PICES S14 2019/10/22

Dispersal pathways of Japanese glass eel in the East Asian continental shelf and its sustainable use

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Outline

1. Dispersal pathways of Japanese glass eel in the East Asian continental shelf

2. Sustainable use of the eel resource

19 *Anguilla* eels in the world

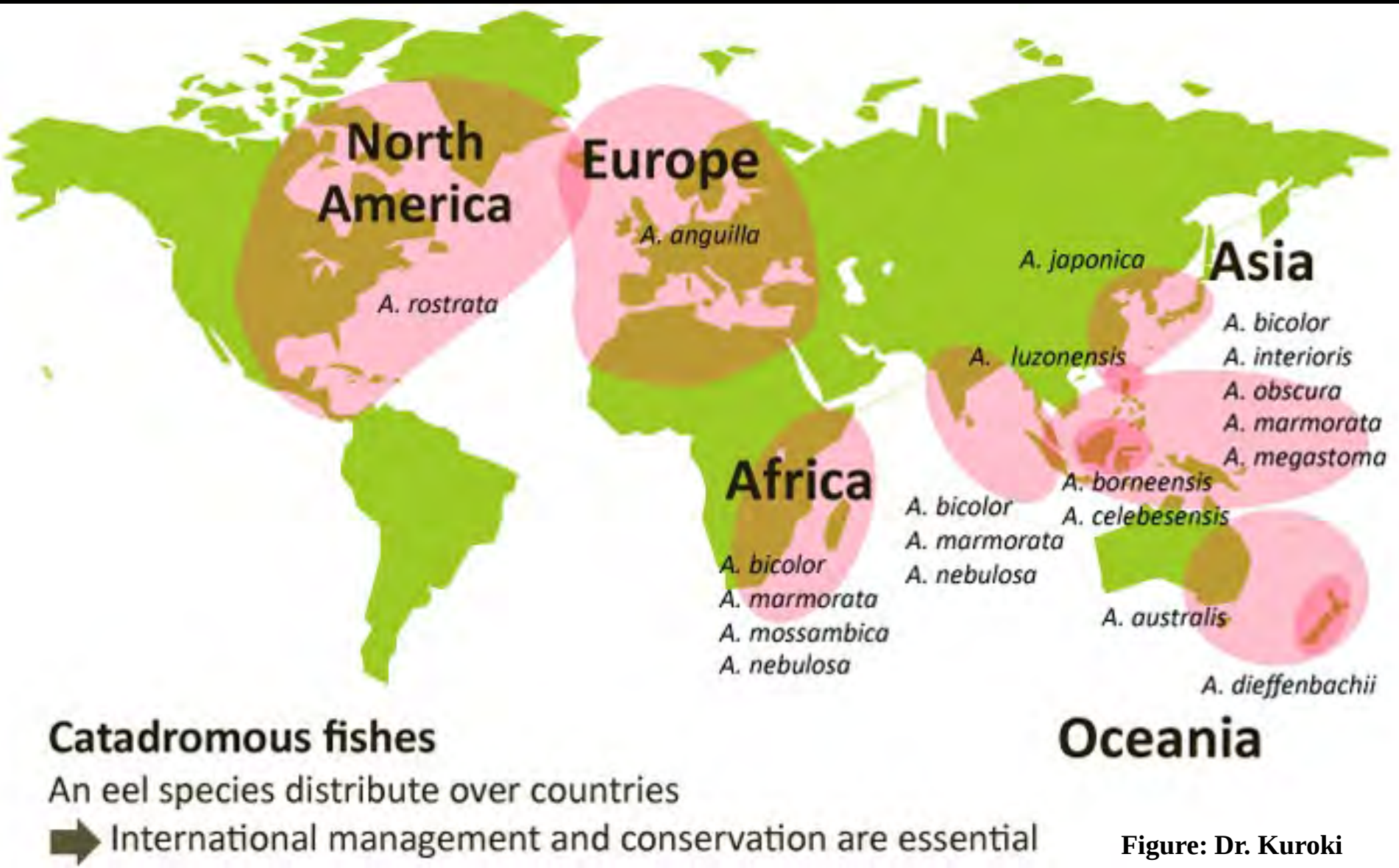


Figure: Dr. Kuroki

Eel life cycle

Glass eel

Catch for aquaculture

Leptocephalus

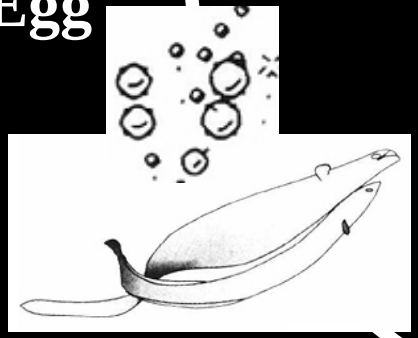
Yellow eel

Catch for food

Ocean

Continent

Egg



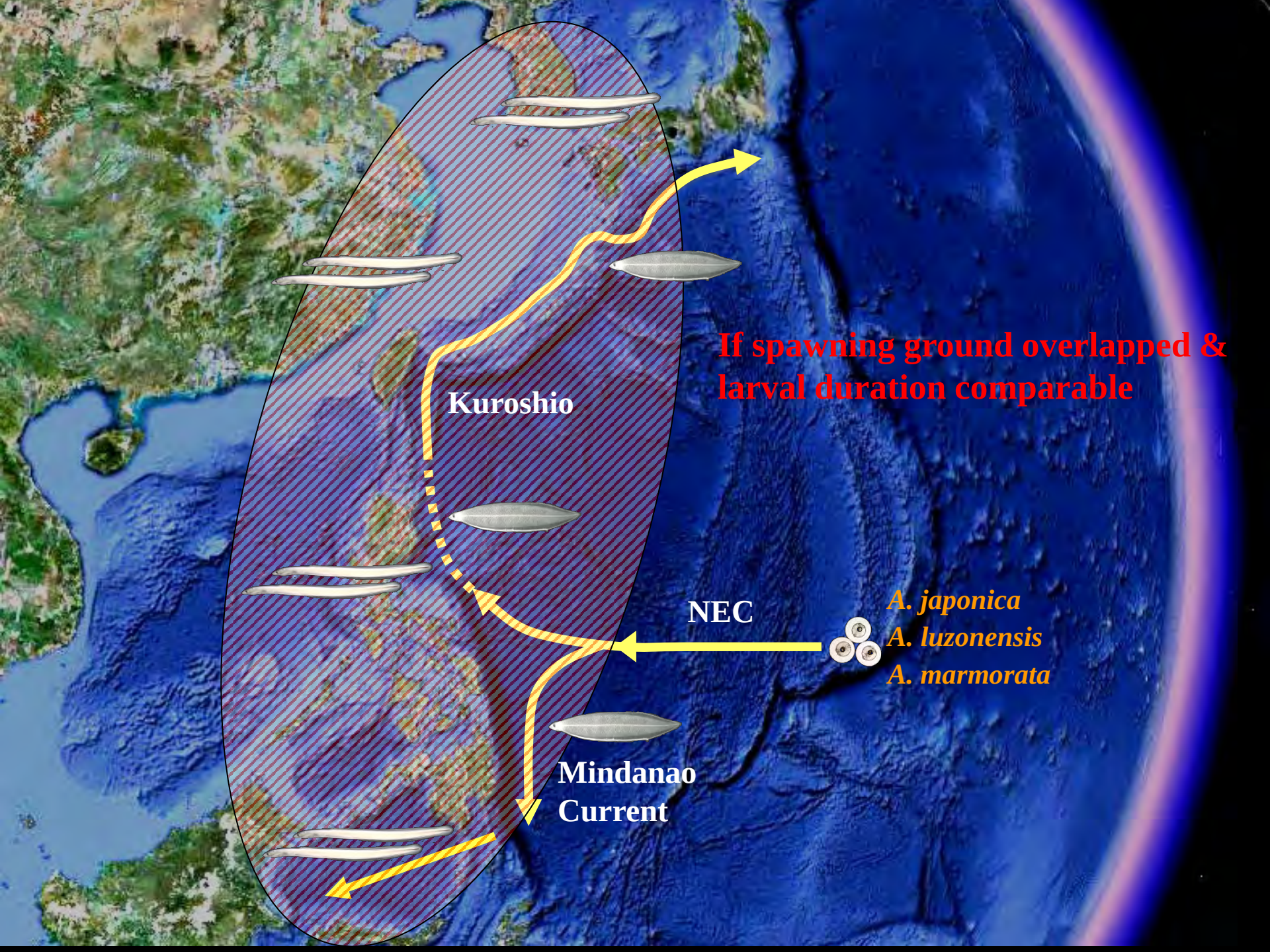
Spawning

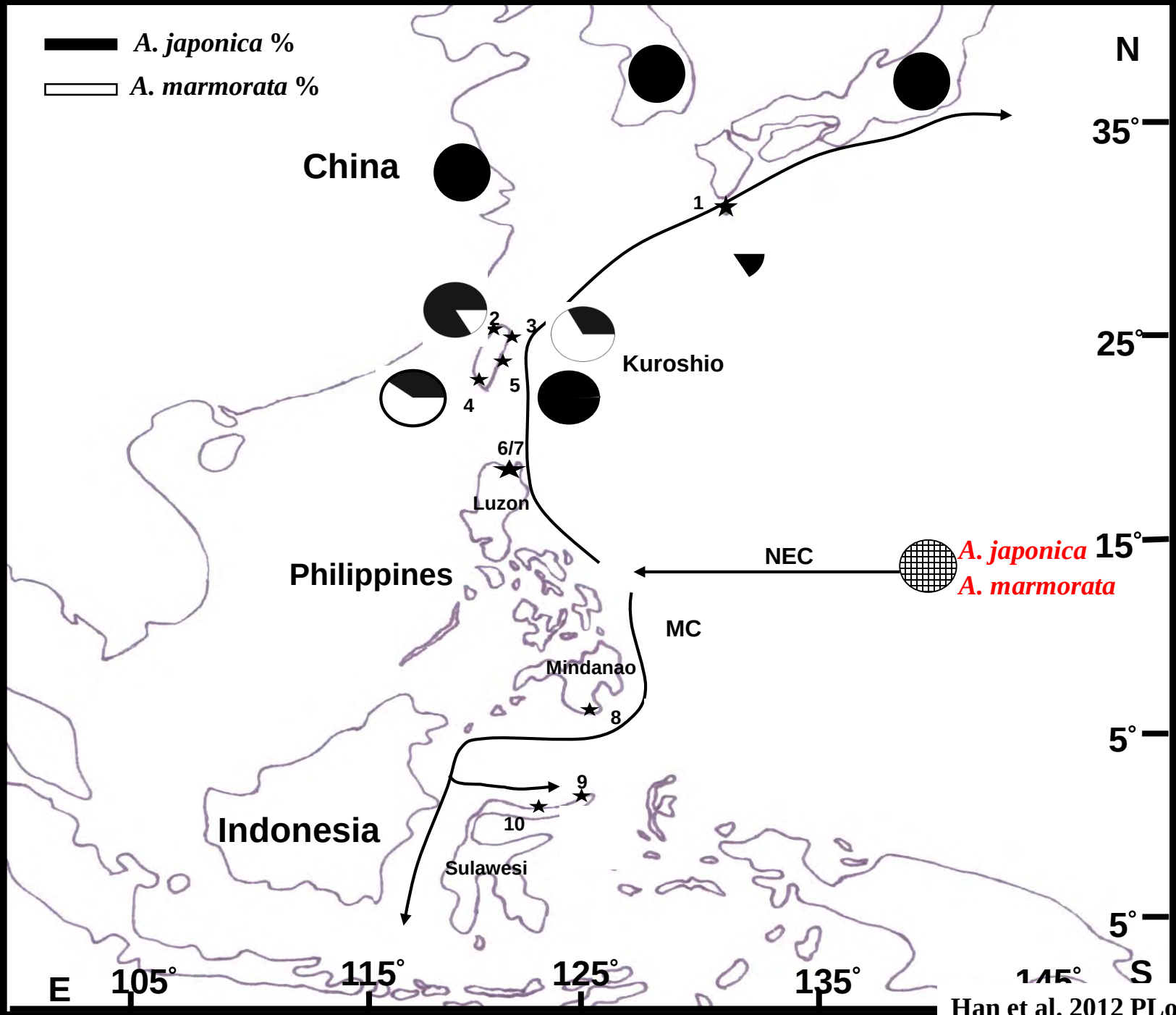
Silver eel

Catch for food

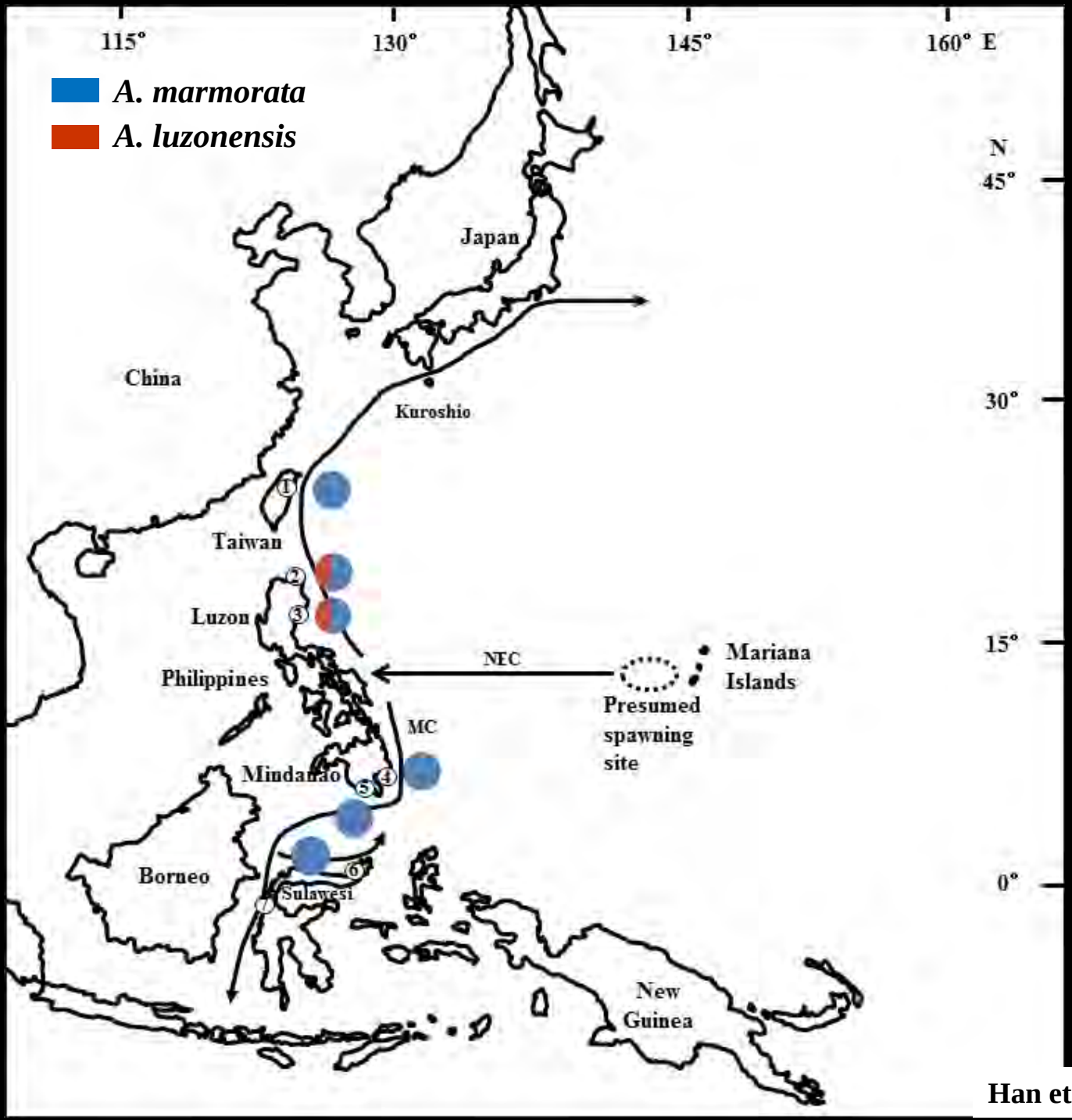
Important factors of eel biogeography

1. Spawning location
2. Length of larval duration
3. Spawning time
4. Temperature preference
5. Oceanic current availability


If spawning ground overlapped & larval duration comparable
Kuroshio
NEC
A. japonica
A. luzonensis
A. marmorata
Mindanao Current

