CENTRE OF MARINE SCIENCES
CENTRO DE CIÊNCIAS DO MAR

Cephalopod Culture & Research

On the aquaculture potential of cephalopod species: developing new culture technology based on the species biology and ecology

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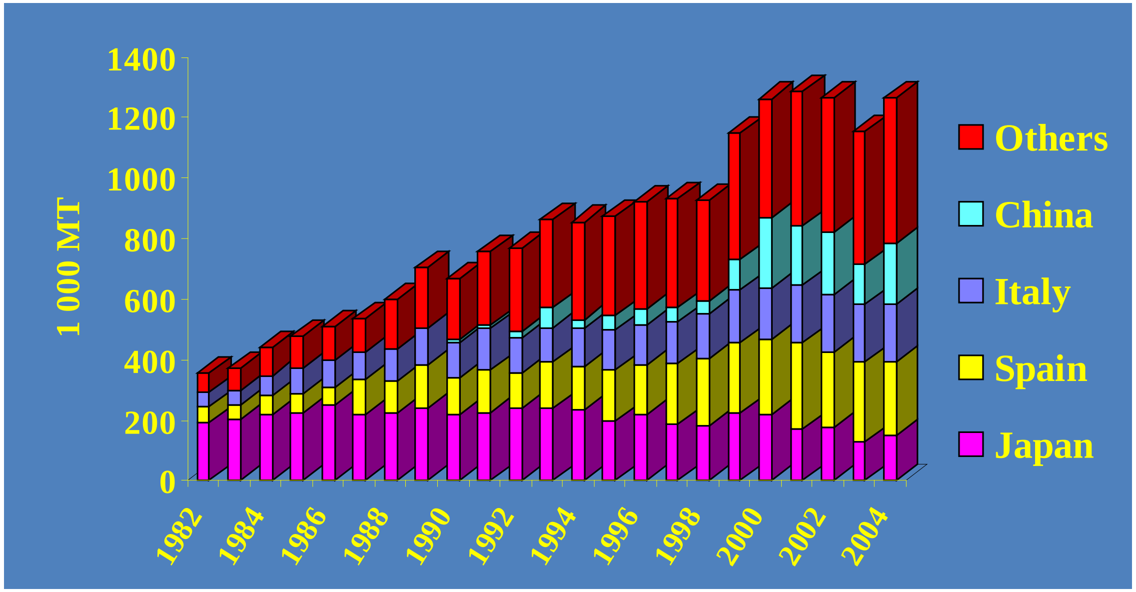
Cephs as Aquaculture Candidates

- Cephalopods are especially consumed in the Mediterranean and Asian markets and the amount is still increasing

