INITIATING A NORTH ATLANTIC NETWORK
ON SUSTAINABLE HOLOTHURIAN TECHNOLOGY AND INNOVATION

Aquaculture prospects for North Atlantic sea cucumber species

JAN SUNDE & GYDA CHRISTOPHERSEN| HOLOSUSTAIN workshop | 20. May 2022

MØREFORSKING

WHY SEA CUCUMBER AQUACULTURE?

- Aquaculture a small part of global supply (20-30 %)
  - mainly *Apostichopus japonicus*
- High Chinese domestic market demand
- Reduce pressure on wild stocks
  - Overexploitation of species in tropical waters
- Potential deposit feeders in integrated systems
- Possible value creation
  - High prices achievable ~100-3000 USD/kg (dried)
  - Product diversification

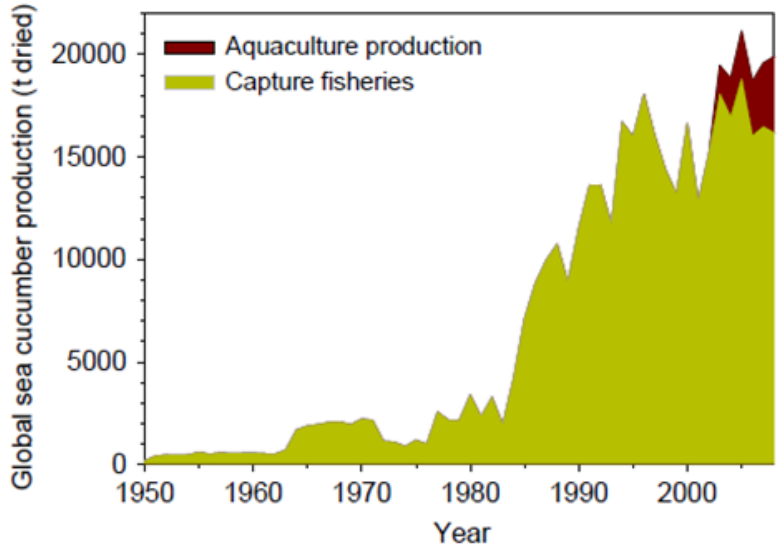

Figure 1 Global wild captures and aquaculture production of sea cucumbers over time; in metric tonnes (t). Source FAO Fishstat, with correction: data for aquaculture production and wild captures of *Apostichopus japonicus* (China, Japan, Korea) refer to fresh animal weights, so these were converted to dried weight using a conversion factor of 0.04, based on other *Stichopus* species (Skewes *et al.* 2004).

Fra: Purcell et al. 2013. Sea cucumber fisheries. global analysis of stocks, management measures and drivers of overfishing. FISH and FISHERIES 14:34–59.

(NORTHERN) NORTH ATLANTIC SPECIES

Within the NORA-area -

two species considered potential aquaculture candidates

Both species commonly occurring in the Atlantic

P. tremulus - bycatch
C. frondosa - fishery

Red sea cucumber
(***Parastichopus tremulus***)

Orange footed sea cucumber
(Cucumaria frondosa)

STATUS – AQUACULTURE – WHERE ARE WE FOR NNA SPECIES ?

PUBLICATIONS

Møreforsking Anthology 2019

Atlantic sea cucumber species in the spotlight – prospects for Norwegian aquaculture

Anja M. Landes*, Jan Sunde and Gyda Christophersen

Møreforsking Ålesund AS, 6009 Ålesund, Norway

Keywords: *Parastichopus tremulus*, *Cucumaria frondosa*, sea cucumber, aquaculture, IMTA, reproduction

REVIEWS IN FISHERIES SCIENCE & AQUACULTURE
https://doi.org/10.1080/23308249.2020.1839015

Taylor & Francis
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REVIEW

Check for updates

Current Knowledge on the Biology, Ecology, and Commercial Exploitation of the Sea Cucumber *Cucumaria frondosa*

Bruno L. Gianasi[a], Jean-François Hamel[b], Emaline M. Montgomery[a], Jiamin Sun[a], and Annie Mercier[a]

