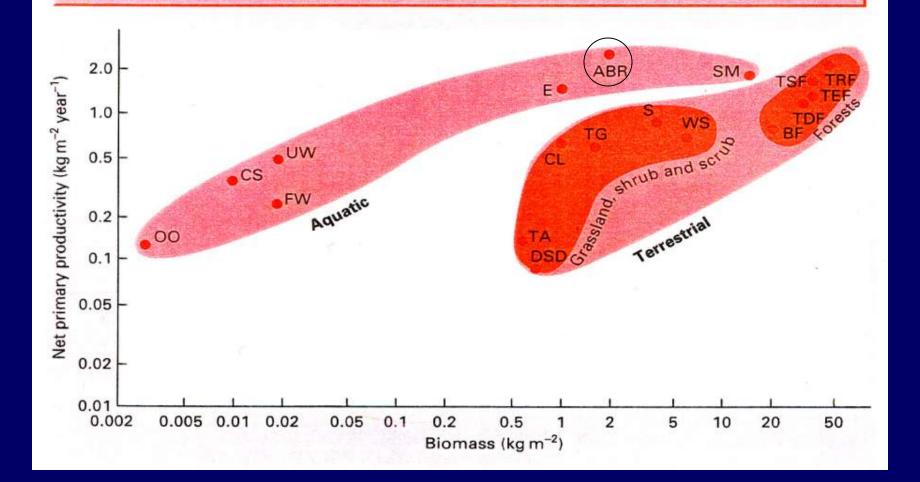
Possible change in seaweed distribution in East Asia under a particular scenario of global warming

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OO Open ocean
CS Continental shelf
UW Upwelling zone
ABR Algal beds and reefs
E Estuaries
FW Freshwater lakes
and streams

SM Swamp and marsh
TRF Tropical rainforest
TSF Tropical seasonal forest
TEF Temperate evergreen forest
TDF Temperate deciduous forest
BF Boreal forest

WS Woodland and scrubland S Savannah TG Temperate grassland TA Tundra and alpine DSD Desert and semi-desert CL Cultivated land



BACKGROUND

Seaweed key roles:

- Nutrient absorption, buffering water motion, preventing erosion
- Spawning, nursery and feeding grounds



The sensitivity of seaweed to water temperature is well-known:

In Japanese, "Iso-yake" means "fire of seaweed forests" due to warmer water temperature

BACKGROUND

Indirect effects related to warmer waters:



Increase of reports
 about damage of
 seaweed forests by
 herbivorous fishes
 such as Prionurus
 scalprum, Calotoms
 muricatum or Siganus
 fuscescens



Sargassum horneri

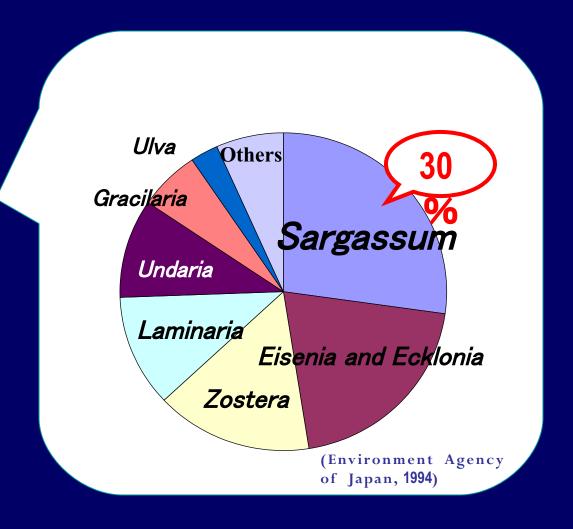
Sargassum species



WHY SARGASSUM?

