Predominant jellyfish (Cnidaria: Scyphozoa) in the Inland Sea of Japan: a recent transition from *Aurelia aurita* to *Chrysaora pacifica*

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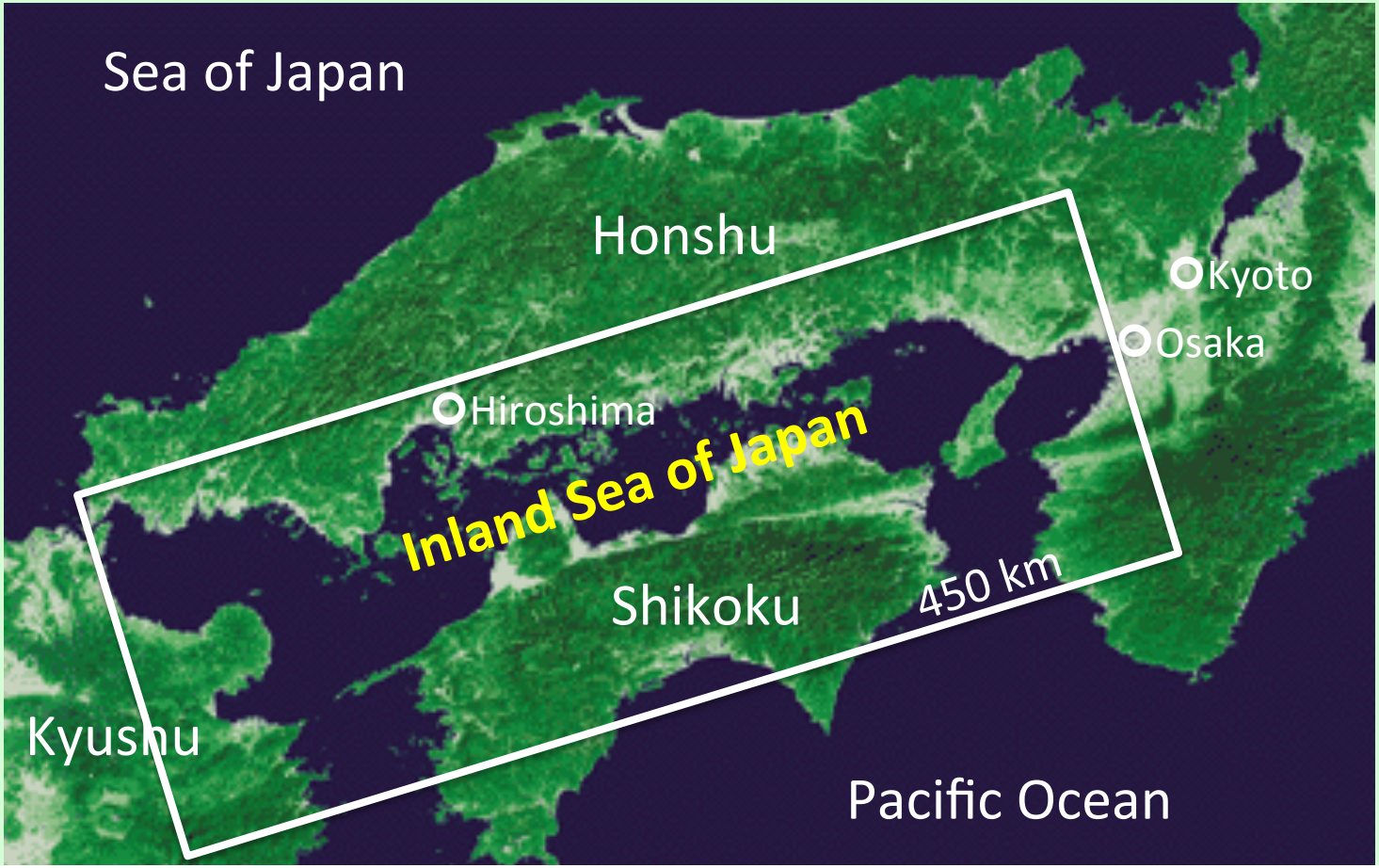
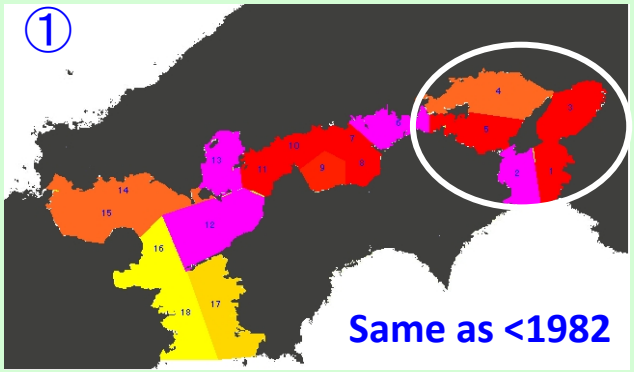


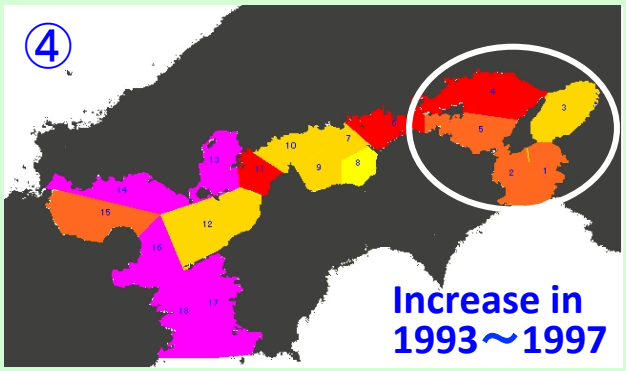
Trend of *Aurelia aurita* increase in eastern Inland Sea of Japan, based on poll of fishermen (Uye & Ueta, 2004)

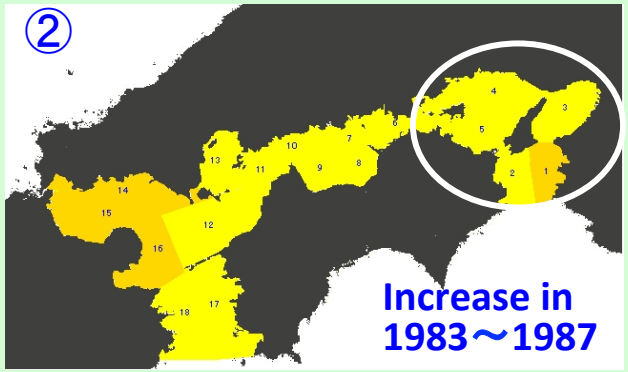
- The poll was conducted in 2002
- Total number of respondents from eastern Inland Sea of Japan: 329

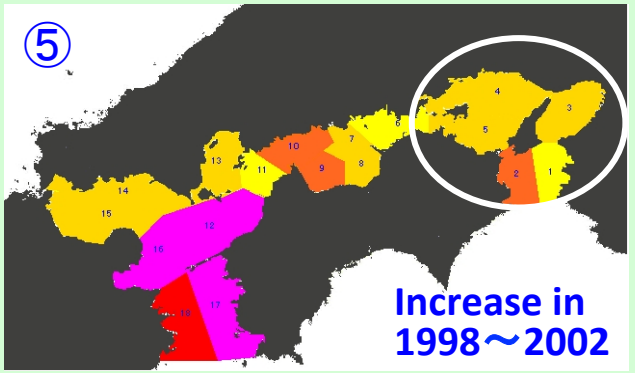
Question: When did *Aurelia* increase?