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MARINE BIOLOGY RESEARCH
https://doi.org/10.1080/17451000.2020.1781188

Taylor & Francis

REPORT

Check for updates

Reproductive cycle of the red sea cucumber, *Parastichopus tremulus* (Gunnerus, 1767), from western Norway

Gyda Christophersen, Ingebrigt Bjørkevoll, Snorre Bakke and Margareth Kjerstad

Møreforsking AS, Ålesund, Norway

Reviews in Fisheries Science, 20(4):212–219, 2012
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ISSN: 1064-1262 print / 1547-6553 online
DOI: 10.1080/10641262.2012.719043

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A Review of the Northern Sea Cucumber *Cucumaria frondosa* (Gunnerus, 1767) as a Potential Aquaculture Species

EMILY J. NELSON,[1] BRUCE A. MACDONALD,[1] and SHAWN M. C. ROBINSON[2]

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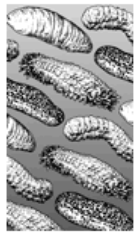

BECHE-DE-MER
information bulletin

Vol. 12: 139–151, 2020
https://doi.org/10.3354/aei00356

AQUACULTURE ENVIRONMENT INTERACTIONS
Aquacult Environ Interact

Published April 9

OPEN ACCESS

Growth, health and biochemical composition of the sea cucumber *Cucumaria frondosa* after multi-year holding in effluent waters of land-based salmon culture

Jiamin Sun[1,*], Jean-François Hamel[2], Bruno L. Gianasi[1], Mike Graham[3], Annie Mercier[1]

[1]Department of Ocean Sciences, Memorial University, St John's, NL, A1C 5S7, Canada
[2]Society for the Exploration and Valuing of the Environment (SEVE), St. Philips, NL, A1M 2B7, Canada
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DOI: 10.1111/jwas.12816

FUNDAMENTAL STUDIES

World Aquaculture Society

WILEY

Controlled spawning and rearing of the sea cucumber, *Parastichopus tremulus*

Ellen Schagerström[1] | Gyda Christophersen[2] | Jan Sunde[2] | Snorre Bakke[2] | Nédia R. Matusse[1] | Sam Dupont[1] | Kristina S. Sundell[1]

CHALLENGES RELATED TO CULTIVATION OF SPECIES FROM N-NA WATERS

- Cold water species – **slow growth rates** in natural environment
- Limited knowledge on **population sizes/structure**
- Limited knowledge on **fecundity/recruitment**

Photo: Jan Sunde

PARAMETERS OF IMPORTANCE FOR AQUACULTURE DEVELOPMENT

- Lack of data on **growth** from early juvenile to **commercial size**
- Lack of data on **temperature tolerance** and **nutritional requirements**
- Time to market size?? - important for **investment** in potential industry

Photo: Gyda Christophersen

DIFFERENT LIFE STAGES – FROM MM TO CM

From: Gianasi, B. L., Hamel, J. F., Montgomery, E. M., Sun, J., & Mercier, A. (2021). Current knowledge on the biology, ecology, and commercial exploitation of the sea cucumber *Cucumaria frondosa*. *Reviews in Fisheries Science & Aquaculture*, *29*(4), 582-653.