Sargassum species are:

- the most common seaweed species in Japanese waters
- more common than the most common seagrass species (*Zostera*)





Sargassum horneri:

- most common species of *Sargassum*

- relatively high tolerance with regard to temperature variations



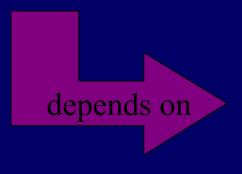
Ecological importance of drifting seaweed

- Carry numerous phytal animals
- Spawning substrate for Pacific saury, flying fish and Japanese halfbeak
- Nursery ground for juveniles of yellowtail, jack mackerel and Sebastes species





Yellowtail (Seriola quinqueradiata) aquaculture





AIMS

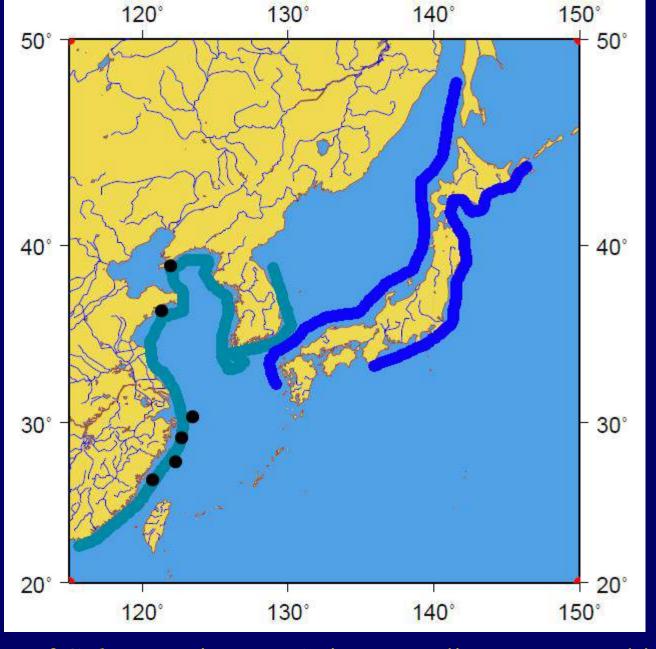
- Predict changes in distribution for the Sargassum horneri under a particular global warming scenario
- Present some of the expected consequences associated with these changes (yellowtail aquaculture; Sargasssum tenuifolium Yamada)

Materials and method

- Collection of water temperature data in winter and summer to determine temperature tolerance range for Sargassum horneri (surface; 20 yearlong dataset; min-max)
- Surface water temperature predictions drawn from a scenario of global warming ("A2" 2000-2099) developed by the Center for Climate System Research (The University of Tokyo – calculation details available online)