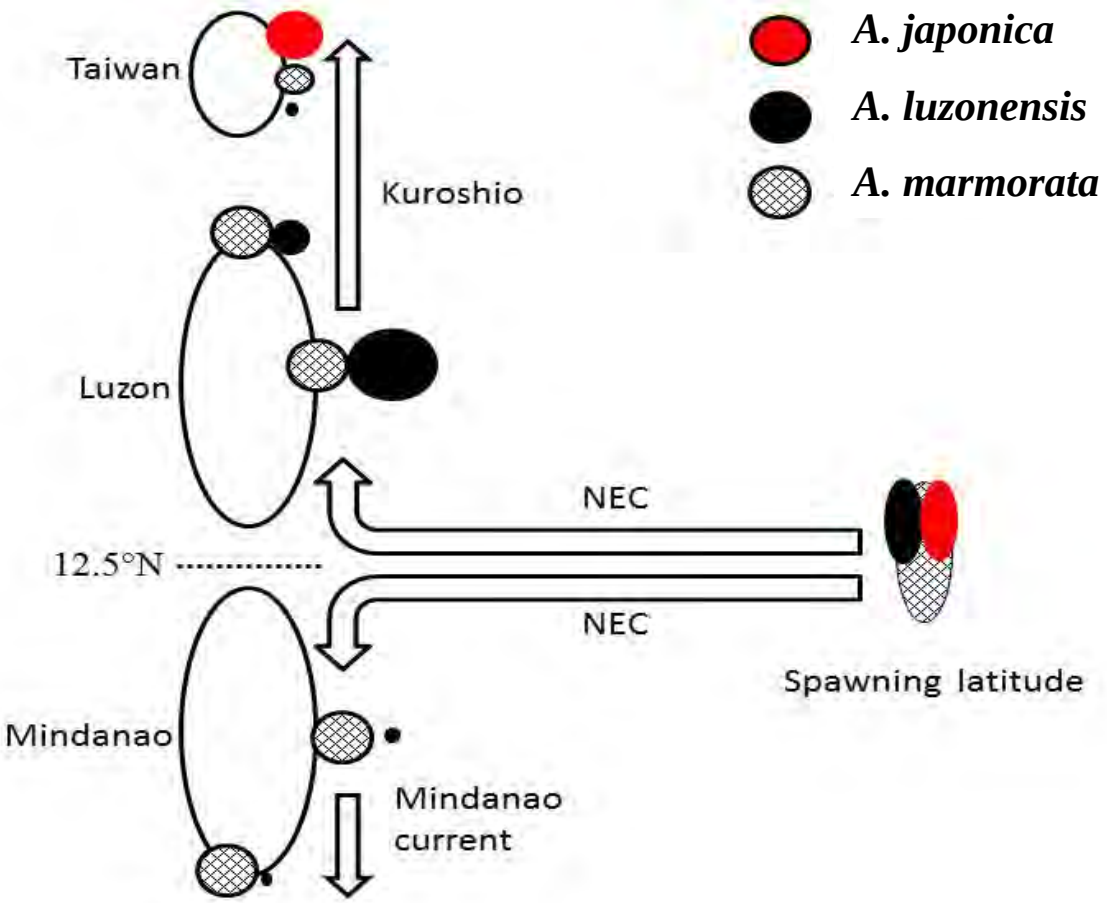


Han et al. 2012 PLoS ONE



Han et al. 2016 MEPS

Spawning site and dispersal range

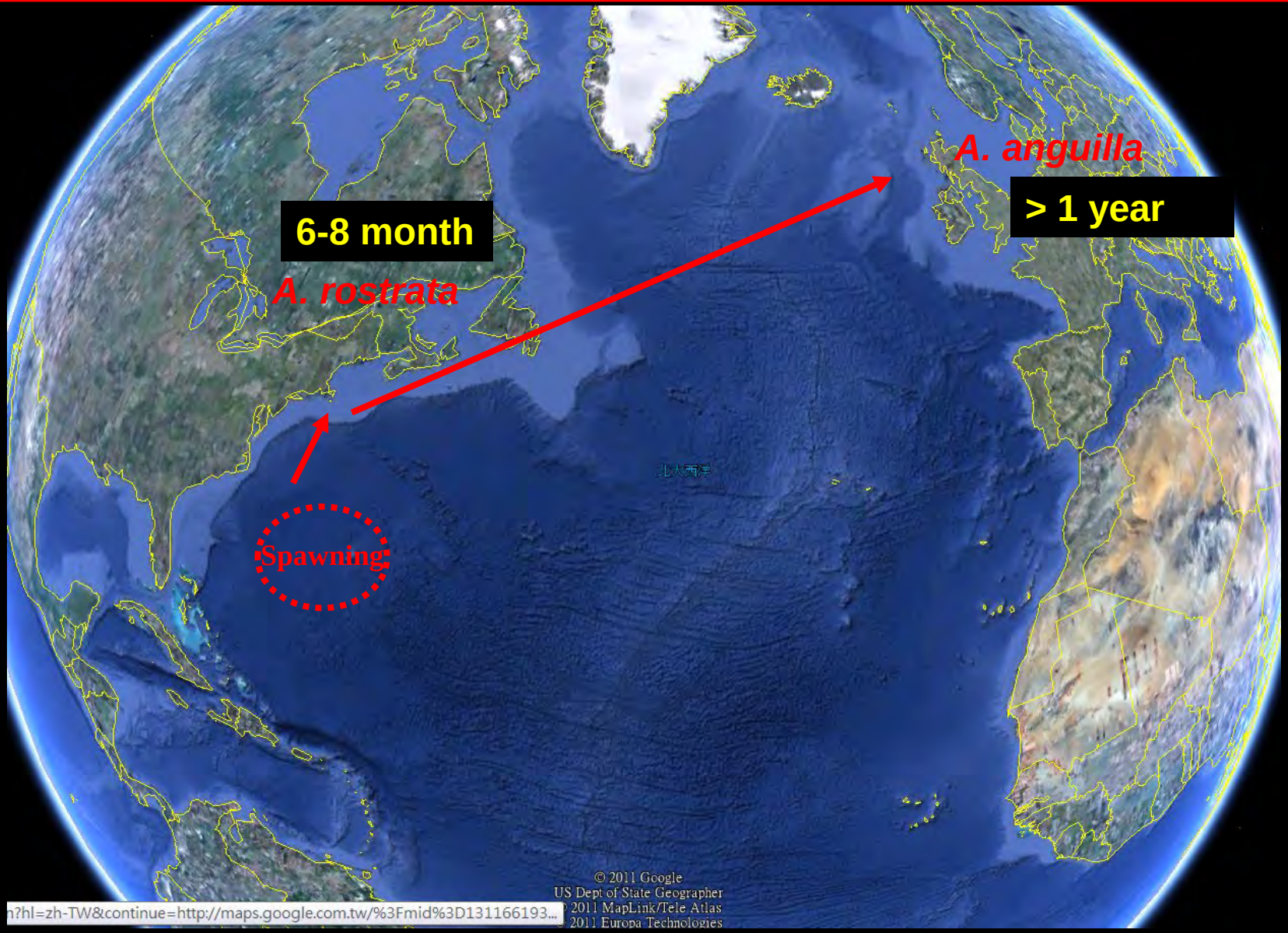


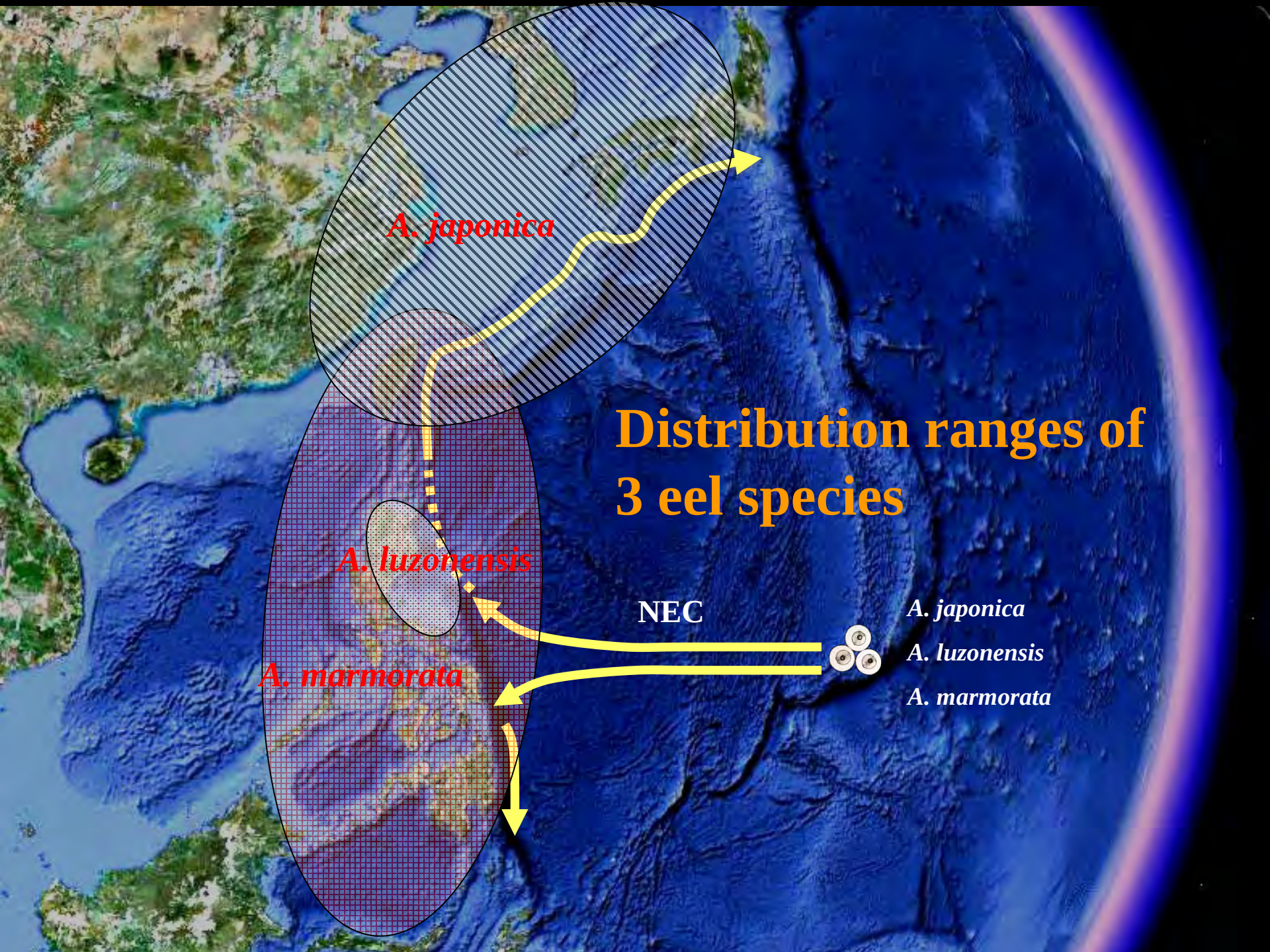
Han et al. 2016 MEPS

Important factors of eel biogeography

1. Spawning location
2. Length of larval duration
3. Spawning time
4. Temperature preference
5. Oceanic current availability

Segregation of American and European eel




A. japonica
A. luzonensis
A. marmorata
Distribution ranges of 3 eel species
NEC
A. japonica
A. luzonensis
A. marmorata

Eel otolith age

Table 1 Sampling and age information of *Anguilla japonica* and *Anguilla marmorata* specimens analyzed in this study

Species	Sampling site	Sampling date	Number	Total length (mm)	Age (days)		
					T_m	T_t	T_{t-m}
A. japonica[a]	Tungkang River, Taiwan	30 December 1992	30 (16)	57.0 ± 2.0	138.7 ± 14.3	177.7 ± 17.8	39.0 ± 11.2
		24 March 93	30 (14)	56.1 ± 2.4	134.0 ± 14.1	174.4 ± 17.9	40.4 ± 11.0
near	Shuangshi River, Taiwan	20 December 92	30 (12)	56.8 ± 2.3	135.7 ± 16.6	175.0 ± 20.9	39.5 ± 9.2
		17 February 93	30 (13)	55.9 ± 2.2	128.9 ± 14.6	174.4 ± 17.7	45.5 ± 13.4
	Mingchiang River, China	1 March 93	30 (20)	55.1 ± 1.9	139.6 ± 10.1	172.1 ± 14.1	32.5 ± 7.7
	Chyantarng River, China	17 February 93	30 (23)	55.6 ± 1.9	148.1 ± 14.7	194.9 ± 18.6	46.8 ± 8.9
	Yalu River, China	3 May 93	30 (23)	58.3 ± 1.8	157.4 ± 16.1	199.3 ± 15.6	41.9 ± 3.9
far	Ichinomiya River, Japan	10 January 94	30 (10)	57.4 ± 2.3	143.3 ± 7.9	186.6 ± 7.0	43.3 ± 5.2
Overall (μ_1)			240 (131)	56.5 ± 2.1	140.7 ± 13.6	181.8 ± 16.2	41.1 ± 8.8
A. marmorata	Cagayan River, the Philippines	19 May 08	45 (13)	49.5 ± 1.5	110.4 ± 12.8	144.8 ± 14.2	34.3 ± 7.9
	Hsiukuluan River, Taiwan	20 May 08	86 (13)	51.6 ± 1.6	112.4 ± 12.3	134.0 ± 15.4	22.6 ± 6.6
	Kurio River, Japan	6 June 96	37 (15)	46.7 ± 1.7	117.7 ± 16.8	145.0 ± 17.8	27.3 ± 8.9
Overall (μ2)			168 (41)	49.3 ± 1.6	113.5 ± 13.0	141.6 ± 15.8	28.1 ± 7.8
Difference ($\mu_1 - \mu_2$)				7.2	27.2	40.2	13.0
Significance				*A. japonica* > *A. marmorata*	*A. japonica* > *A. marmorata*	*A. japonica* > *A. marmorata*	*A. japonica* > *A. marmorata*

Leander et al. 2013 ZS

Eel otolith age

Locations	Sampling date	n	Age*	Presumed birth month
A. marmorata				
Baler, Philippines	Sep. 2013	10	110.1 ± 6.0[a]	May/Jun.
Cagayan, Philippines	May 2008	13	143.0 ± 11.1[b]	Dec.
Gen. San., Philippines	Sep. 2013	15	140.7 ± 6.6[b]	Apr./May
Siouguluan River, Taiwan	May 2008	12	146.1 ± 14.1[b]	Dec.
A. luzonensis				
Baler, Philippines	Sep. 2013	20	116.2 ± 6.4[a]	May
Cagayan, Philippines	Sep. 2009	15	127.2 ± 7.5[b]	Apr./May
Gen. San., Philippines	Jul. 2013	13	137.9 ± 10.7[b]	Feb./Mar.
Siouguluan River, Taiwan	Oct. 2010	16	137.0 ± 8.3[b]	May/Jun.

near

far

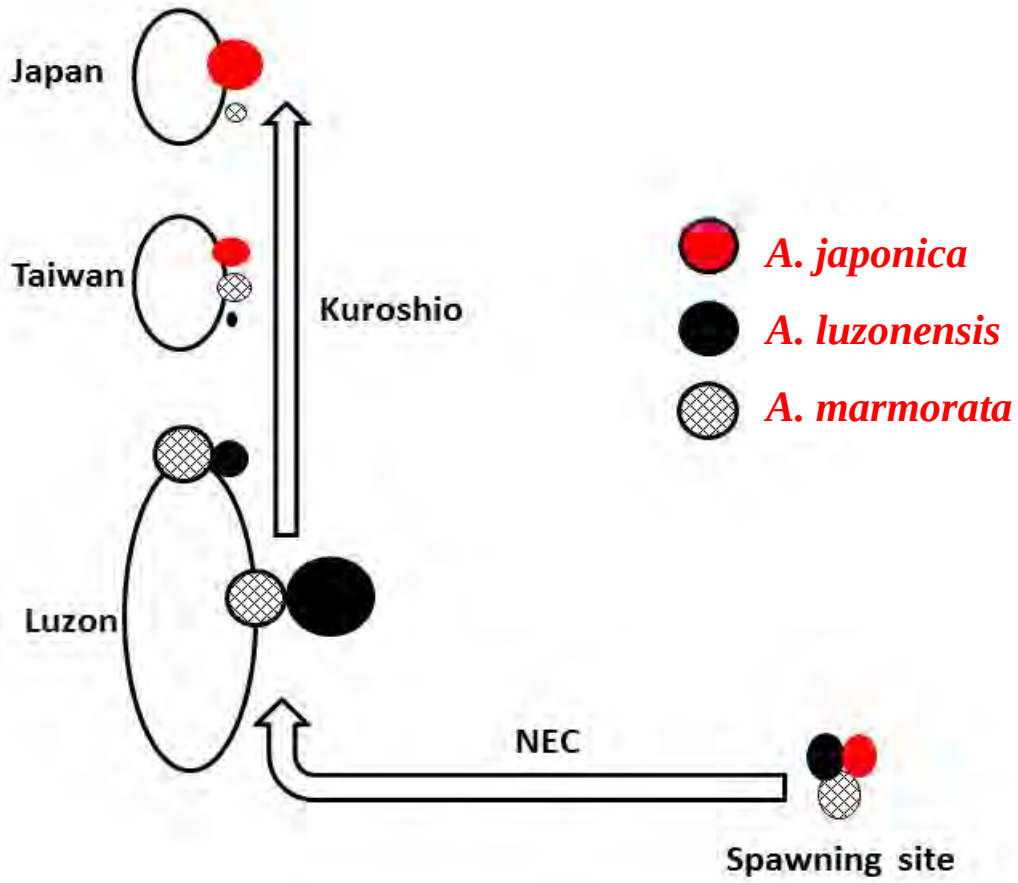
near

far

*The 9 d of the preleptocephalus stage were added to the total age.