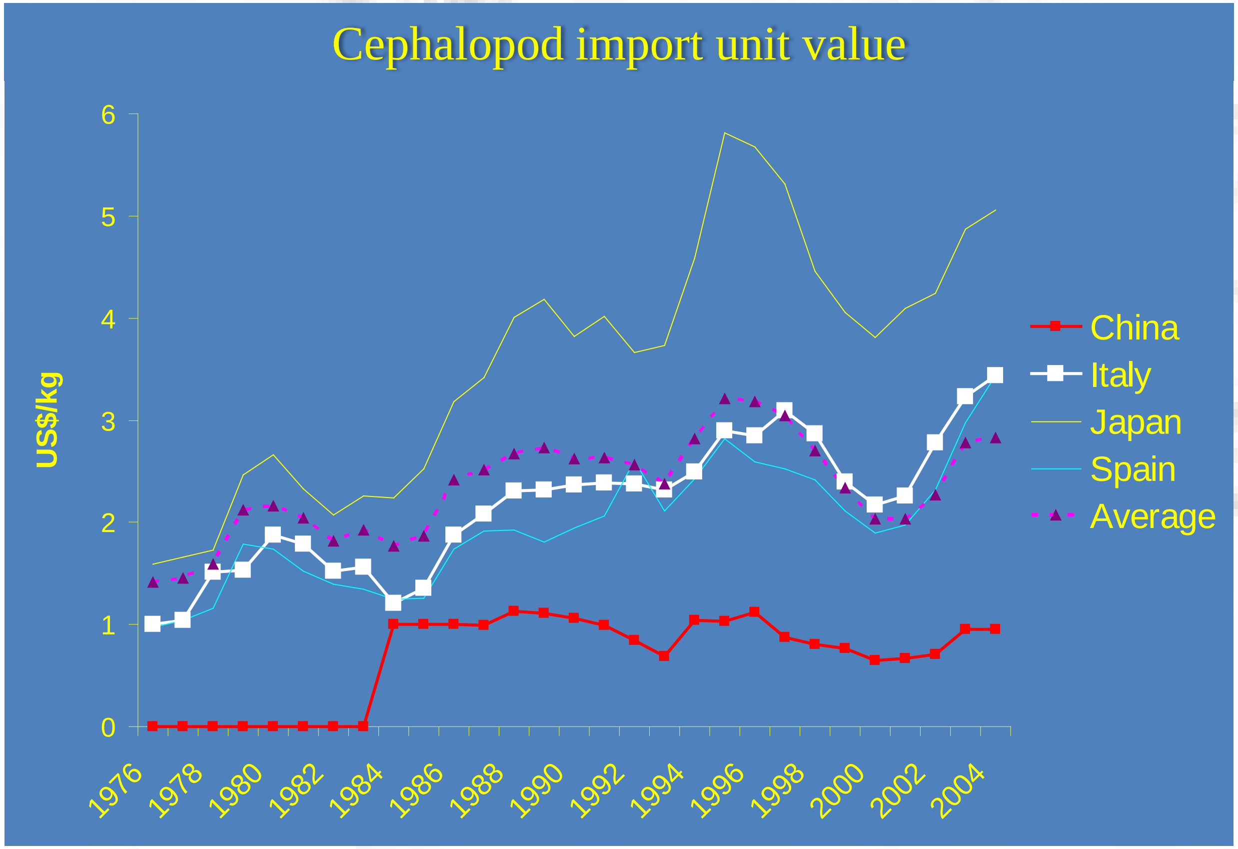
WORLD CEPHALOPOD IMPORTS
(BY MAJOR IMPORTING COUNTRIES)



GLOBEFISH

Cephs as Aquaculture Candidates

Their market values follow a similar increasing trend

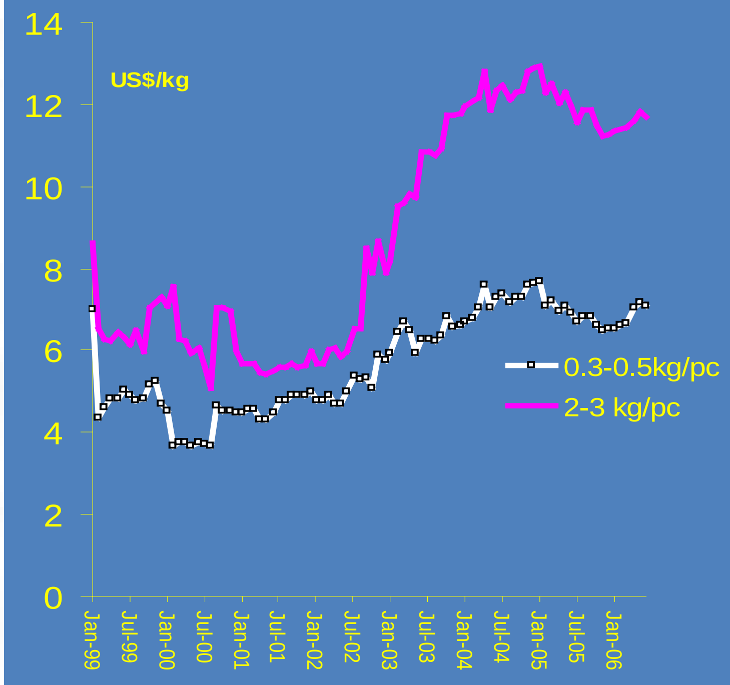


GLOBEFISH

Cephs as Aquaculture Candidates

- **With different sizes/weights displaying higher values, specially for octopus and cuttlefish**