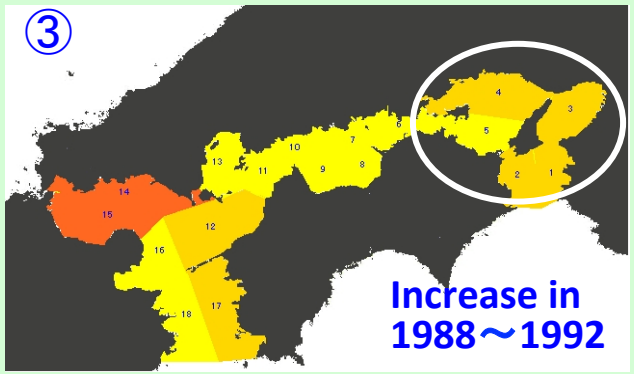
(1) They bloomed since many years before.
(2) In the 1990s, they increased prominently.

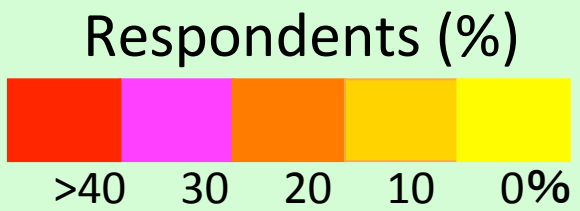








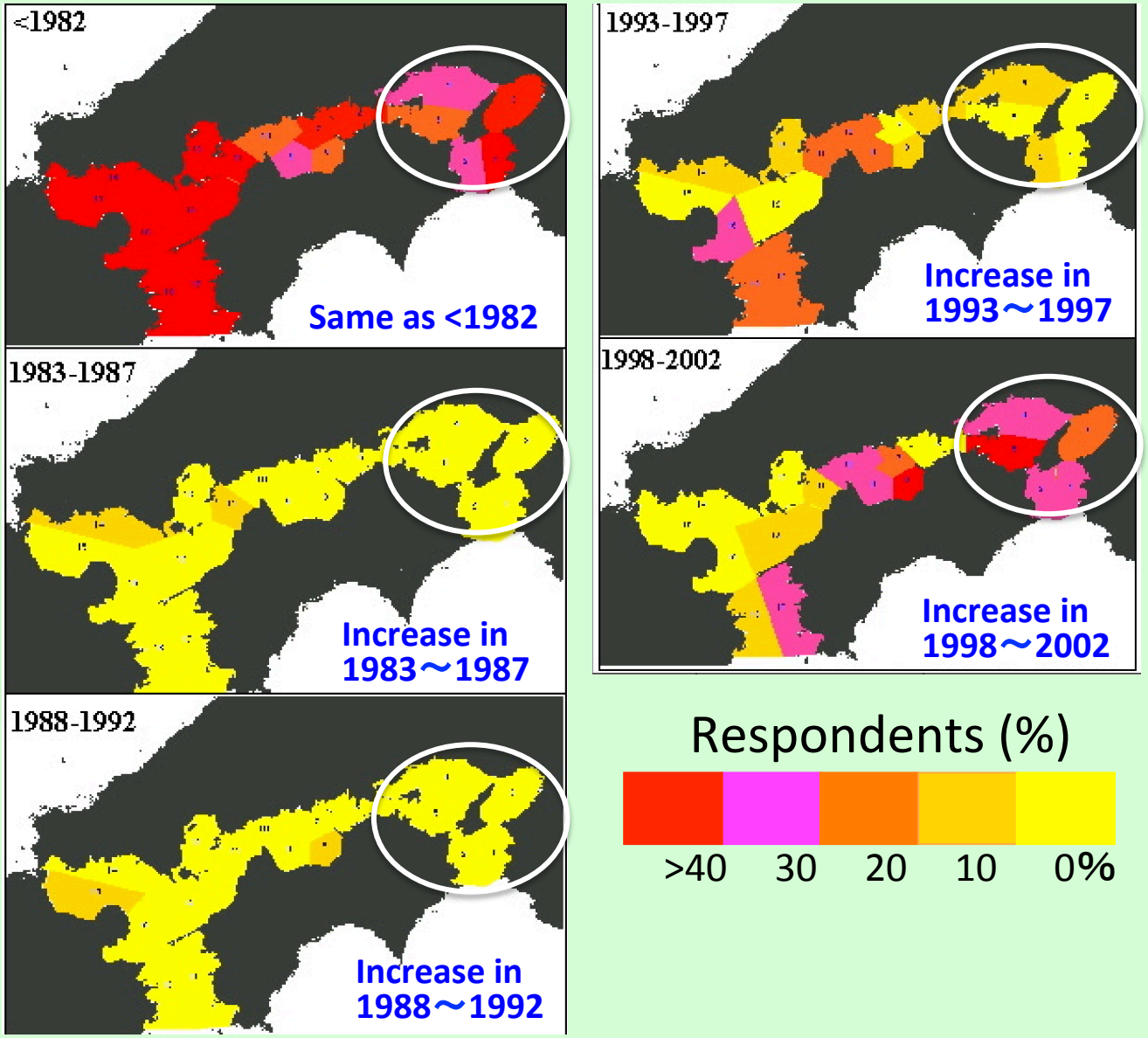




Trend of *Chrysaora pacifica* increase in eastern Inland Sea of Japan, based on poll of fishermen (Uye & Ueta, 2004)

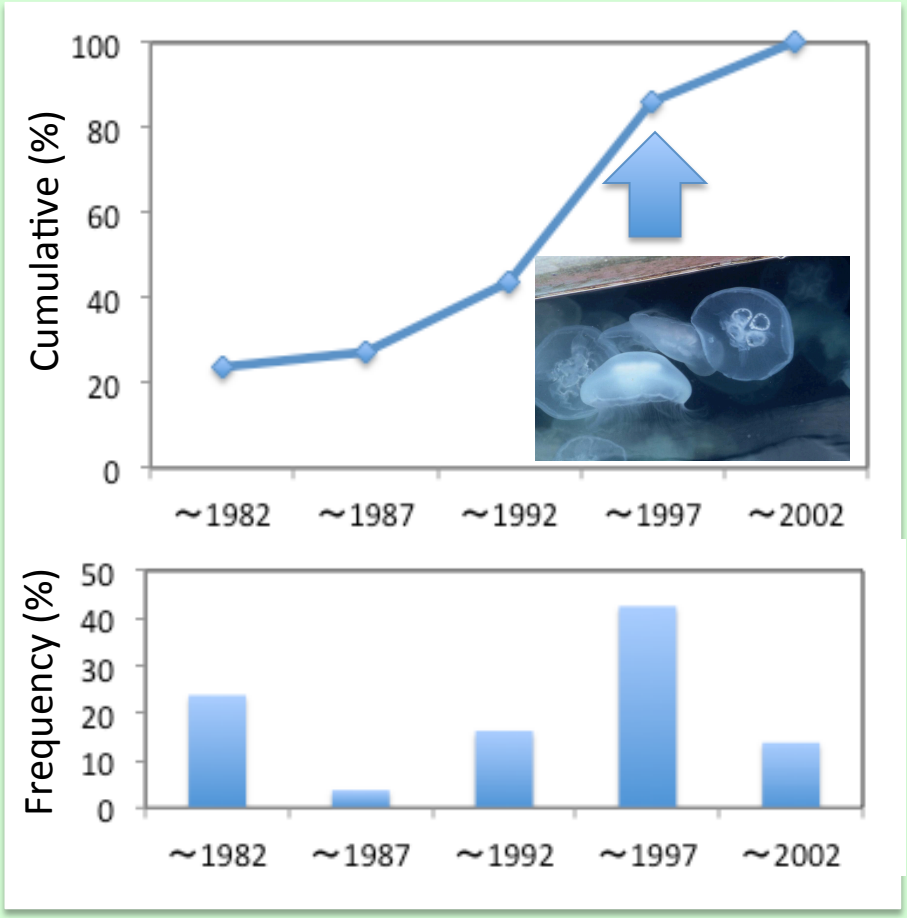
Question: When did *Chrysaora* increase?