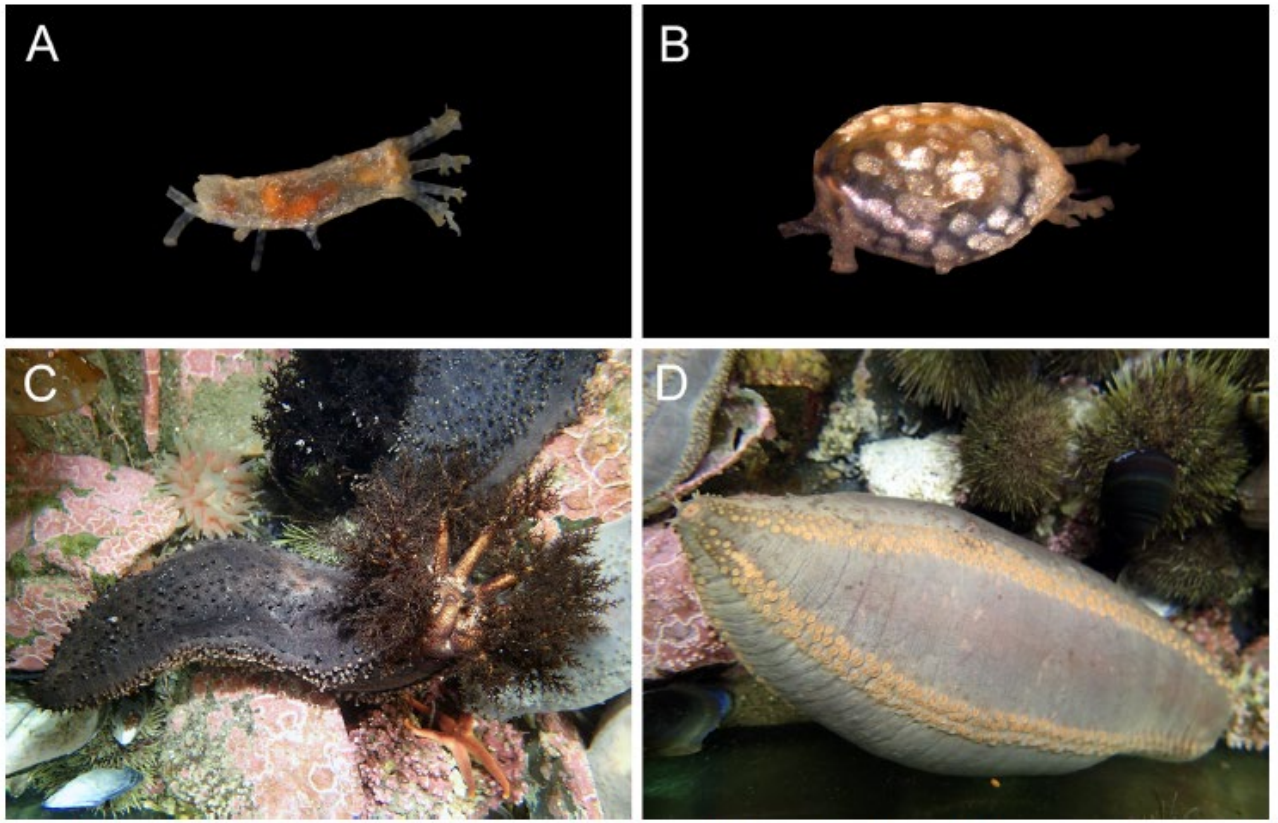


Figure 31. Illustration of juveniles and adults of *Cucumaria frondosa* in their normal posture and during active buoyancy adjustment. Six-month-old juvenile displaying (A) normal posture and (B) bloated behavior resulting from active buoyancy adjustment. Adult showing (C) normal posture and (D) bloated behavior. Juveniles are ~1.8 mm long and adults are ~22 cm long (relaxed length mouth-anus). Modified from Hamel et al. (2019).