Octopus prices in Japan



Squid and cuttlefish prices in Japan

GLOBEFISH

Cephs as Aquaculture Candidates

- **Cuttlefish and Octopus are therefore aquaculture candidates, not only for their market prices but for several other biological aspects, such as:**
  - Short life cycles
  - Fast growth rates
  - High nutritional value

That imply:

- Lower production periods
- Lower associated costs
- New products, such as the production of undersized individuals that cannot be obtained in nature

Cephs as Aquaculture Candidates

➡ **Constraints in developing cephalopod aquaculture technology which are biology and ecology related:**

Cuttlefish, *Sepia officinalis*	**Octopus, *Octopus vulgaris***
semelparous	semelparous
direct embryonic development	larvae stage
low fecundity	high fecundity but eggs require female
carnivorous, mainly crustaceans and some fish	carnivorous, crustaceans, bivalves and fish
lifecycles as low as 3 months	lifecycles of 1 year at the least
increased metabolism	increased metabolism
intelligent	intelligent

Cephs as Aquaculture Candidates

Based on the previous, a multidisciplinary approach to these problems is needed:

- **Study and gather a profound knowledge of ecology, biology and physiology aspects of the species under captivity:**

  first phase – maintenance

  second phase – culture

  third phase – production and mass production

- **Development of intensive aquaculture techniques and seawater systems in order to start cephalopod culture commercially**

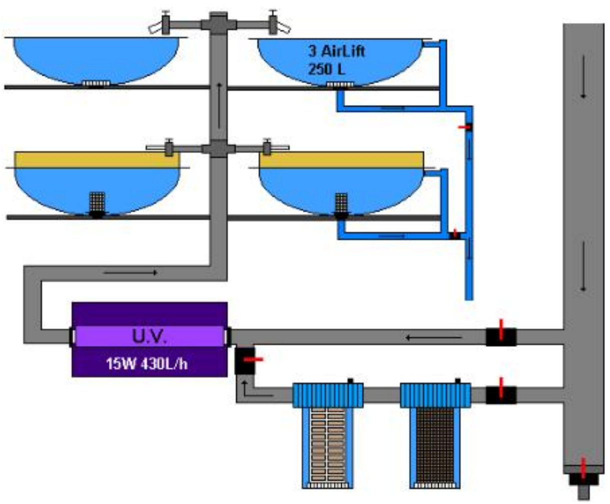
Cephs as Aquaculture Candidates

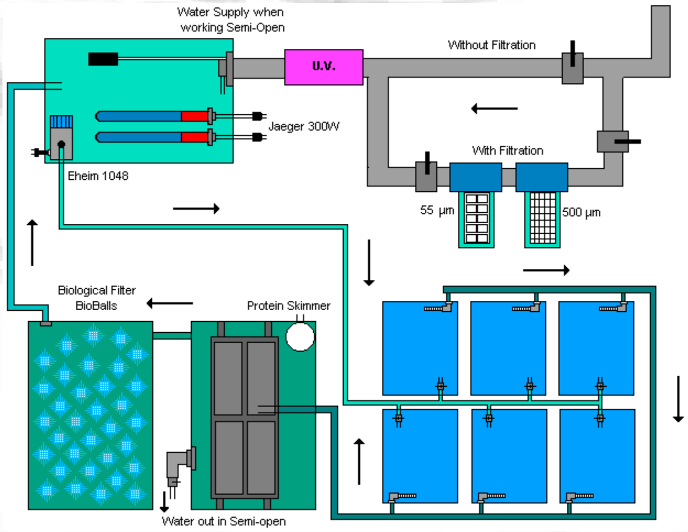
Zoo-technology

Seawater culture systems:

Both species require systems with:

- low nitrogenous compounds
- high dissolved oxygen
- U.V. filter





Cephs as Aquaculture Candidates

Zoo-technology

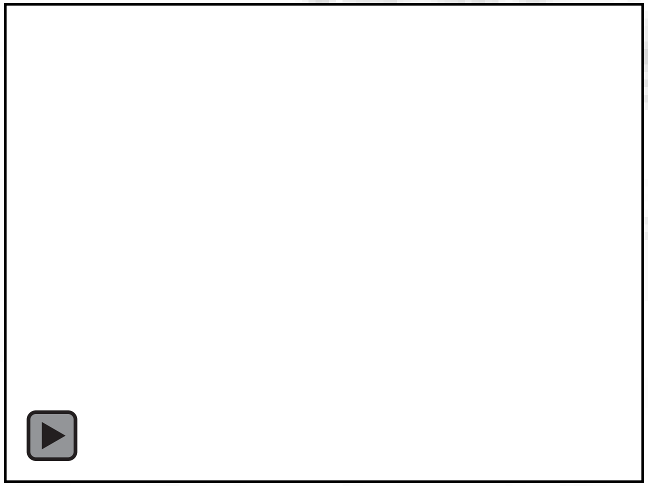
Egg stage:

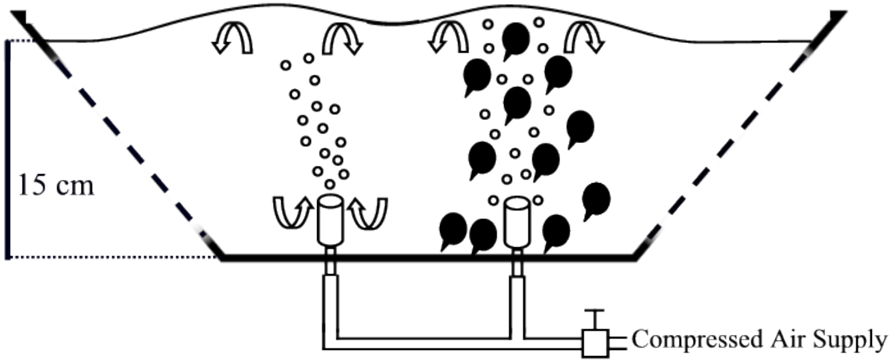
- Fecundity: low in cuttlefish (300-2000 eggs) and high in octopus (50000-80000 eggs)
- Fertility: higher in cuttlefish (60-100%) and medium in octopus (40-60%)
- Different embryonic development between cuttlefish and octopus
- Cuttlefish lay eggs and die, while octopus females lay eggs and keep them aerated until hatching, dying afterwards
- Eggs are manipulated and have a developed technology in cuttlefish to optimize hatching efficiency
- Embryonic development depends on water temperature and ranges from 20 days to as much as 60 days

Cephs as Aquaculture Candidates

Zoo-technology

Egg stage (cont):