(1) They bloomed since many years before.
(2) At the turn of this century, they increased prominently.

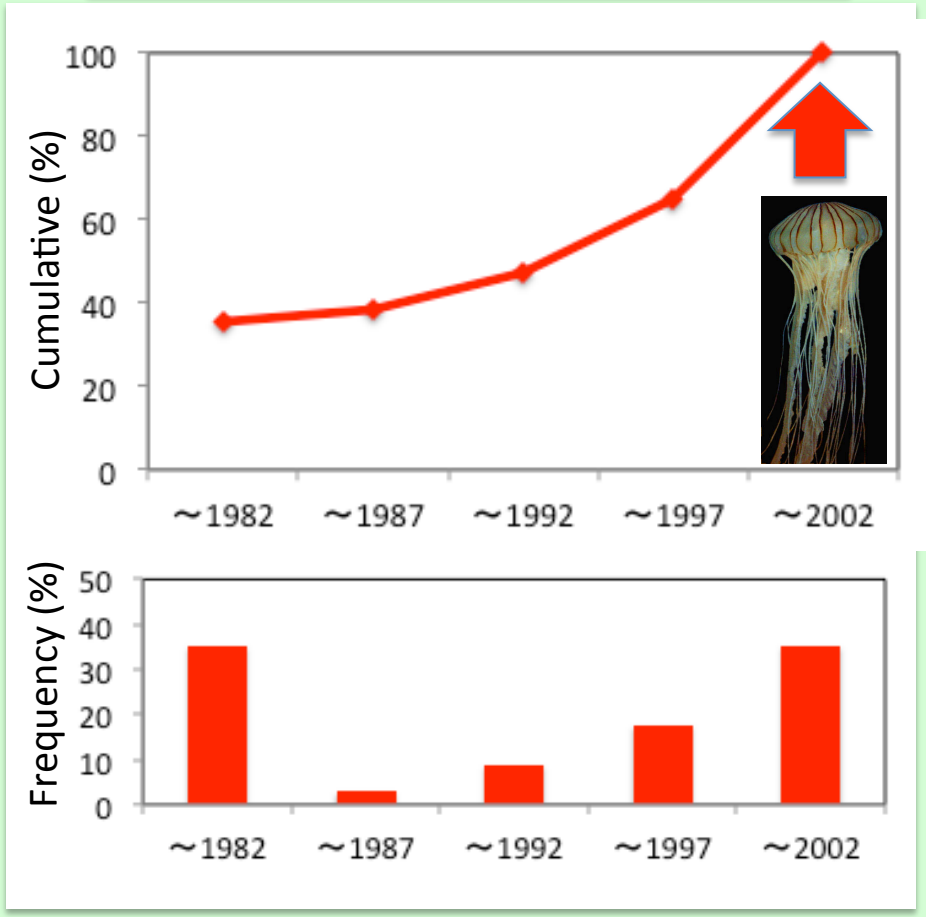


Periods of population increase in eastern Inland Sea of Japan (Uye & Ueta, 2004)

Aurelia aurita



Chrysaora pacifica



Chrysaora overwhelm *Aurelia* in a recent decade

神戸新聞　2010年(平成22年)4月21日　水曜日

クラゲ退治 漁業資源確保

播磨灘・大量発生で坊勢漁協

魚卵、稚魚食べ、漁網破る

西播磨沖の播磨灘で、小型のクラゲが大量に発生し、漁業の妨げになっている。この時期は低水温を好むアカクラゲが多く、今後ミズクラゲなども大量発生する恐れがあるため、姫路市家島町の坊勢漁協（約520人）が20日、90隻の漁船を出し、初めて駆除に乗り出した。

日本海で大発生したエチゼンクラゲをはじめ、クラゲの生態に詳しい広島大の上真一（かみしんいち）教授が、赤潮対策などで交流があった同漁協関係者に駆除を助言。上教授によると、温暖化による水温上昇でクラゲの増殖速度が上がり、各地で大量発生しているという。

クラゲはイワシなどが好む動物プランクトンのほか魚卵、稚魚も食べ、6月ごろから始まるシラス漁などへの影響が懸念されている。また網が破れるなどし、漁の妨げにもなっているという。

同漁協は、特別に強度を増したポリエチレン繊維製の駆除用網を30セット購入。2隻一組で網を引っぱり、クラゲが引っかかると、水圧で切り裂かれる仕組みだ。

この日は、午前9時前から午後2時ごろまで一斉に駆除に取り掛かった。姫路市網干区沖から赤穂市まで約20㌔の沖で5月中旬まで続け、播磨灘全域への拡散を防ぐ。

同漁協の小林博生さん（63）はクラゲ駆除を「これからの生活を懸けた戦い」という。上教授は「まだ抜本的対策はみつかっていないが、毎年駆除すれば増殖を防げる」と話す。（坂本　勝）

