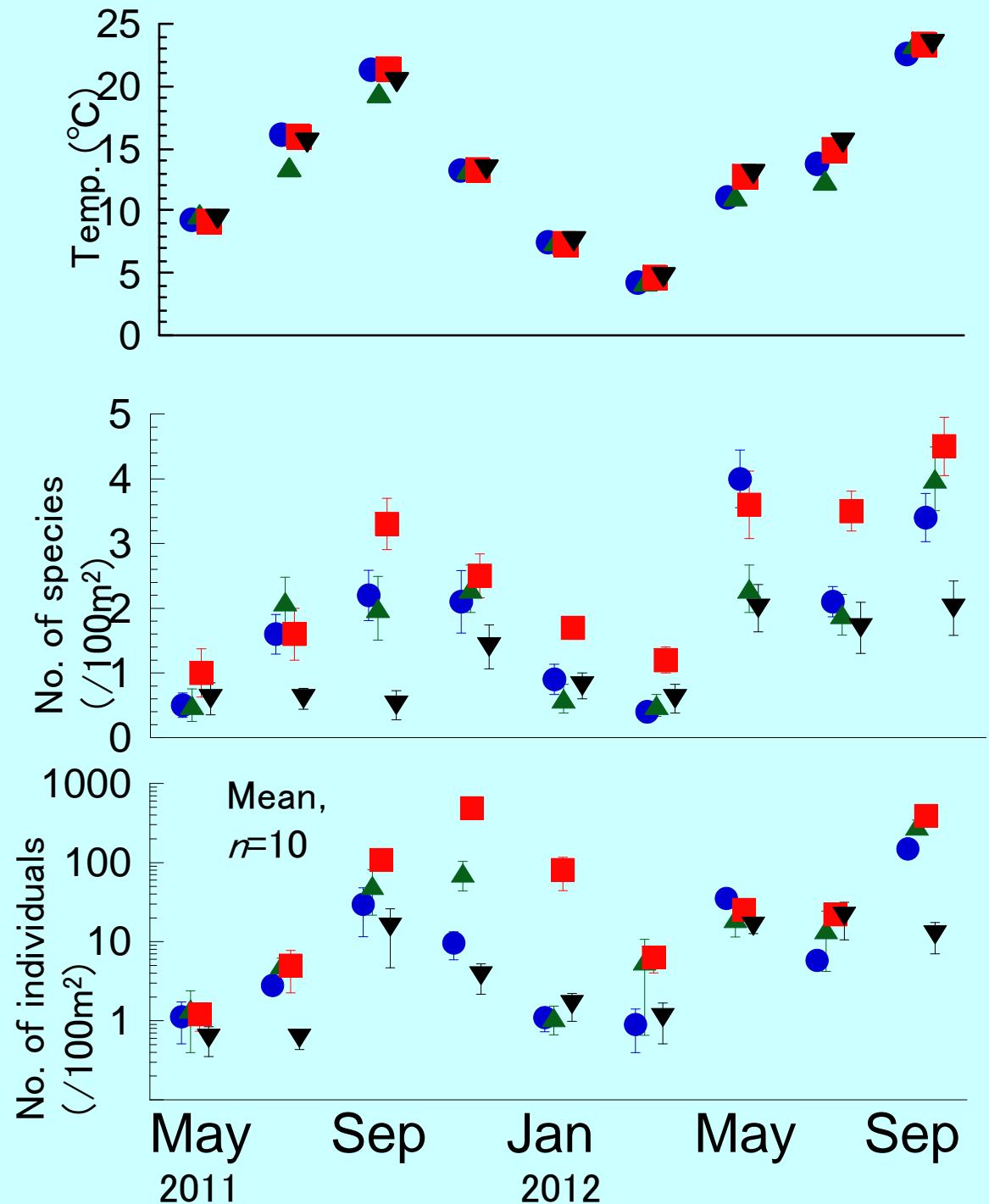
Surfperch *Ditrema temmincki* (Sep 2012)



ウミタナゴ

Sunrise sculpin mating (Sep 2012)





**Fish are increasing
Rocky shore is quick in recovery**

**Natural rocky reef shore
enabled rapid recovery
of seaweed forest**

QuickTime®
ÔLÍFÉvÉçÉOÉâÉÄ
Ç™C±ÇÃÉÉNÉÉC¾å©CÈCžÇ½C...ÓÖiKóvÇ-ÇÅB

(Sep 2012, Moune Bay)

U/W visual census

Species richness, abundance,
BL, biomass

Comparing location,
time, treatment

Insights

(Nov. 2003, Nagahama)