Han et al. 2016 MEPS

Eel larval duration and distribution



Mean larval duration:

A. japonica* > *A. marmorata* > *A. luzonensis

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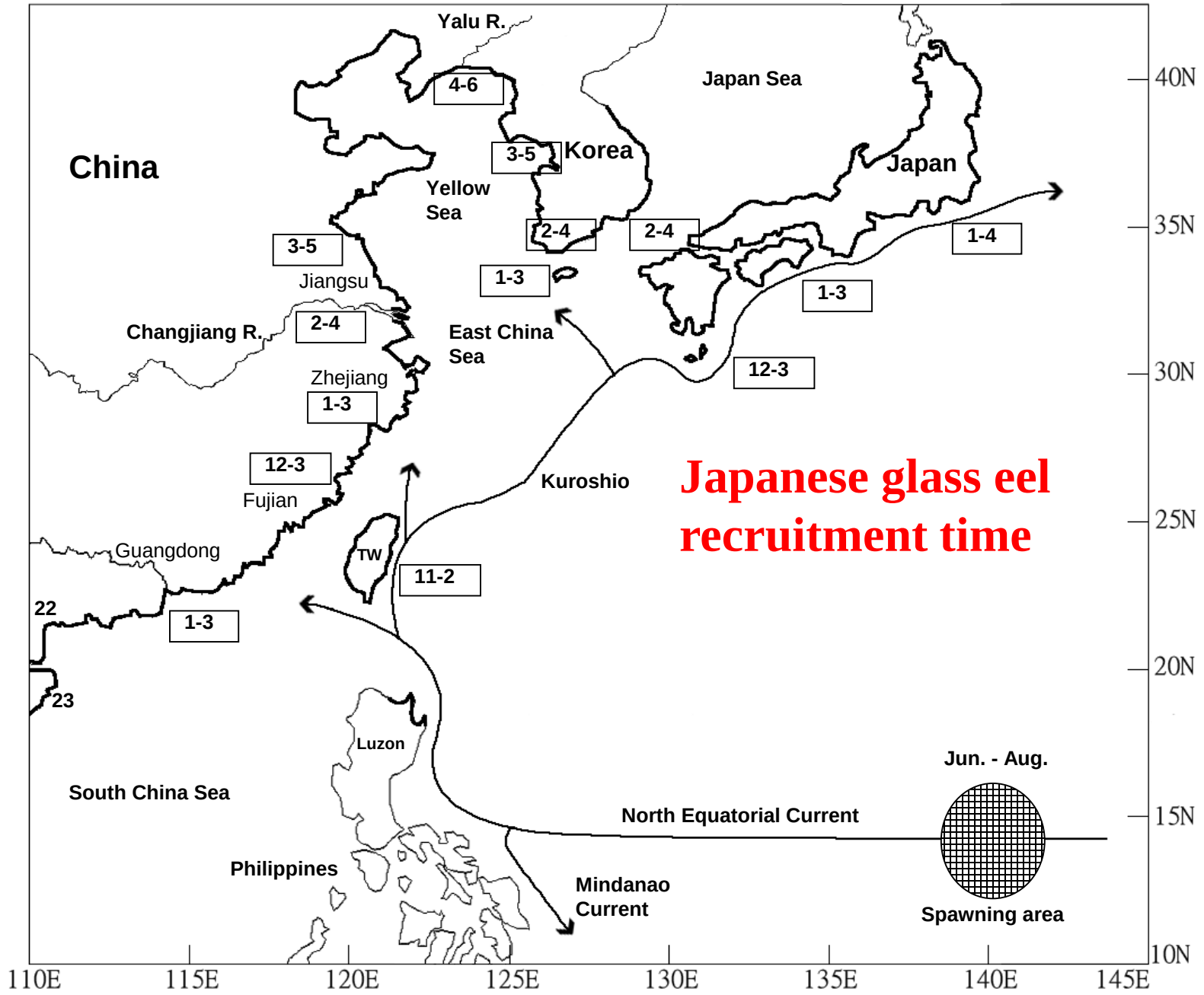
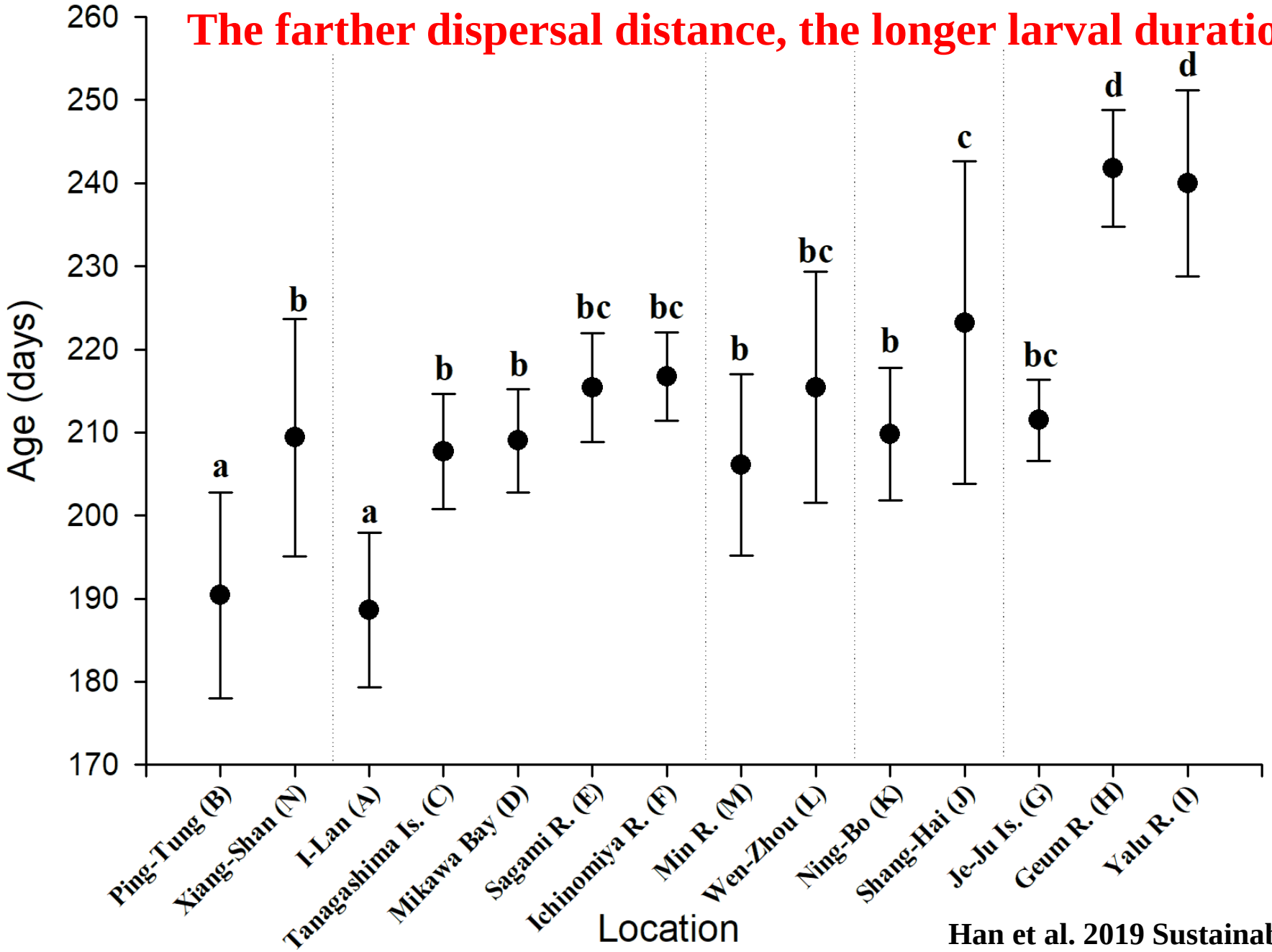


Han 2011 Marine Biology

The farther dispersal distance, the longer larval duration



Han et al. 2019 Sustainability

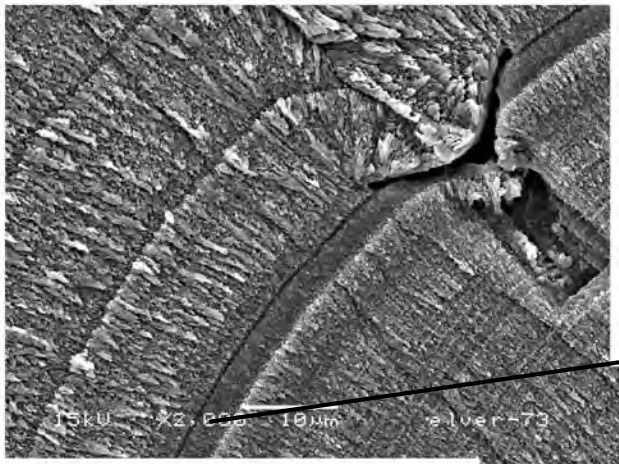
Estimated age and otolith age of Japanese glass eel