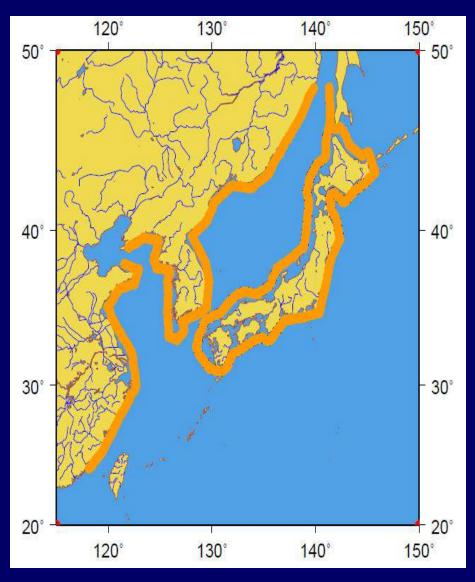
Model output: an example

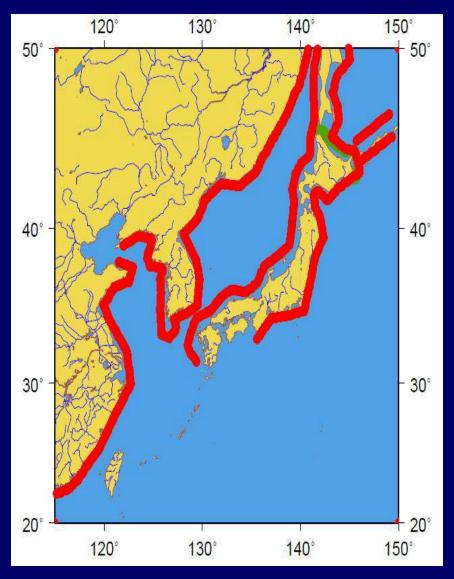
20001	15.1	116.	117.	118.	119.	120.	121.	122	123.	124.	125.	128.	127.	128.	180.	180.	131.	132.	133.	134.	135.	138.	137.	138.	139.	140.	141.	142.	143.	144.	145.	148.1	147.	148.	149.149.5E
49.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15	15	15	15	15	15	1.5	1.5	1.5	1.5	1.5	1.5	15	15	1.5	1.5	1.5	0.4	-1	-0	0.8	1.5	1.5	-1	-2	-2	-2
48.5	1.5	15	1.5	1.5	15	15	1.5	1.5	15	15	15	1.5	15	15	1.5	1.5	15	1.5	1.5	1.5	15	15	1.5	1.5	1.5	1.1	0.6	1.5	1.8	1.5	1.5	± 1	-2	-2	-2
47.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1,5	15	15	1.5	1.5	15	15	1.5	1.5	1.5	1.5	1.5	1.5	15	15	2	3.3	3.5	3.5	3.6	4	3.8	3.3	3.1	-0	-2	-2	-2
46.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1,5	1.5	1,5	1,5	1.5	15	15	1,5	1,5	1.5	1.5	1.5	1,5	15	1.5	2.8	- 6	6.5	- 7	7.3	7.2	7.1	6.9	6.5	2.3	4	-2	-2
45.5	1.5	1,5	1.5	1,5	1,5	1.5	1.5	1,5	15	15	1,5	1,5	15	15	1,5	1.5	15	1.5	15	1.5	15	15	3	6.7	7.6	8.5	9.3	9.1	8.8	8.6	8.5	6.4	3.1	-0	-1
44.5	1.5	1,5	1.5	1,5	1.5	1.5	1.5	1,5	15	1.5	1,5	1,5	1.5	1.5	1,5	1.5	1.5	-0	1.5	4.5	4.8	- 5	5.9	7.7	8.7	9.7	10	7.2	5.2	4.1	4.1	6.7	6.1	3.1	1.7
	1.5	1,5	1.5	1,5	1.5	1.5	1.5	1,5	15	15	1,5	1,5	15	15	1,5	1,5	15	3.4	52	6.7	7,1	7.6	8.1	8.9	1.7	10	9.7	2.9	1.4	1,5	1.5	6.2	7.5	59	4.7
42.5 1	1.5	1,5	1.5	1,5	1,5	1.5	1,5	1,5	15	1,5	1,5	1,5	15	15	1.5	1.5	1.8	5.3	7.2	7.9	8.6	92	9.8	10	11	11	9.7	1.5	0.8	1.5	1.5	6.2	8	72	6.6
	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	4.3	6.5		7.8		9.8	11	11	_11	-11	12	7.9	2.4	1.5	4.8	7.8	8.2	8.7	8.7	8.4	8
	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15	1.5	1.5	1.5	1.5	1.5	- 5	7.9	8.9	10		12	12	12	12	12	12	7.6	1.5	1.5	- 6	10	11	11	11	11	10
39.5	1.5	1.5	1.5	1.5	1.5	15	1.8	18	1.8	1.8	1.8	1.5	15	15	5.9	9.6		13	13	13	13	13	13	12,	12	7.4	1.5	1.5	7.5	13	14	14	14	14	13
	1.5	1.5	1.5	1.5	1.5	1.8	3.1	3.4	3,6	3.6	3.7	2.7	1.5	1.5	6.9		13	14	14	14	14	14	10	1.5	1.5	1.5	1.5	1.5	8.4	14	15	16	18	16	15
37.5	1.5	1.5	1.5	1.5	1.5	1.8	3.1	3.5	3.6	3.6	4	31	15	15	7.9	13	14	-15	15	-14	-14	-14	11	18	1.5	15	15	1.5	9.2	18	17	17	17	17	17
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	15	15	15	1.5	1.5	2.3	5.4	41	44	7.3	7.4	6.6	6.8	11 12	13	-14	15	5.2	1.5	1.5	15	15	1.5	1.5	1.5	7.5	16	1/	1/	18	18	19	19	18	18 19
34.5	1.0	1.0	1.5	1.5	1.5	4.0	5.7	1.1	8.7	2.1	9.7	9.4	2.7 40	12	13	14	17	- 21	0.0	1.2	0.5	0.5	0.5	1.2	1.0	8.1	10	10	18	19	19	13	19	19	19
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	1.5	1.0	1.0	1,0	1.0	1.0	1.5			14	10	12	19	40	40	10	10	10	10	10	10	10	10	10	10	10	19	10	10	40	10	100	100	46	10
ALC: N	1.5 1.5	15	1.5	1.5	1.5	1.5	1.5	1.5	5.4	15	17	10	10	10	10	10	10	10	10	10	19	10	10	10	10	10	10	10	19	10	10	10	10	10	10
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	15	1.5	2.2	11	17	20	22	22	23	22	21	21	20	20	20	20	20	20	20	20	20	21	21	21	21	21	22	22	22	22	22	22	22	22	22
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22.5	7.3	7.4	8.3	18	22	23	23	23	23	23	22	22	21	22	22	22	22	22	22	22	23	23	23	23	23	23	23	23	24	24	24	24	24	24	24
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Distribution of *S. horneri* in East Asia according to Umezaki (1984), Tseng (2000), Komatsu et al. (2006)