EXAMPLE *C. frondosa* FROM EAST COAST CANADA

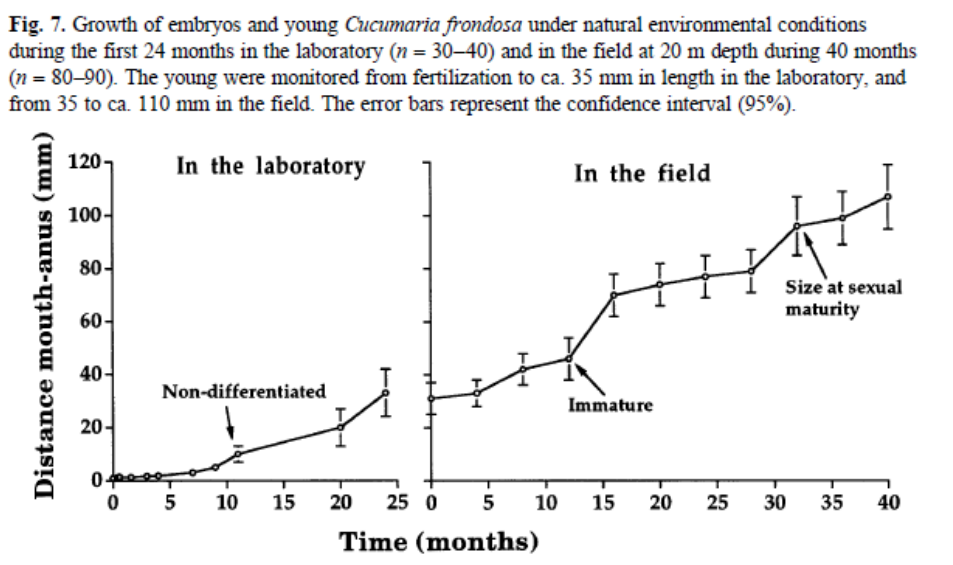


Fig. 7. Growth of embryos and young *Cucumaria frondosa* under natural environmental conditions during the first 24 months in the laboratory (n = 30–40) and in the field at 20 m depth during 40 months (n = 80–90). The young were monitored from fertilization to ca. 35 mm in length in the laboratory, and from 35 to ca. 110 mm in the field. The error bars represent the confidence interval (95%).

From: Hamel, J. F., & Mercier, A. (1996). Early development, settlement, growth, and spatial distribution of the sea cucumber *Cucumaria frondosa* (Echinodermata: Holothuroidea). *Canadian Journal of Fisheries and Aquatic Sciences*, *53*(2), 253-271.