底引き網に入った大量のアカクラゲ

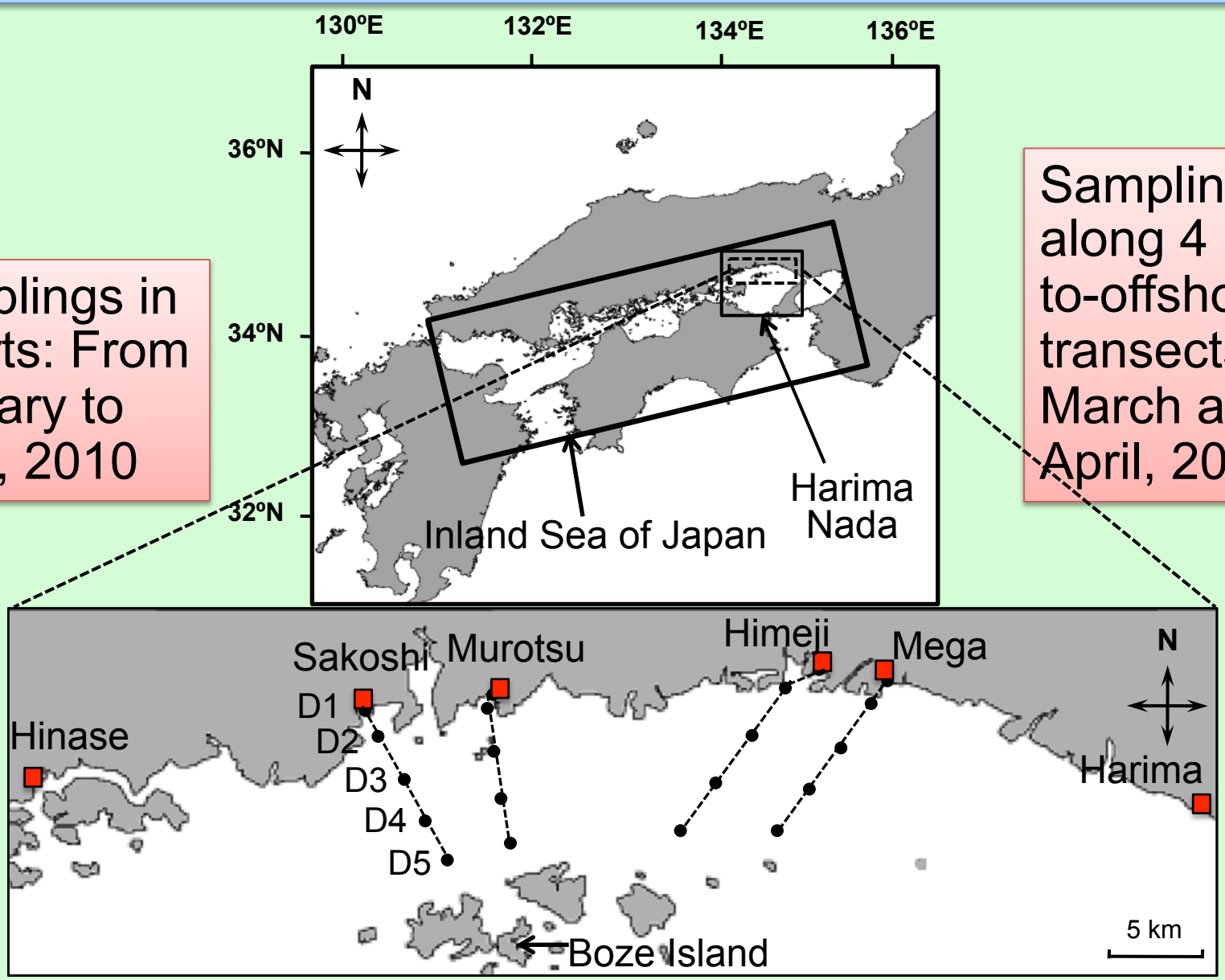
クラゲ駆除の網を引き揚げる坊勢漁協の組合員たち＝いずれも家島本島北の播磨灘

播磨灘のクラゲ

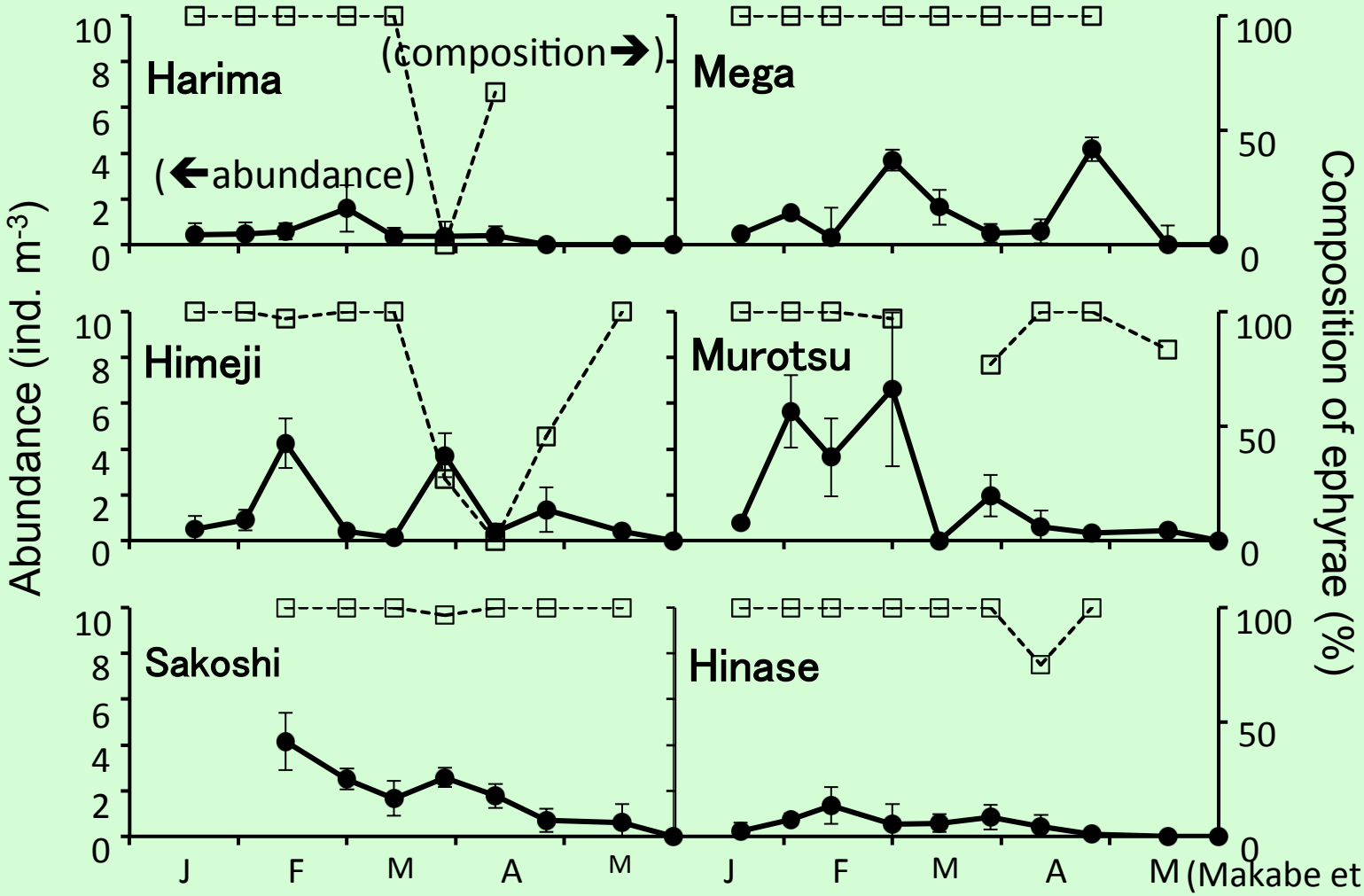
アカクラゲとミズクラゲはかさの直径が最大で25㌢程度。夏には播磨灘全域でみられる。かさの直径が約40㌢にもなる大型のユウレイクラゲも夏に増える。

Aim: To determine causes of the recent transition of predominant jellyfish species from *Aurelia* to *Chrysaora*