Predictions for 2006, according to A2 model

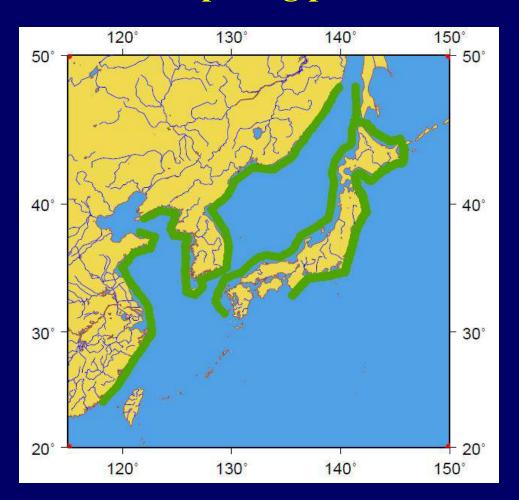


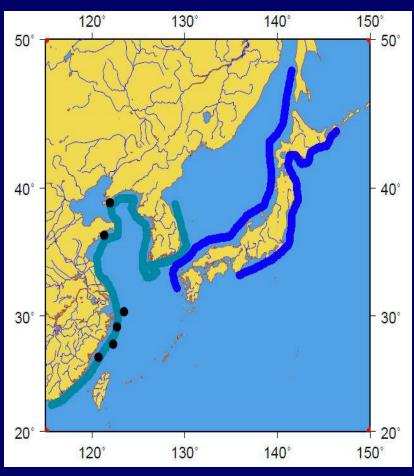


February 2006

August 2006

Comparing predictions with observations (2006)