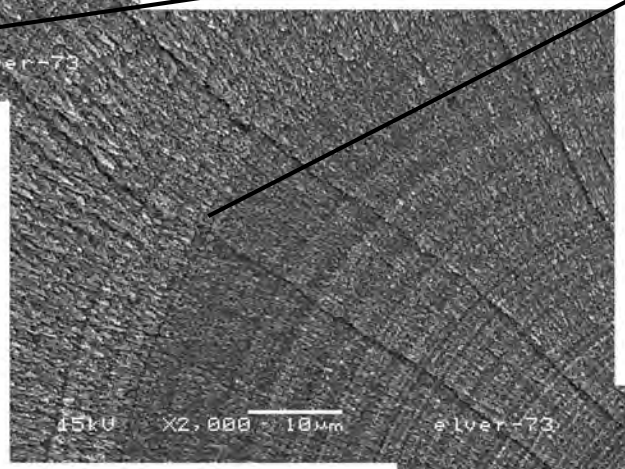
Sampling Sites (code)	Estimated Age (day)	Counted Otolith Age * (day)	Time Difference (day)	Body Weight (Pieces per Kg)
I-Lan (宜蘭)	180	188.6 ± 9.3	0–10	5000–5500
Ping-Tung (屏東)	190	190.4 ± 12.4	0–10	5000–5500
Tanegashima Island (種子島)	200	207.7 ± 6.9	0–10	5000–5500
Mikawa Bay (三河灣)	210	209.0 ± 6.2	0–10	5500–6000
Min River (閩江)	210	206.1 ± 10.9	0–10	5500–6000
Sagami River (相模川)	220	215.4 ± 6.5	0–10	5500–6000
Ichinomiya River (一宮川)	220	216.7 ± 5.3	0–10	5500–6000
Wen-Zhou (溫州)	220	215.4 ± 13.9	0–10	6000–6500
Xiang-Shan (廣東象山)	220	209.4 ± 14.3	10–20	6500–7000
Je-Ju Island (濟州島)	220	211.5 ± 4.9	0–10	6000–6500
Shang-Hai (上海)	260	223.2 ± 19.4	30–40	6500–7000
Ning-Bo (寧波)	260	209.8 ± 8.0	50–60	6500–7000
Geum River (錦江)	270	241.8 ± 7.0	20–30	7000–7500
Yalu River (鴨綠江)	330	240.0 ± 11.2	90–100	8000–9000