Spatiotemporal distribution of *Aurelia* and *Chrysaora* in northern Harima Nada



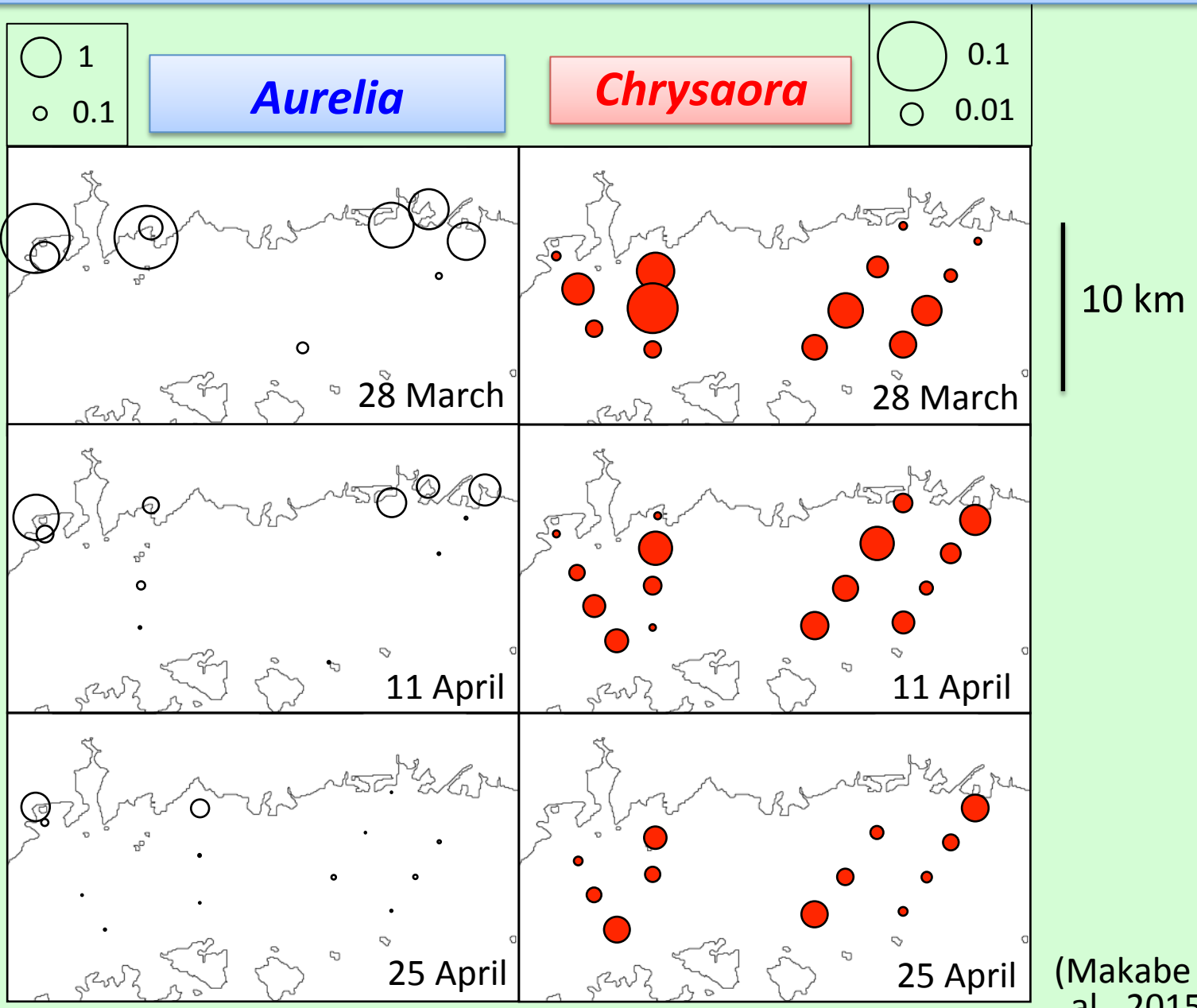
Seasonal occurrence of ephyrae (*Aurelia*) in 6 ports



(Makabe et al., 2015)

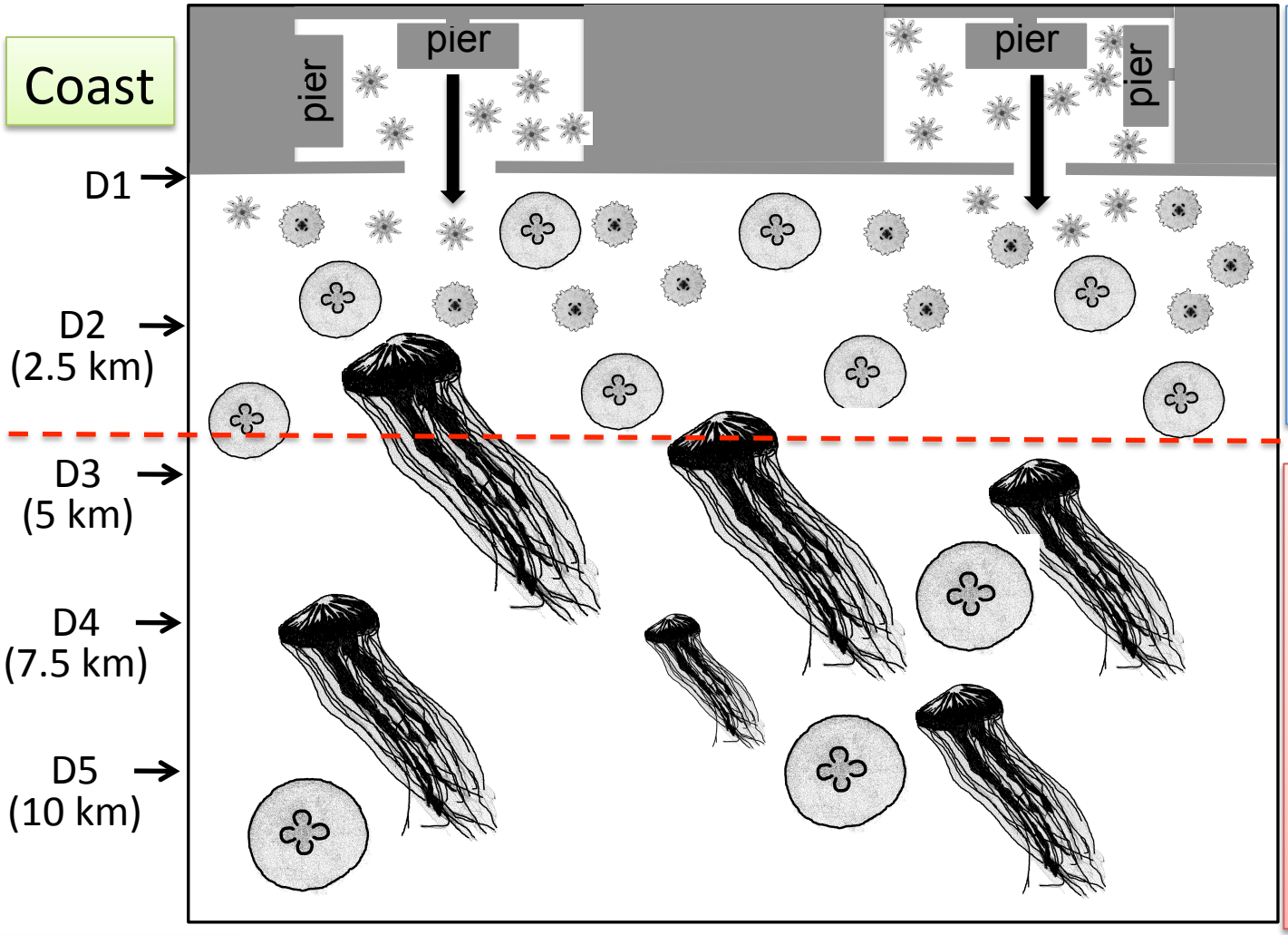
1. These ports harbor *Aurelia* polyps, but not *Chrysaora* polyps.
2. Released *Aurelia* ephyrae are rapidly transported offshore by tidal flushing (mean water residence time: 1-10 weeks)

Geographical distribution of medusae along 4 lines



(Makabe et al., 2015)

Schematic diagram of the spatiotemporal dispersion of *Aurelia* and *Chrysaora* in northern Harima Nada