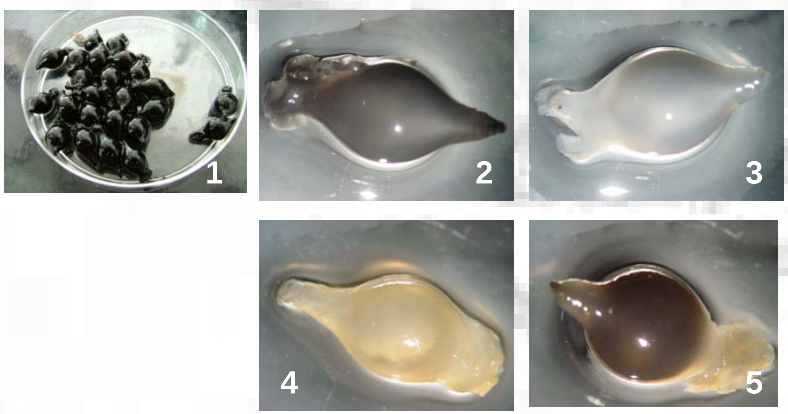


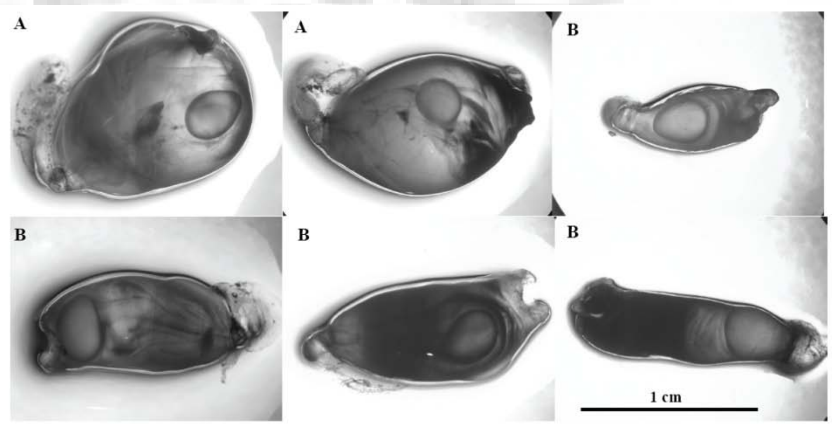


Cephs as Aquaculture Candidates

► Egg stage (cont): Selection of viable eggs

	Morphology			
Egg type	***Shape***	***Colour***	***Transparency***	
Normal	Flask	Black	No	1
Grey	Flask	Grey	No	2
White	Flask	White	No	3
Orange	Flask	Orange	Semi	4
Yellow-Grey	Flask	Yellow-Grey	No	5
Malformations Type I	Globular	No Colour	Yes	A
Malformations Type II	Elongated	Dark Brown	Semi	B





Cephs as Aquaculture Candidates

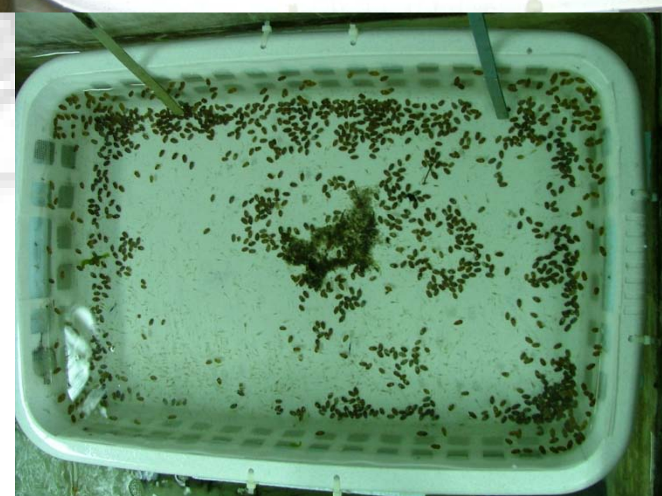
Zoo-technology

Hatchling/Para-larvae Stage:

- Hatchlings – cuttlefish and Para-larvae – octopus
- Results from different embryonics
- 20-30 days in cuttlefish and as much as 60 days in octopus
- Cuttlefish – animals are similar to juveniles and adults in both external morphology and behaviour; maturation of digestive and central nervous systems require live and/or enriched prey
- Octopus – animals undergo metamorphosis from para-larvae to juveniles, changing from planctonic to benthic. Major bottleneck in octopus culture due to high mortalities

Cephs as Aquaculture Candidates

- **Hatchling/Para-larvae Stage:**



Cephs as Aquaculture Candidates

Juvenile Stage:

- Only difference from adults is that they are not mature
- Cuttlefish withstand high culture densities but feeding and bottom area requirements are high
- Despite being solitaire in nature, individuals congregate and display schooling
- Octopus do not withstand such higher culture densities because of territorialism (den occupation)
- For both, lack or innapropriate food will promote cannibalism

Cephs as Aquaculture Candidates

- **Juvenile Stage:**

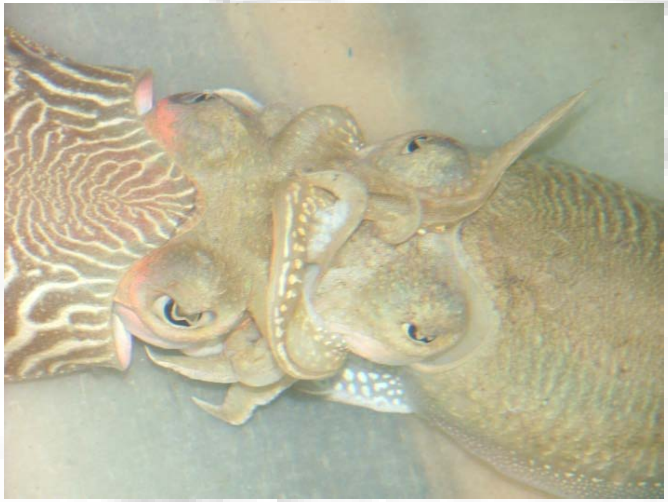
Cephs as Aquaculture Candidates

Adult/Breeder Stage:

- Growth diminishes in both species, specially in females
- In cuttlefish, male adopt a series of sexual behaviours towards other males and females
- Sperm competition exists and every male will first clean the female mantle prior coppulation
- Females are able to store sperm for large periods of time and despite they are semelparous animals, intermitent spawning occurs

Cephs as Aquaculture Candidates

- Adult/Breeder Stage:



Cephs as Aquaculture Candidates

Accomplished Goals in Cuttlefish Culture:

- It is possible to culture *S. officinalis* exclusively on a live grass shrimp diet supplied *ad libitum.*
- Temperature is still the most important factor explaining differences between generations.
- Winter generations have always at least 50% longer cycles and consequently grow larger.
- Shorter life cycles than those reported by NRCC and Caen Researchers at similar culture temperatures are probably due to smaller tank bottom areas.

Cephs as Aquaculture Candidates

Current Bottlenecks in Cuttlefish Culture

- Limited knowledge regarding the biology and physiology of the species under captivity
- Limited dietary alternatives for mass culture
- Limited overall nutritional profile knowledge about both predator and prey
- Temperature seems to affect sex ratio (♀/♂)
- Fertility does not display a clear pattern, but drops completely after 6 generations

Final Considerations

Grass Shrimp

- Only one prey reduces both logistics and expenses.
- It should be considered the ideal prey while designing one artificial diet for cuttlefish.
- Its lipid content is rich in phospholipids, CHO and PUFA and is moderate in TAG.
- Its lipid content is also quite similar to that of cuttlefish eggs, hatchlings and juveniles.

Final Considerations

Cuttlefish

- Further insight into the lipid, protein and carbohydrate metabolisms of cuttlefish is needed.
- The issue of different populations needs to be properly addressed in order to determine if different culture methods and nutritional requirements are needed.

Current Research

Towards the development of an artificial diet

- Early hatchling weaning – early acceptance of dead food.
- Metabolism:

  a) Biochemical determinations of cuttlefish food – protein and carbohydrate fractions;

  b) Energetics;

  c) Enzymes and tracers.

Towards the ideal zoo-technical knowledge

- Fecundity and fertility increase through the use of higher bottom areas, tank color and light intensities.
- Growth and mortality homogeneity through the use of light intensities.

The End