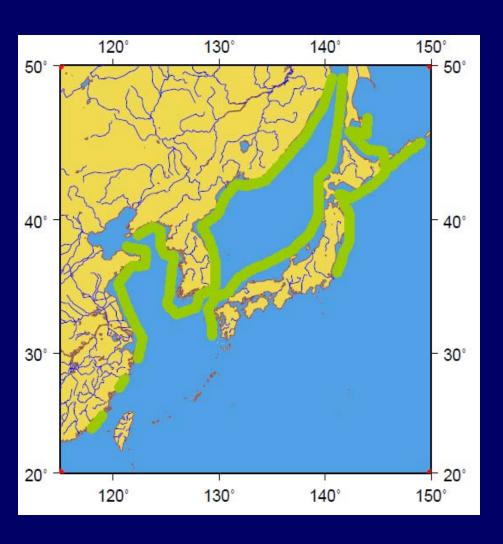


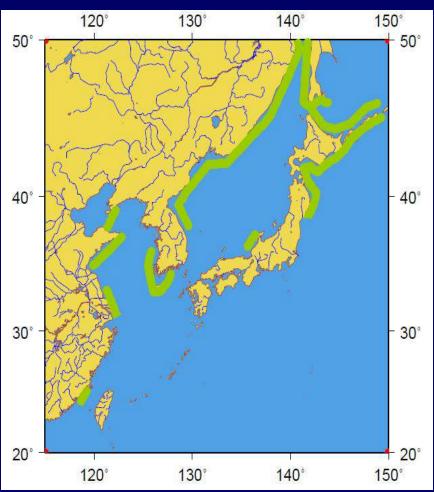
A2 model (combined)

Observations

Differences = lack of data + rough environment (limit) Hence, predictions = realistic but OVERESTIMATION