Aurelia

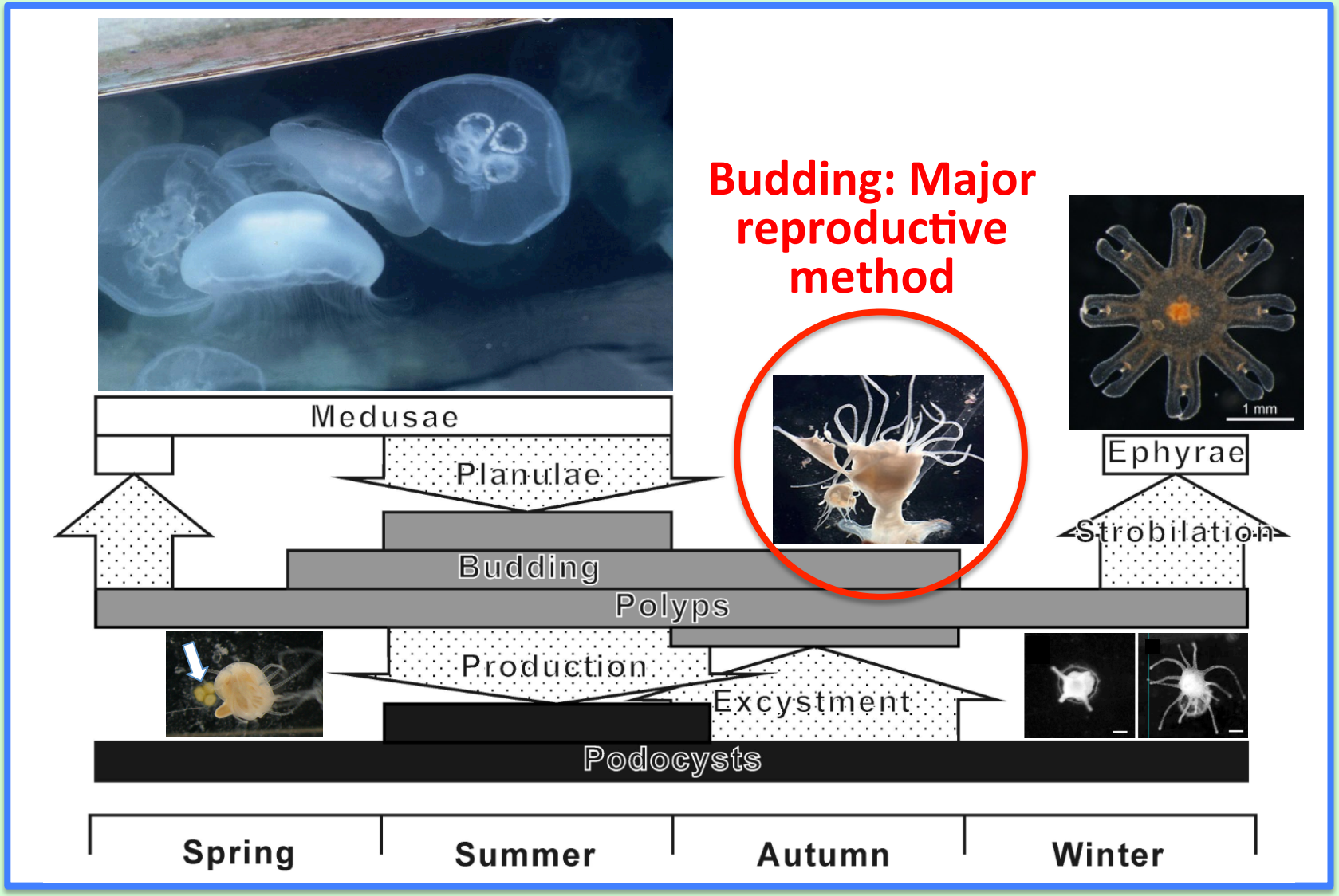
Polyps: Attach to artificial substrates.
Ephyrae: Released in port enclosures, and dispersed offshore by physical processes.

Chrysaora

Polyps: Perhaps attach to natural substrates in offshore waters.
Ephyrae: Released earlier than Aurelia.
Medusae: Grow faster than *Aurelia*.

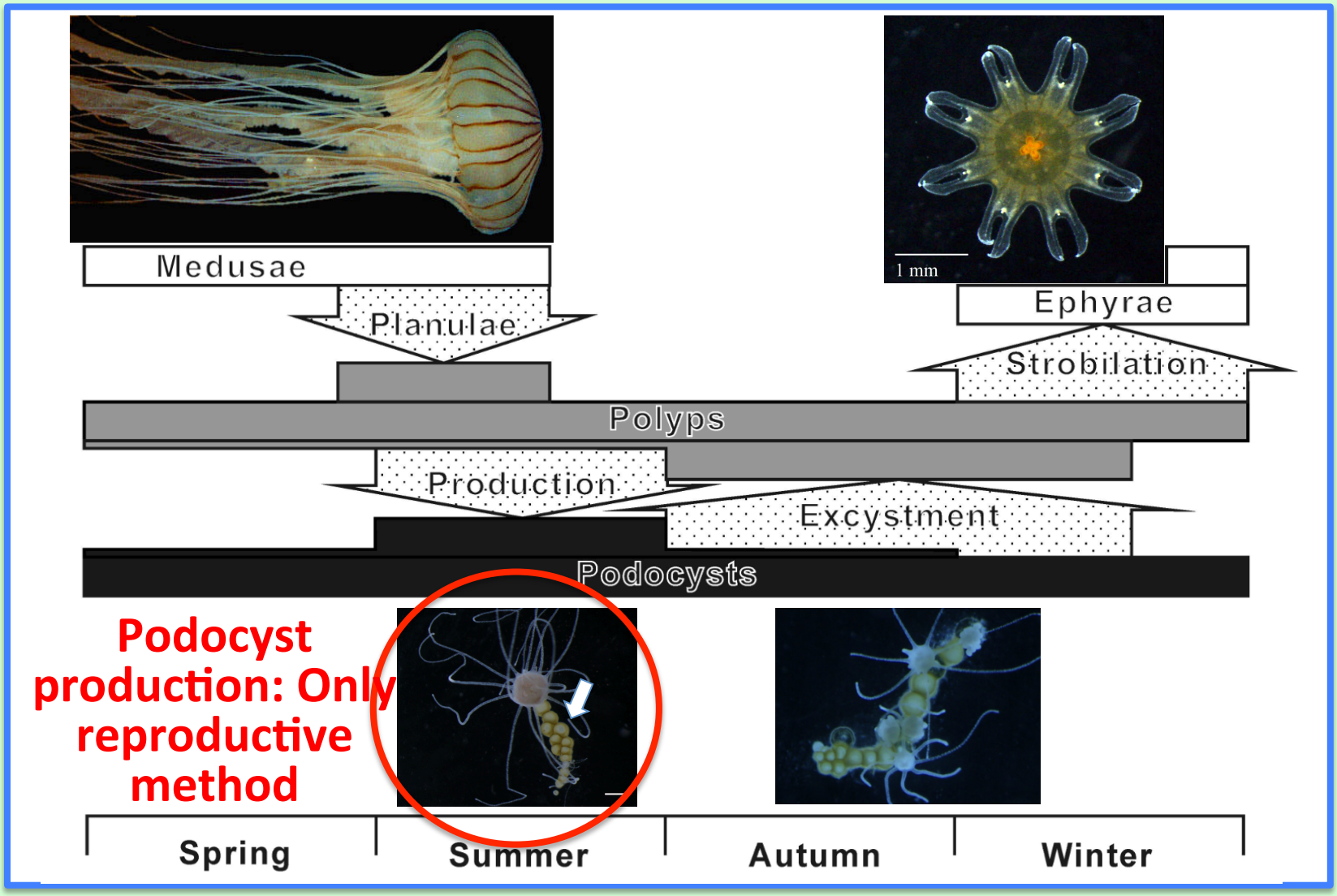
(Makabe et al., 2015)