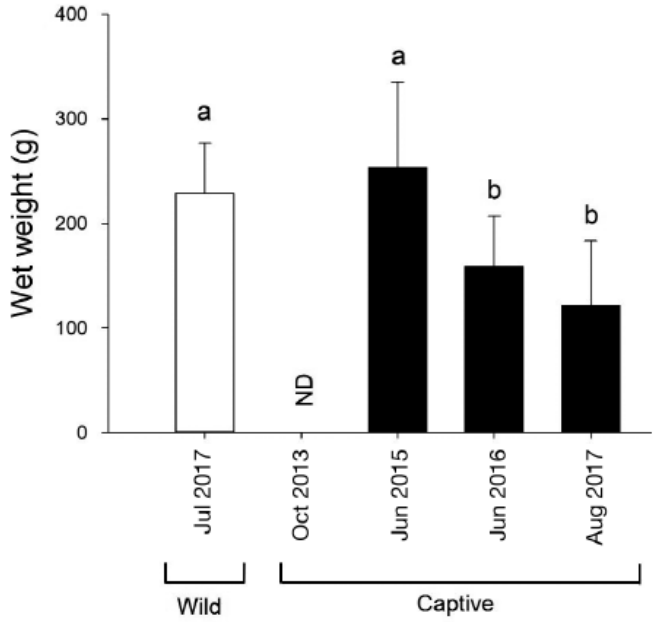
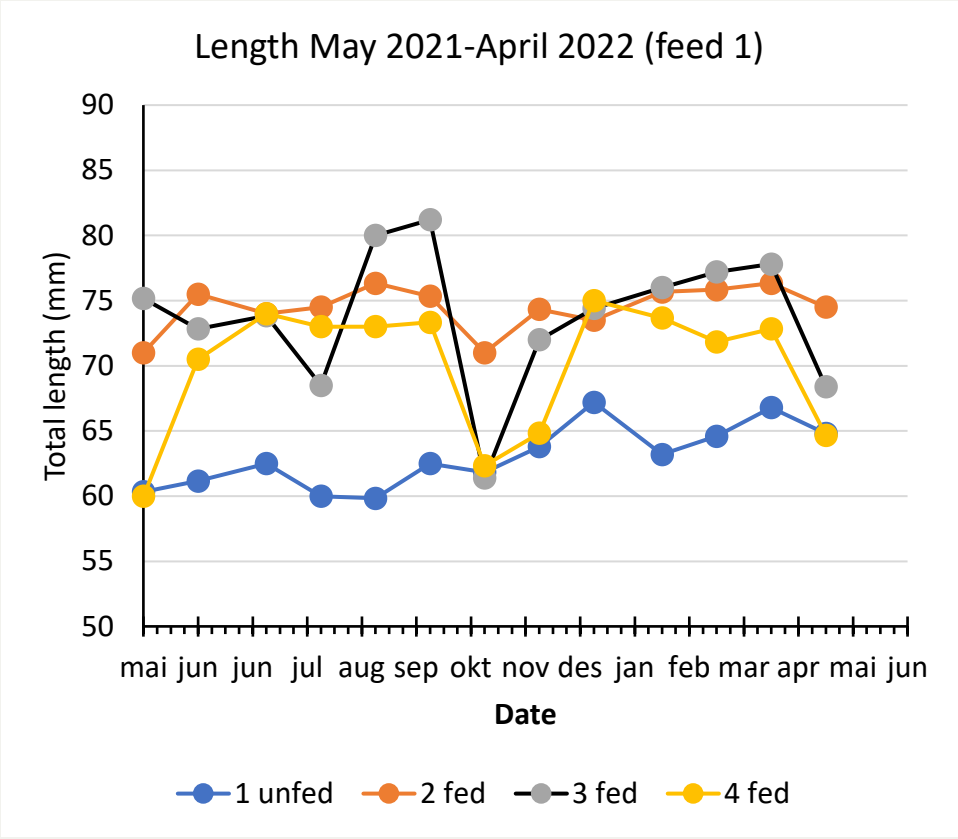
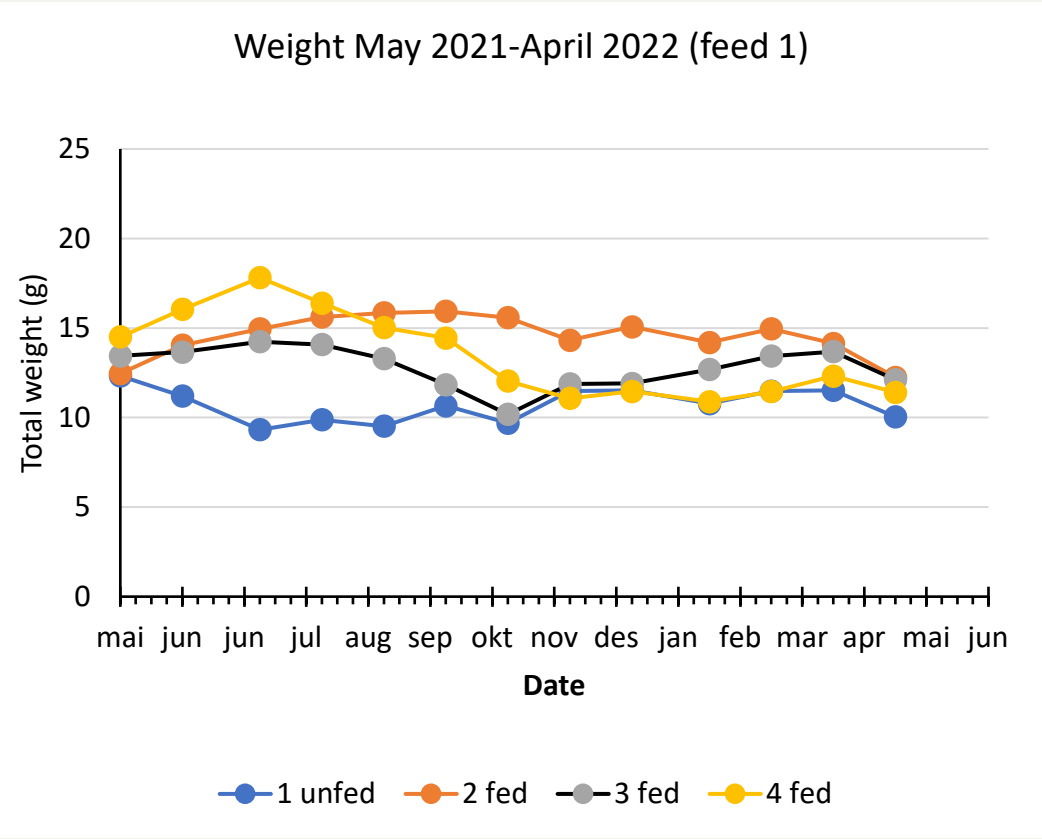