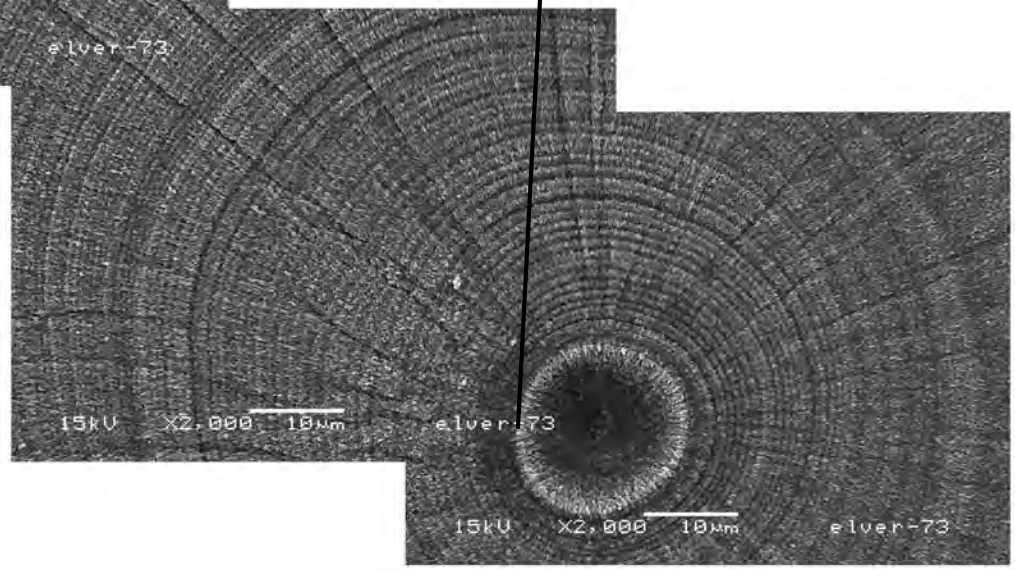
* Unit: Mean ± SD

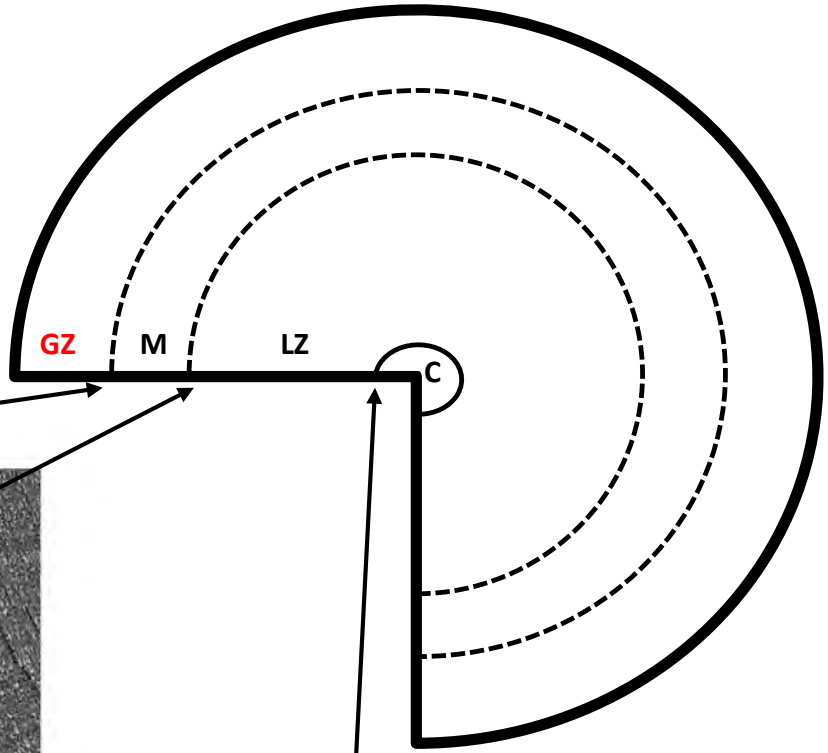
Han et al. 2019 Sustainability

Glass eel zone

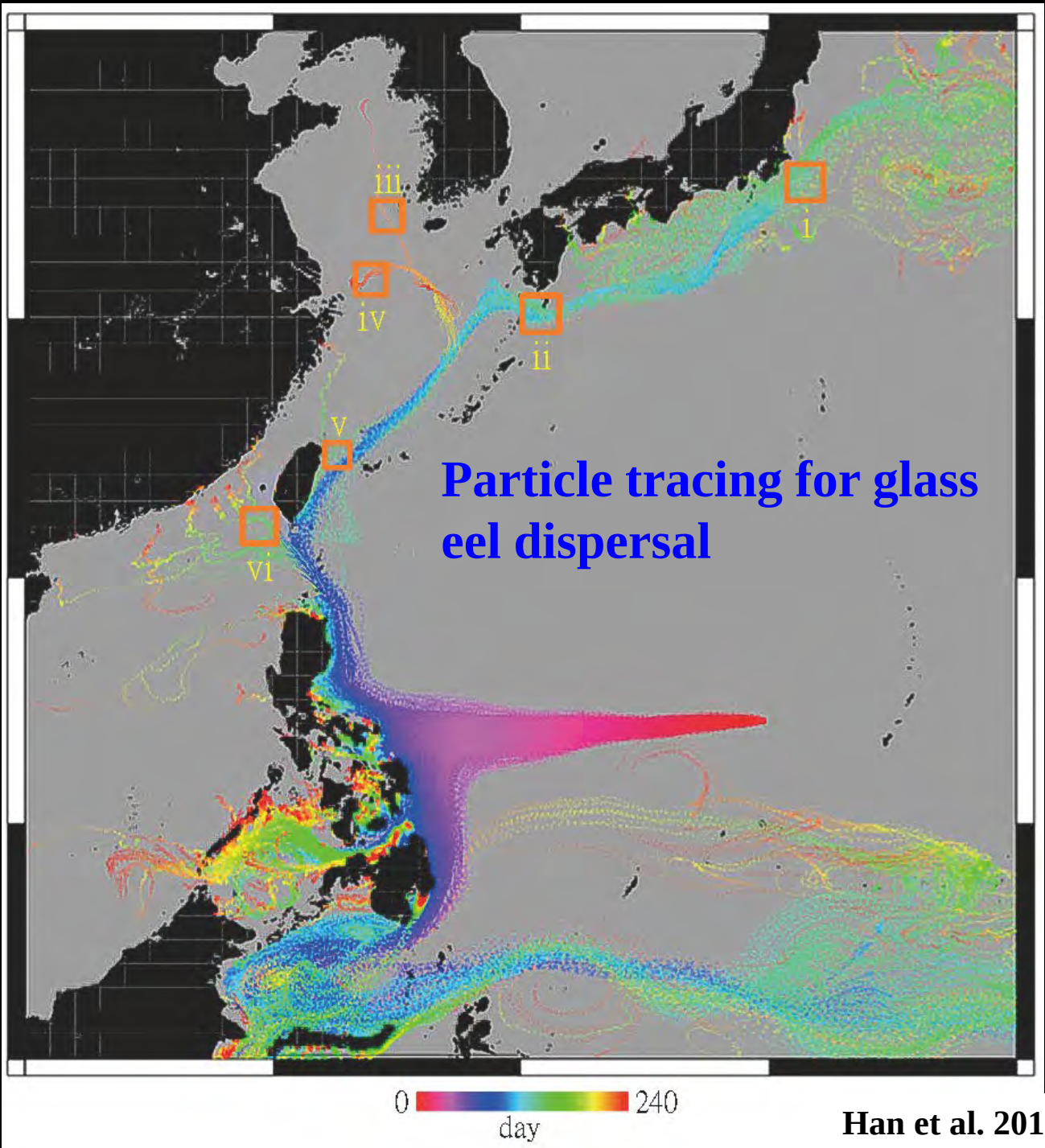




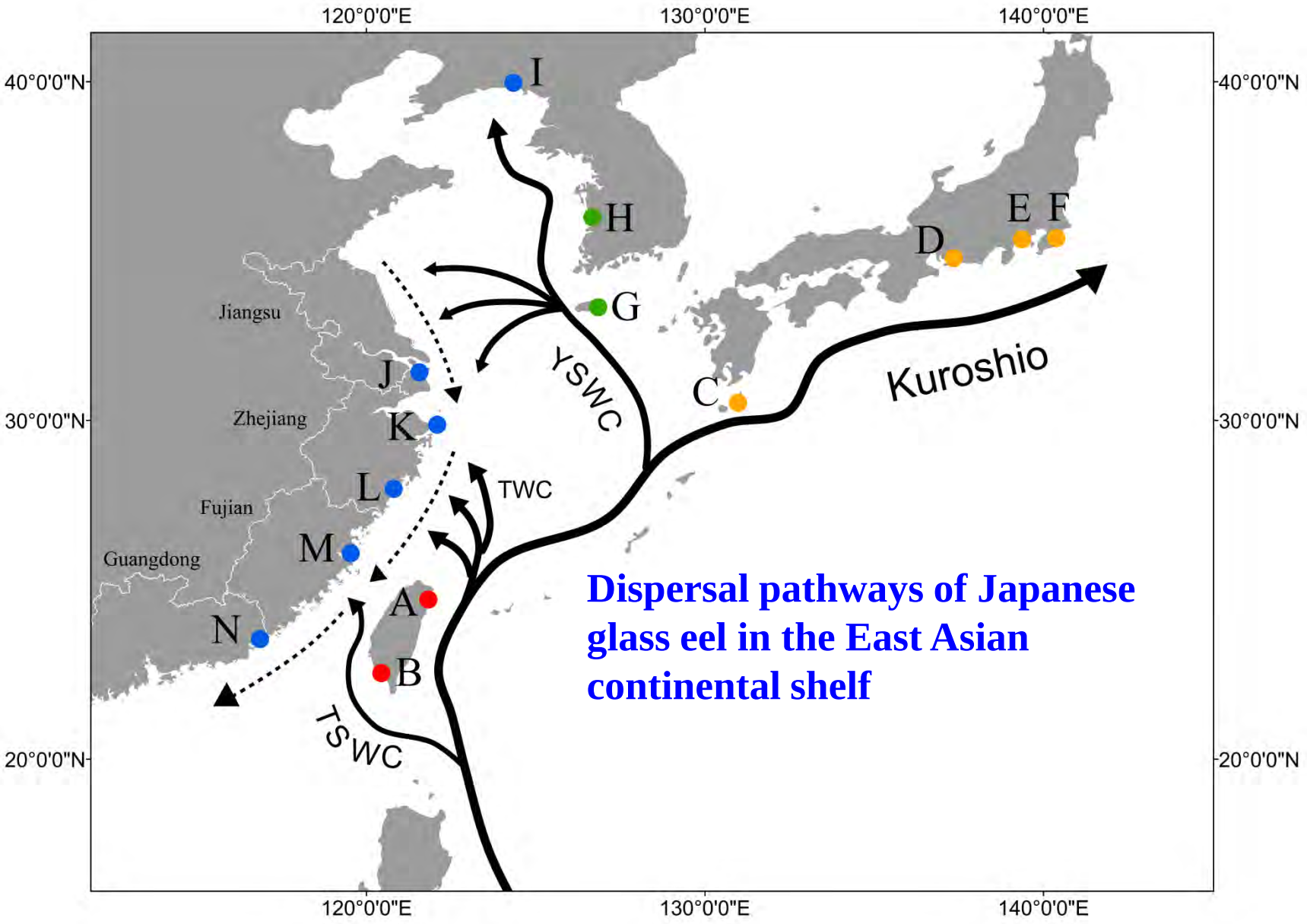




The increment rings in glass eel zone are usually obscure and may stop formation under low temperature.



Han et al. 2019 Sustainability



Han et al. 2019 Sustainability

Outline

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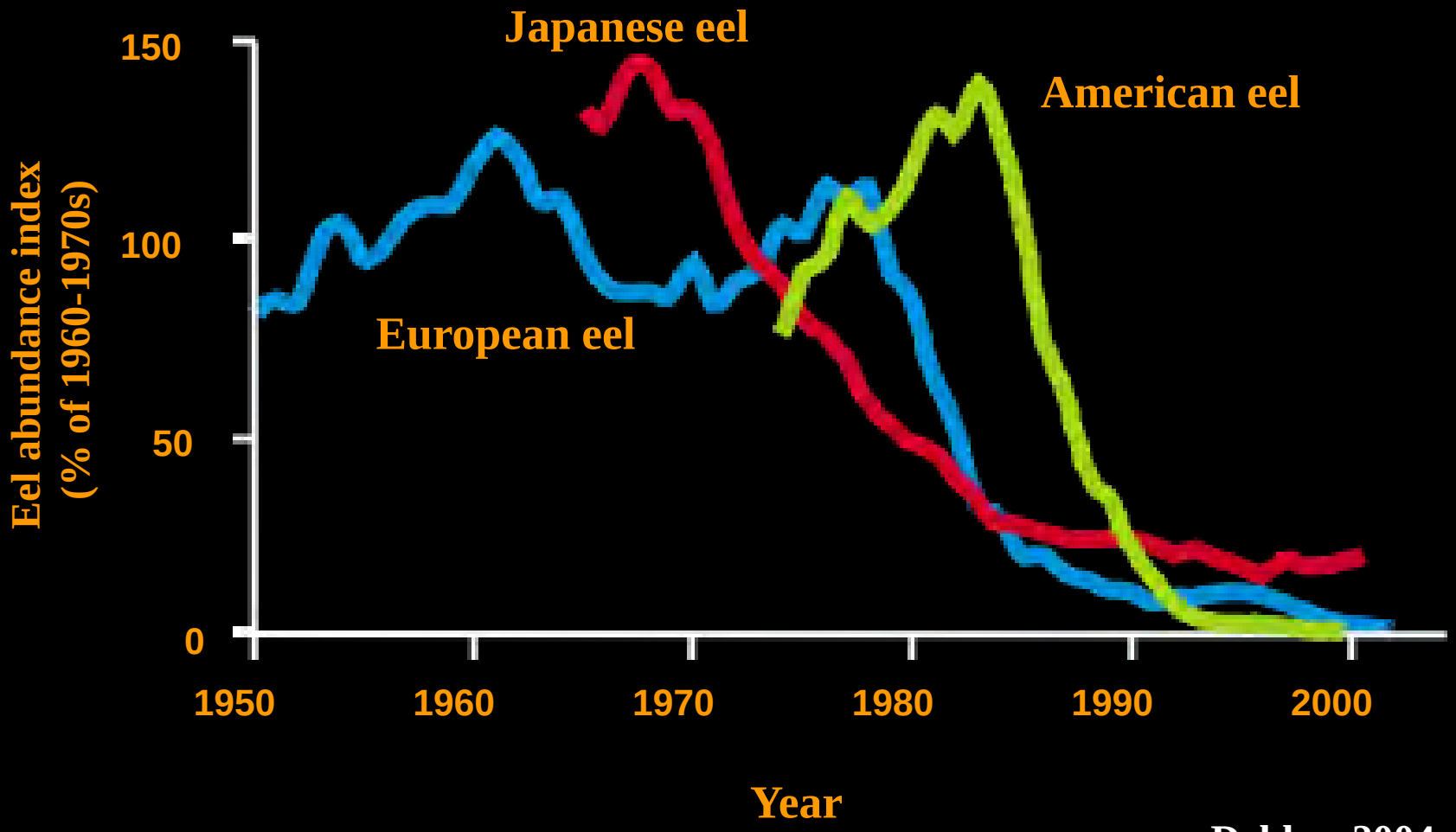
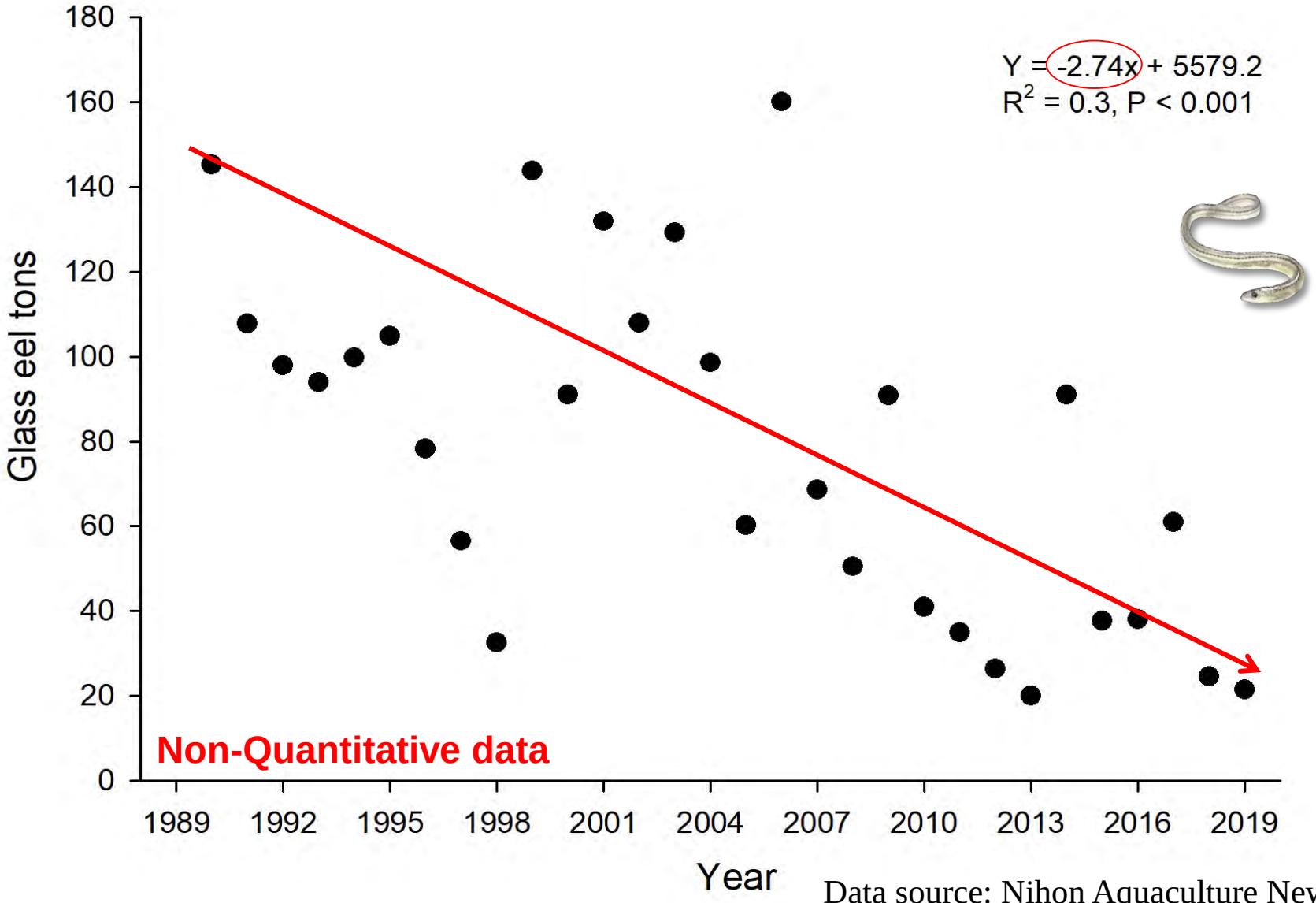
2. Sustainable use of the eel resource

Resource decline in 3 temperate eel species



Dekker 2004

Japanese glass eel catch in East Asia