Seasonal life cycle of *Aurelia aurita* in the Inland Sea of Japan



(Modified from Thein, Ikeda & Uye, 2013)

Seasonal life cycle of *Chrysaora pacifica* in the Inland Sea of Japan



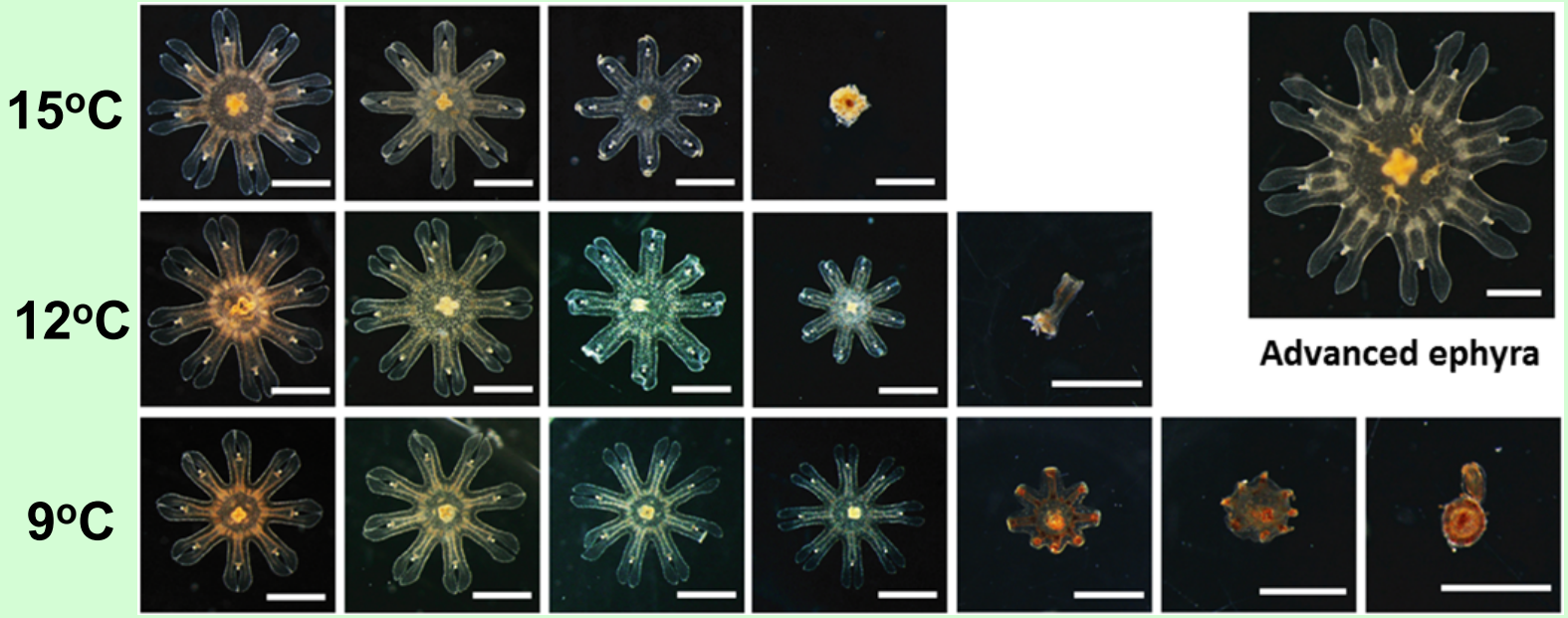
(Modified from Thein, Ikeda & Uye, 2013)

Comparison of asexual reproduction

	Aurelia	*Chrysaora*	Reference
Budding (buds polyp^{-1} week^{-1})	**8.1**	**0**	Han & Uye, 2010 Thein, Ikeda & Uye, 2013
Podocyst production (cysts polyp^{-1} week^{-1})	**(0.75)**	**2.1**	Thein, Ikeda & Uye, 2013
Strobilation (discs strobila^{-1})	**5-10**	**5-10**	Han & Uye, 2010 Thein, Ikeda & Uye, 2013
Polyp habitat	**Inshore, Artificial substrates**	**Offshore, Natural substrates?**	Toyokawa et al., 2012 Makabe et al., 2014

Reproductive rate: *Aurelia* >> *Chrysaora*

Comparison of median longevity of starved ephyrae



(Fu et al., 2014)

Temperature	*Aurelia*	*Chrysaora*
15°C	50 days	153 days
12°C	70 days	>287 days
9°C	100 days	243 days

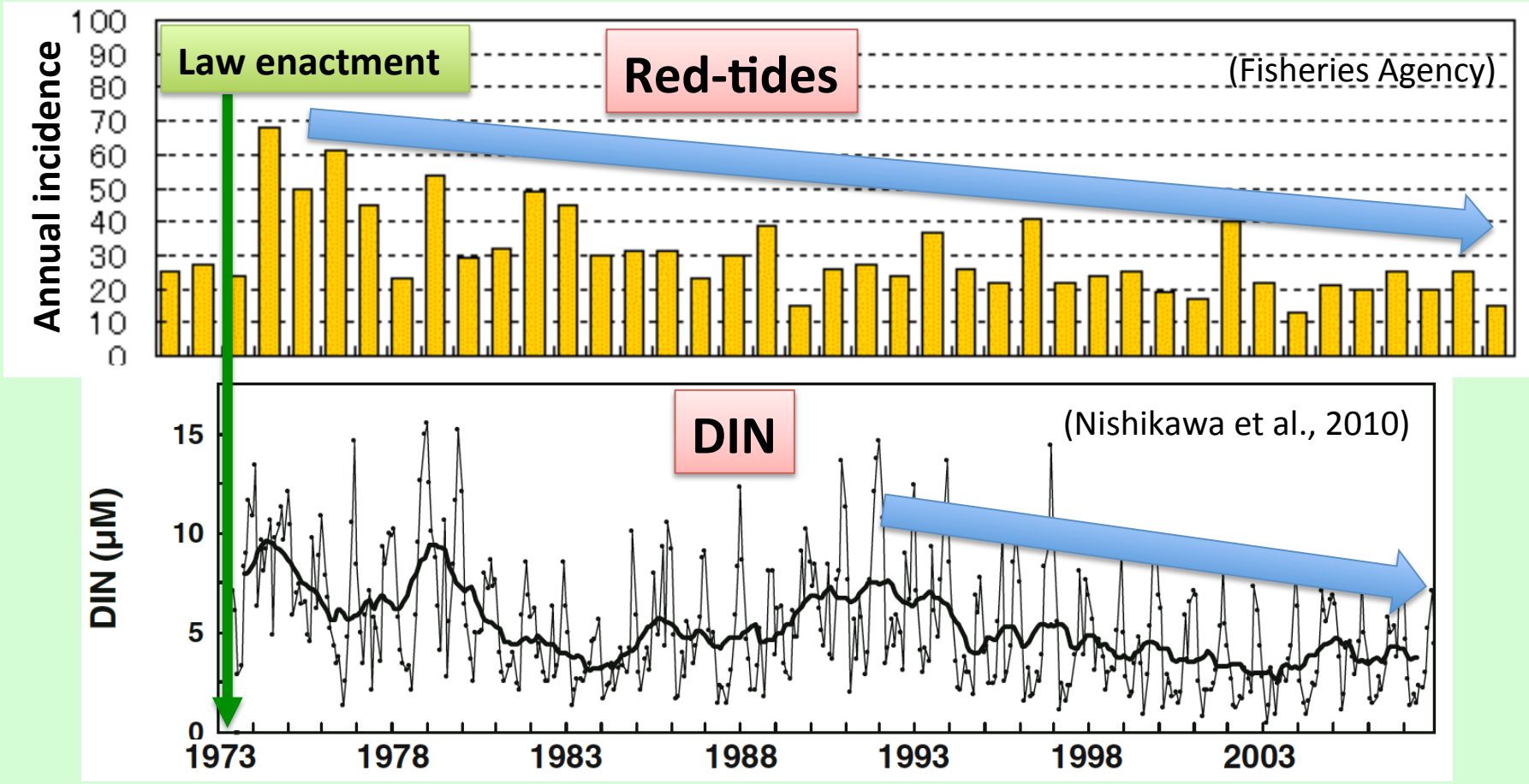
Adaptation to scarce food condition: *Chrysaora* > *Aurelia*