Predictions: 2050 and 2099

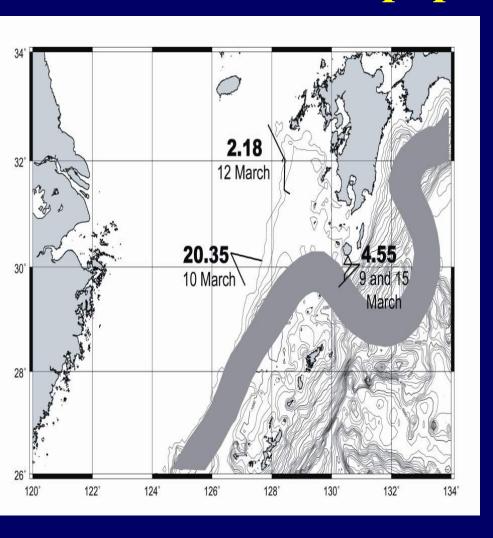


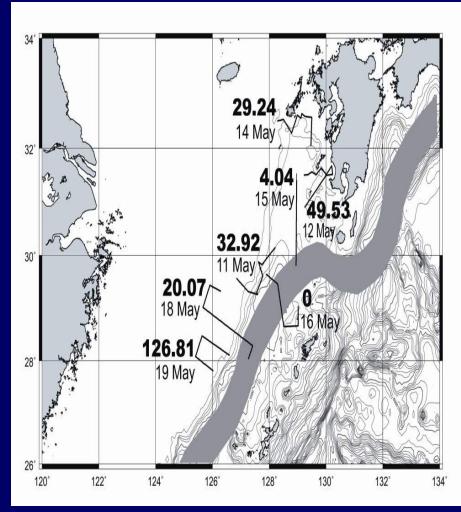


2050 2099



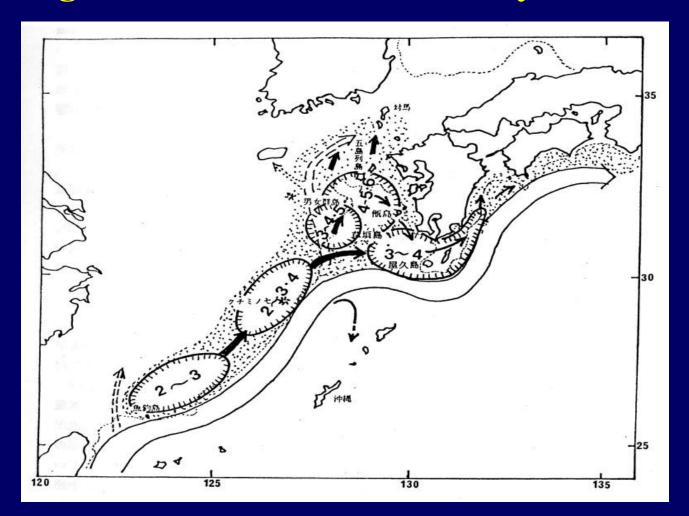
The Chinese population importance





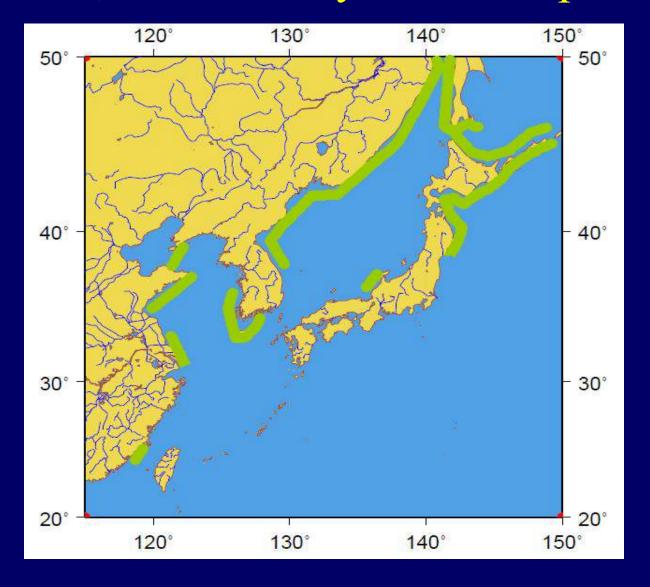
Distribution of drifting *S. horneri* in East China Sea observed from R/V Hakuho-maru in 2006. Standing stock (wet kg km⁻²)

Yellowtail spawning grounds and drifting Sargassum horneri are closely related



Location of yellowtail spawning grounds throughout months according to Shinami (1982)

In 2099, where will yellowtail spawn?



Interesting projection with regard to the current aquaculture projects

Which species may benefit from *S. horneri* disappearance?

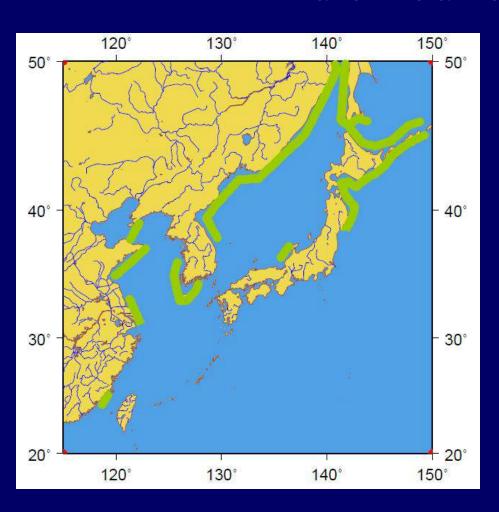


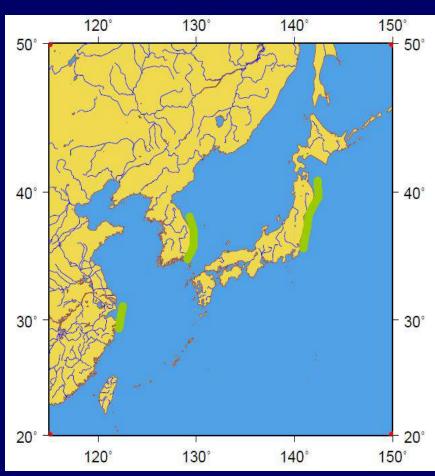
Sargasssum
tenuifolium Yamada
appears as one of the
possible candidates

Species living traditionally in subtropical waters

Already recorded in some southern areas

S. horneri and S. tenuifolium expected distributions in 2099





Sargassum horneri

Sargassum tenuifolium

Summary

- The abundance of *S. horneri* is expected to decrease significantly by 2099, remaining primarily in northern areas.
- As a result, the abundance of drifting seaweed along the Kuroshio current is expected to drop as well.
- •As yellowtail spawning grounds and juvenile survival rate are closely related to these drifting seaweeds, a shift in behaviour is expected.
- Gaps left by S. horneri are expected to be bridged by sub-tropical species like Sargassum tenuifolium