Data source: Nihon Aquaculture News

Japanese eel listed in IUCN 2014 Red List

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICALLY ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX

Anguilla interioris

Anguilla megastoma

Anguilla obscura

Anguilla nebulosa

Anguilla bicolor

Anguilla celebesensis

Anguilla luzonensis

Anguilla borneensis

Anguilla marmorata

Anguilla mossambica

Anguilla japonica

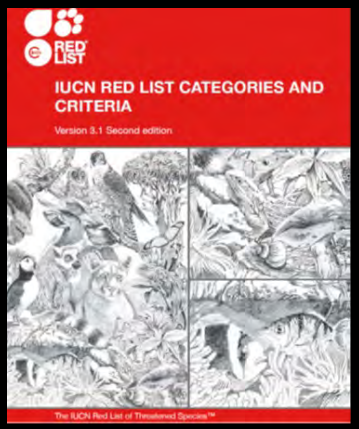
Anguilla rostrata

Anguilla anguilla

→CITES 2007

IUCN 2010

IUCN 2014



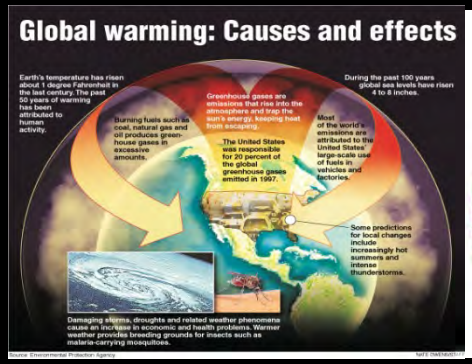
Main aquaculture eel species in the world

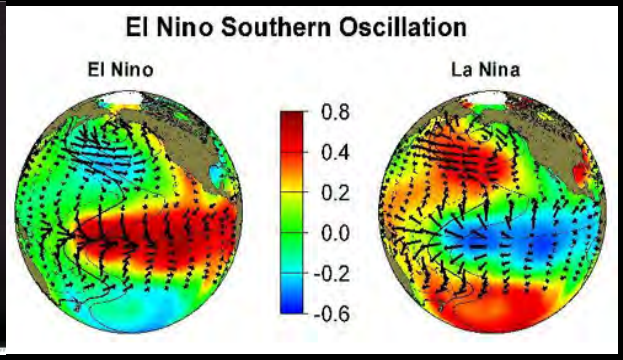
Why does eel resource decline ?