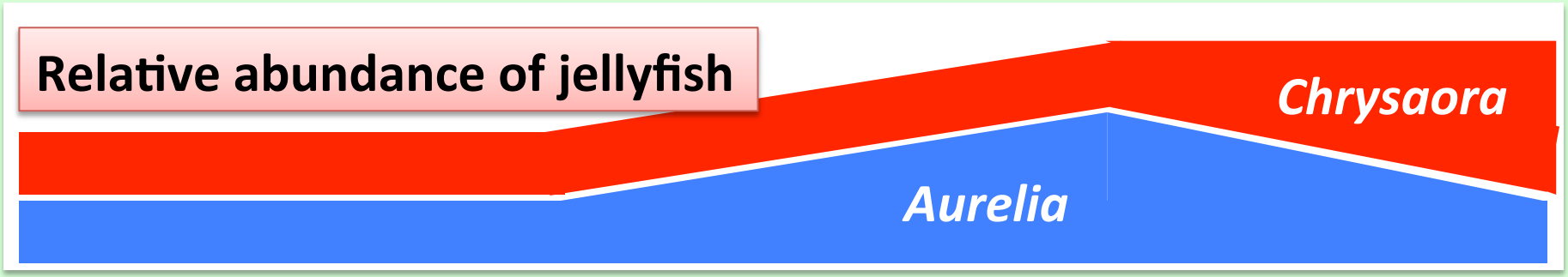
Chrysaora can prey on *Aurelia*

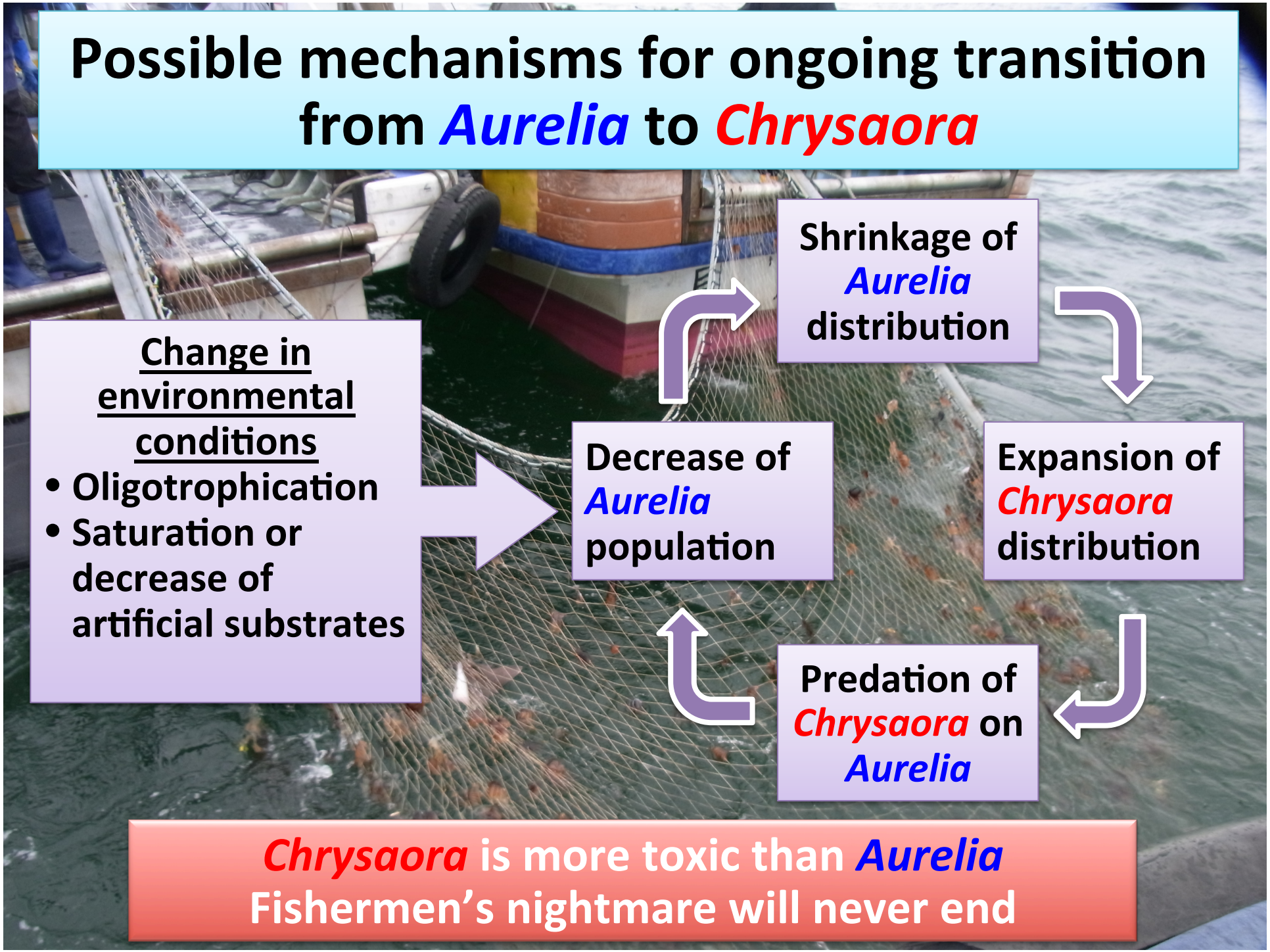
Chrysaora (bell diameter: 6 cm) feeding on *Aurelia* ephyrae (Predation rate: 108 ephyrae medusa^{-1} h^{-1})

Chrysaora (bell diameter: 10 cm) feeding on a green-stained *Aurelia* medusa

Recent environmental change: Oligotrophication






Possible mechanisms for ongoing transition from *Aurelia* to *Chrysaora*
Change in environmental conditions
• Oligotrophication
• Saturation or decrease of artificial substrates
Decrease of *Aurelia* population
Expansion of *Chrysaora* distribution
Predation of *Chrysaora* on *Aurelia*
Shrinkage of *Aurelia* distribution
Chrysaora is more toxic than *Aurelia*
Fishermen's nightmare will never end