Habitat destruction

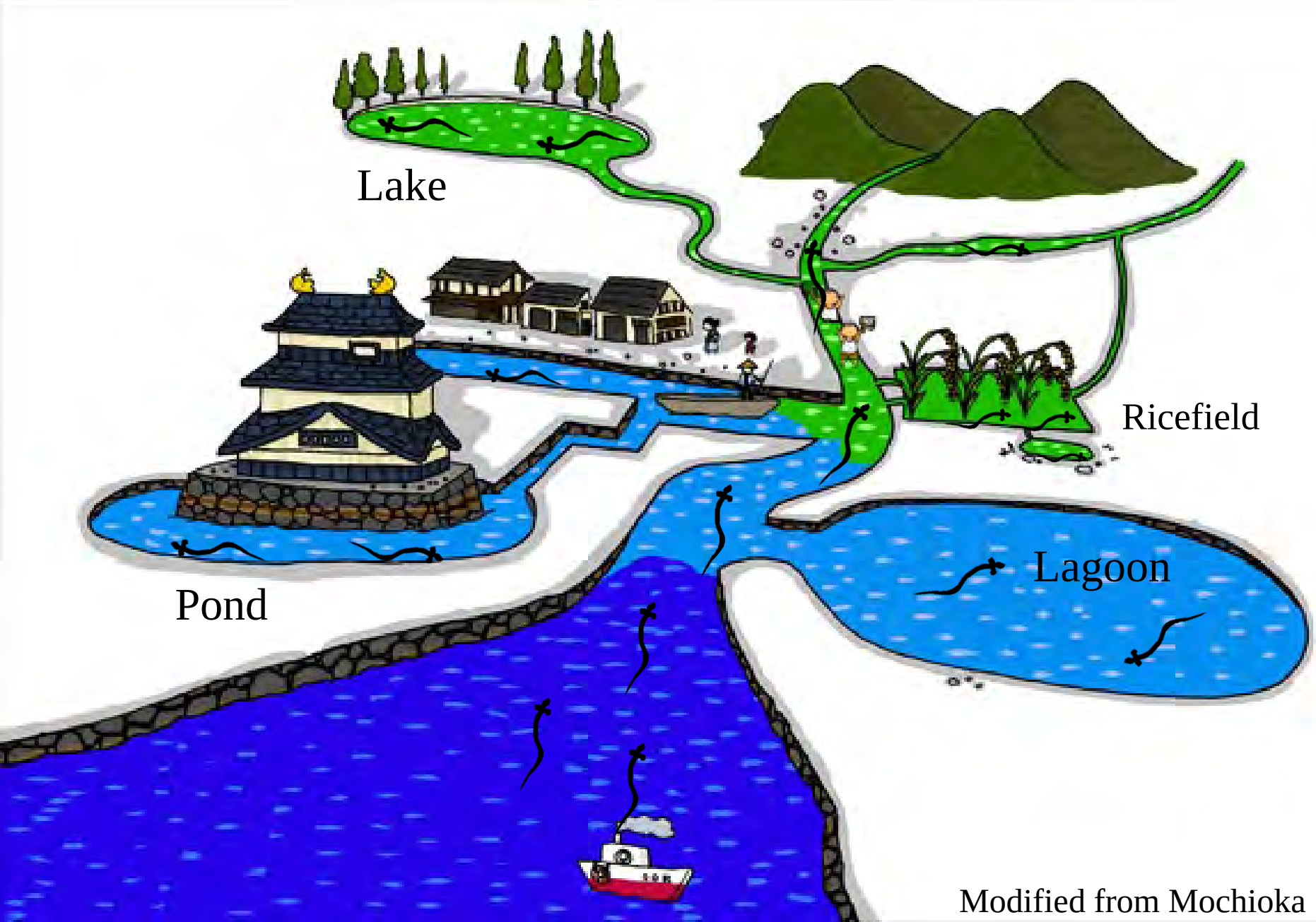
Overfishing

Global climate change





Eel habitat before



Modified from Mochioka

Eel habitat now

Modified from Mochioka

Dams and coastal reclamations

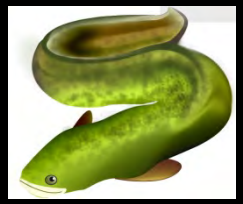
Geum River mouth dam
1.2 km

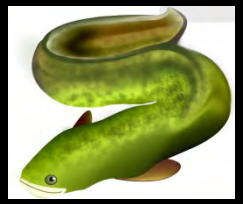
Saemangeum barrier
33.9 km

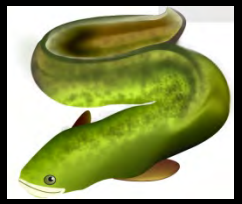
>33 km

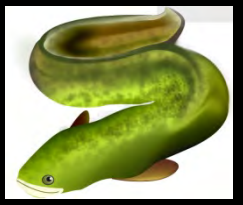
Revetment of riverbank

v.s.





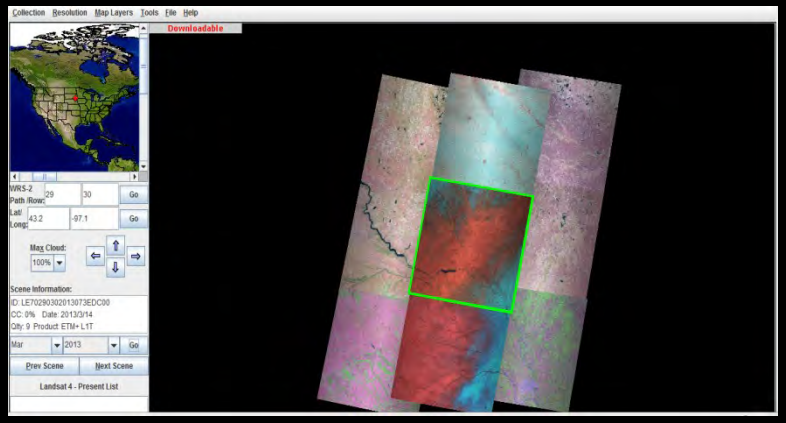




Kimura et al. 2012; Itakura et al. 2015

Satellite remote analysis of eel habitat loss in East Asia

USGS



Chronological Landsat image analysis

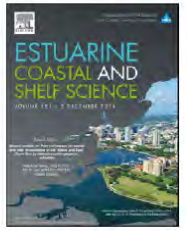
Eel habitat in danger

Estuarine, Coastal and Shelf Science 151 (2014) 361–369

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

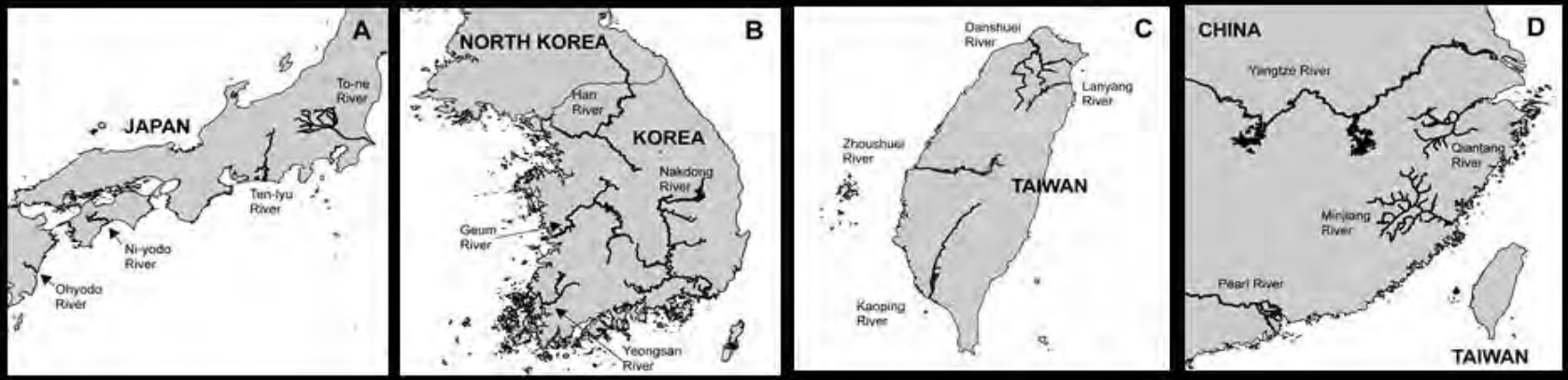


Impact of long-term habitat loss on the Japanese eel *Anguilla japonica*

Jian-Ze Chen [a], Shiang-Lin Huang [b], Yu-San Han [a, *]

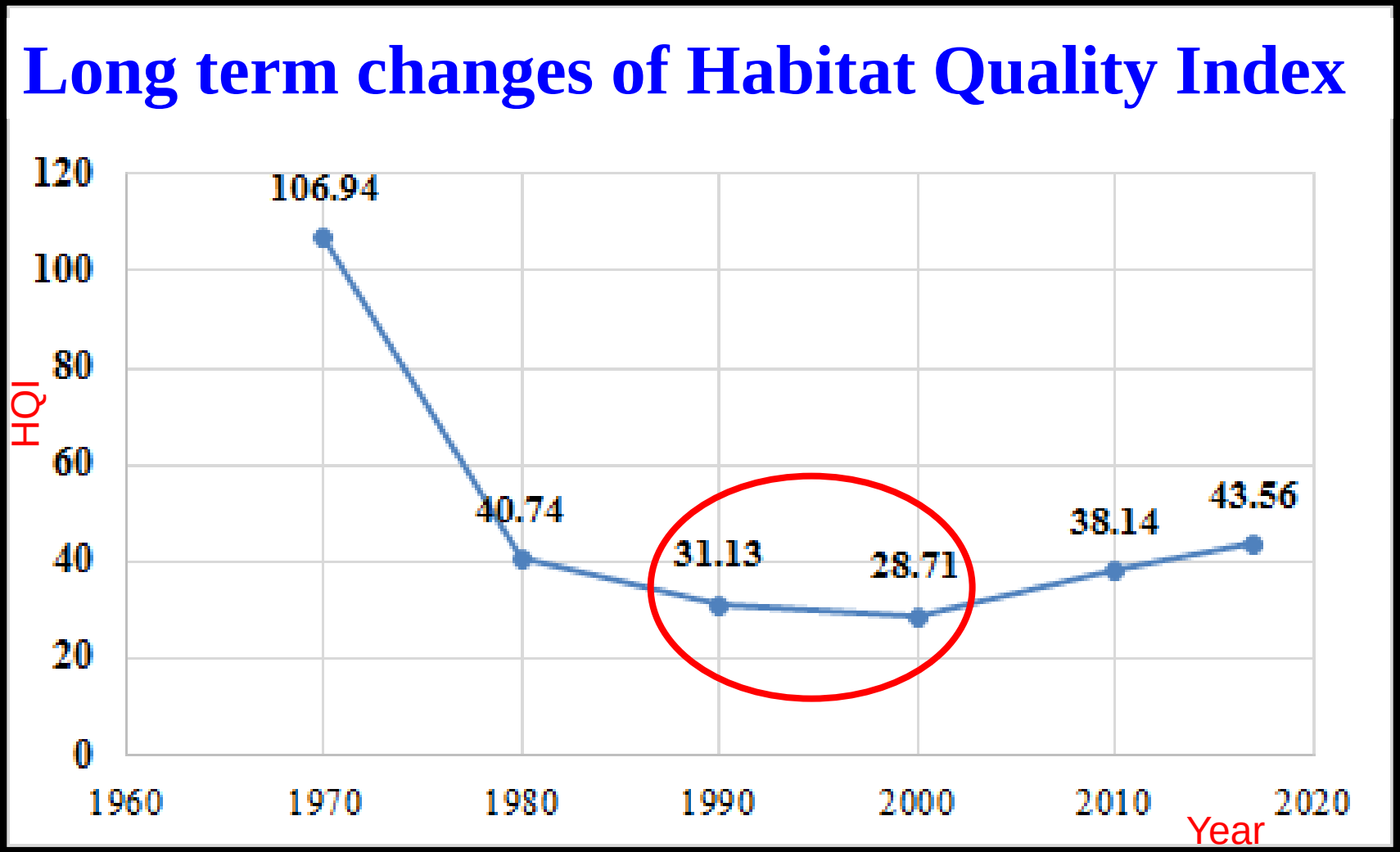
[a] *Institute of Fisheries Science, College of Life Science, National Taiwan University, Taipei, Taiwan*
[b] *The Swire Institute of Marine Science, School of Biological Sciences, The University of Hong Kong, Cape d'Aguilar, Shek O, Hong Kong*

East Asia long-term eel river habitat quality decline > 75%



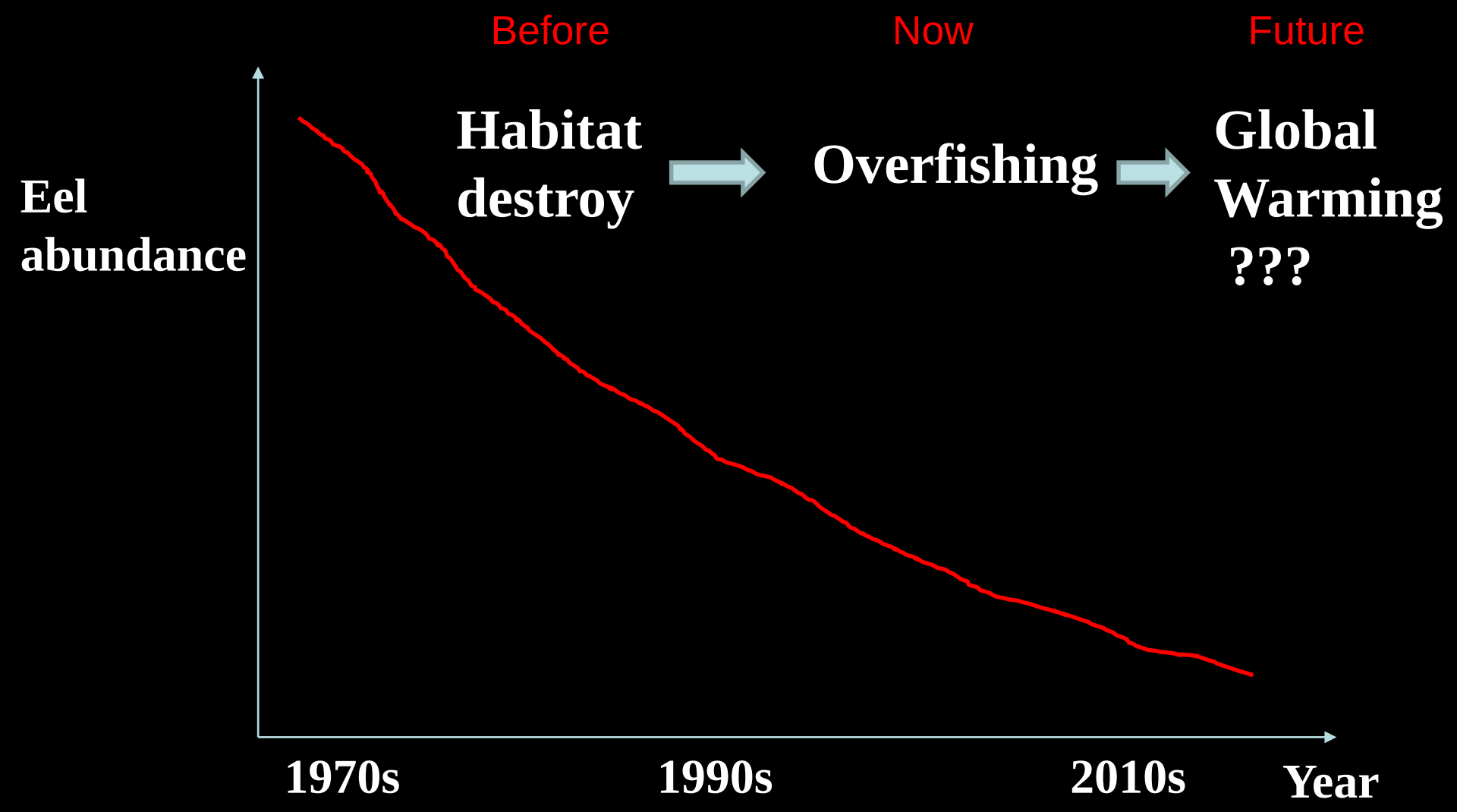
Han et al. 2014 ECSS

Long term trend of eel HQI in Taiwan rivers



Han, unpublished

Fate of the Japanese eel resource



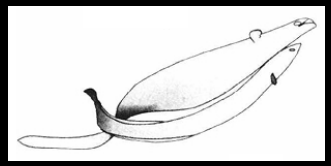
Conservation or Economy ?

Which should be protected with priority?

100

Adult eel

Mortality
98%



Spawner 2

Egg 1,000,000

Mortality
99%

Glass eel

10,000

Mortality
99%

Benefit estimation

Catch one pair of spawners, you get only

2 individuals *50 USD/kg = 100 USD

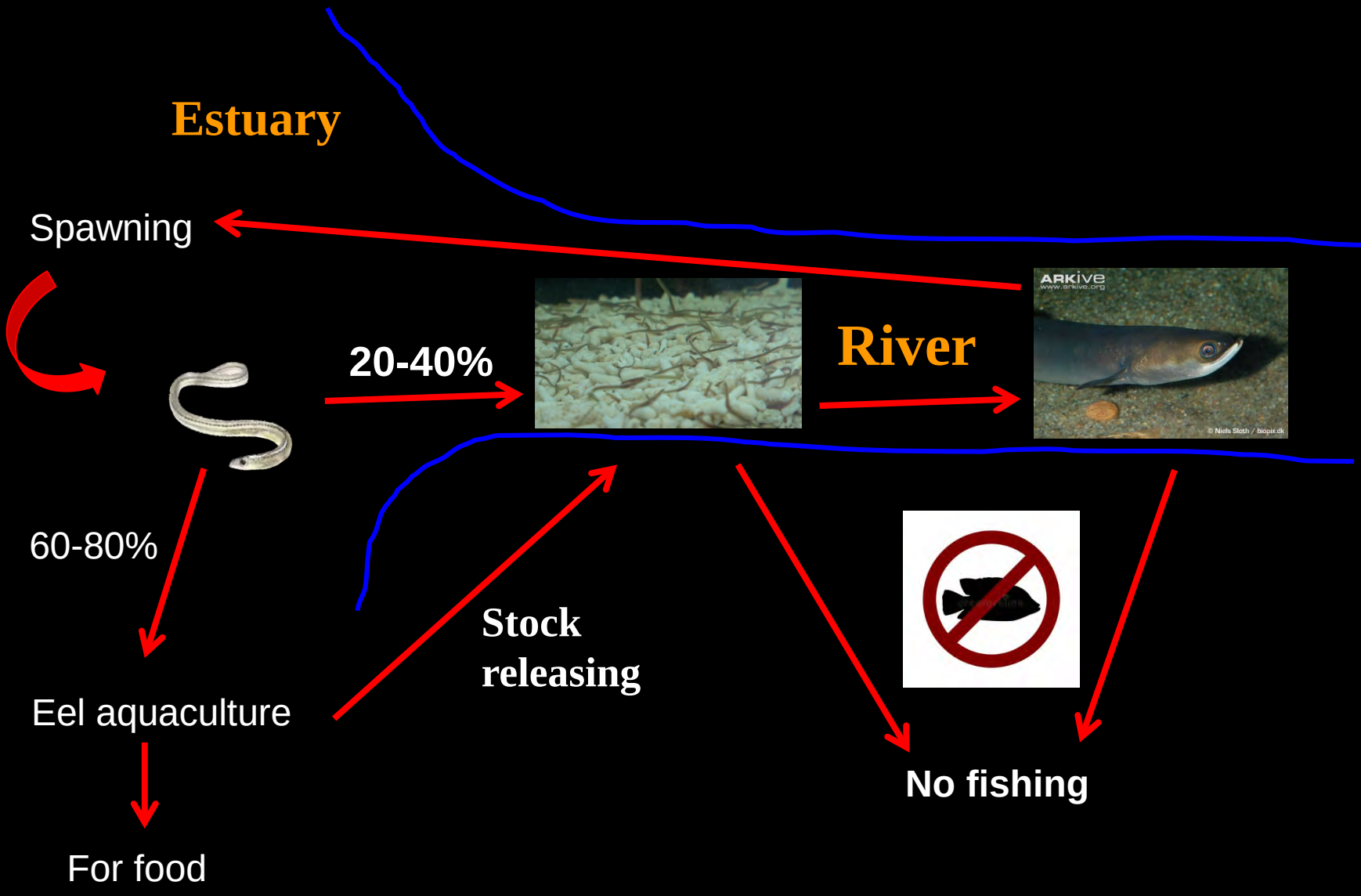
V.S.

Release one pair of spawners, you may get

2%*1 million eggs *1% survival rate

***5 USD/glass eel = 1,000 USD**

Suggested eel conservation plan



Better Conservation

Better Future Life

Thank You