Fig. 1. Wet weight of wild individuals of *Cucumaria frondosa* (collected in 2017) and wet weight of captive individuals over time (2013–2017). Data are shown as means ± SD (n = 24 for wild and captive individuals in 2017; n = 40 for 2015 and 2016). Means with different letters are significantly different (Tukey's test, $p < 0.05$). ND: not determined

From: Sun, J., Hamel, J. F., Gianasi, B. L., Graham, M., & Mercier, A. (2020). Growth, health and biochemical composition of the sea cucumber *Cucumaria frondosa* after multi-year holding in effluent waters of land-based salmon culture. *Aquaculture Environment Interactions*, *12*, 139-151.

EXAMPLE OF GROWTH *P. tremulus* – LAB STUDIES





REDUCED ENVIRONMENTAL FOOTPRINT FROM SALMON FARMING USING SEA CUCUMBER IN IMTA SYSTEM

Project funded by Møre and Romsdal County Municipality

Photos: Ingebrigt Bjørkevoll

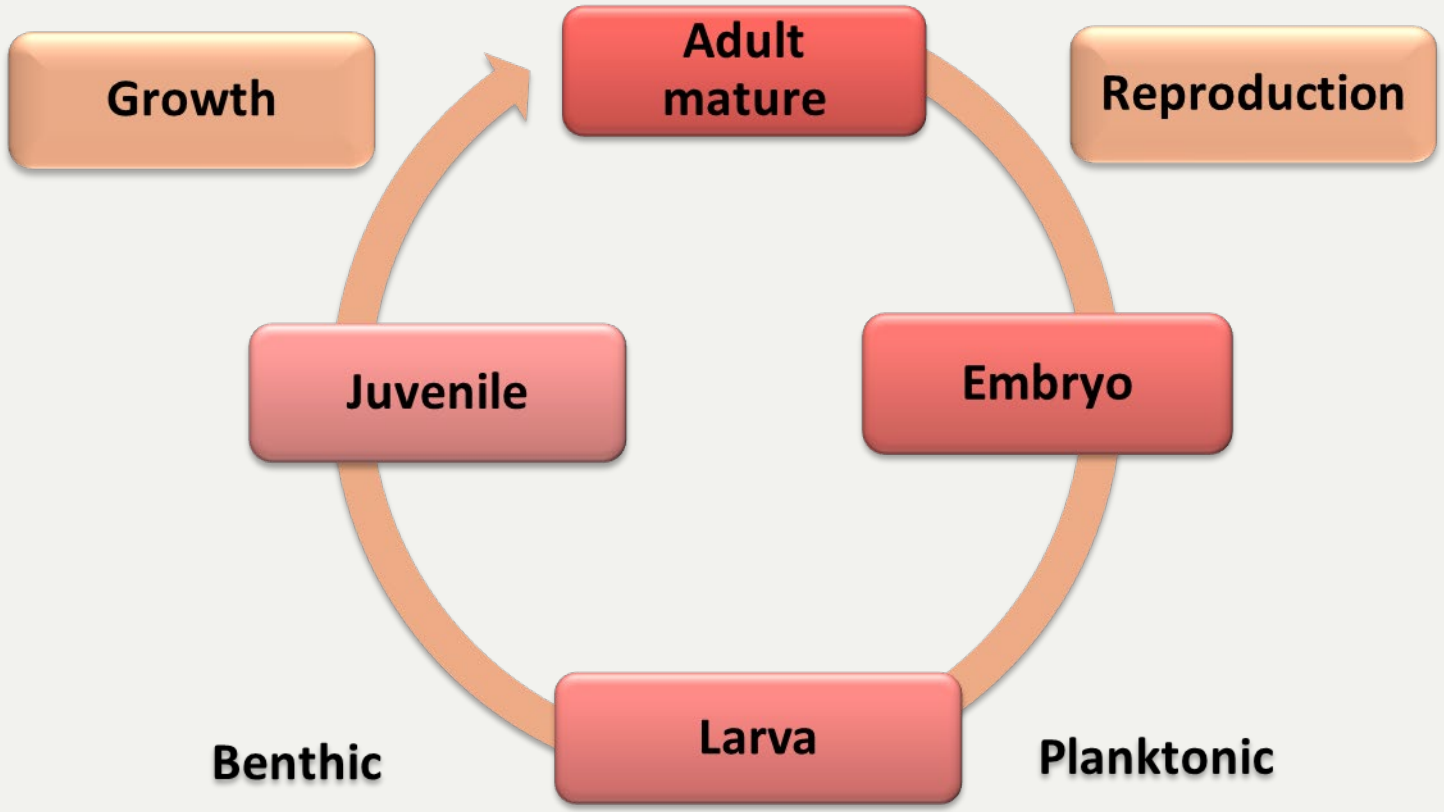
POSSIBILITES - AQUACULTURE METHODS

- Capture based aquaculture
- Intensive aquaculture (hatchery production)

- Sea ranching
- Co-cultivation/polyculture
- Integrated multitrophic aquaculture (IMTA)

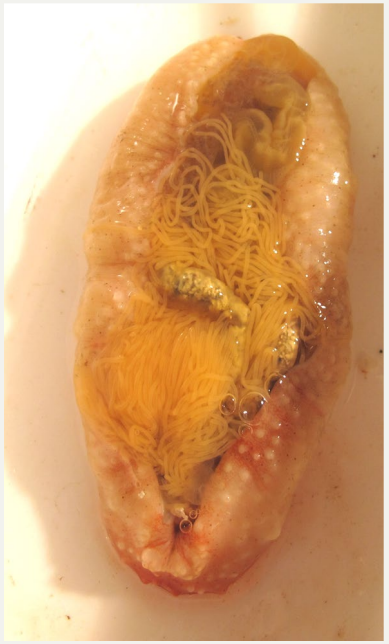
- Land-based
- Sea-based

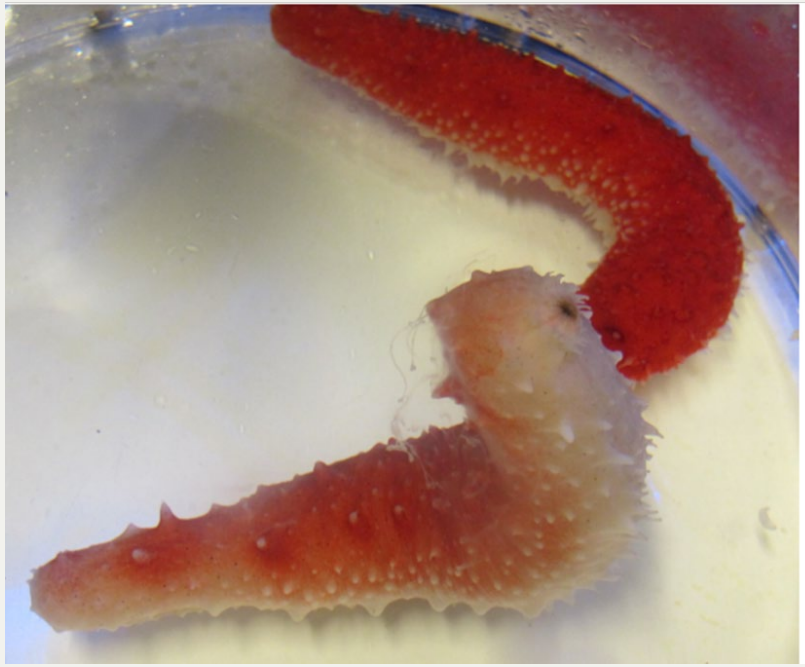
INDUSTRIAL HATCHERY PRODUCTION:
Available juveniles (spat) & controlling the life cycle

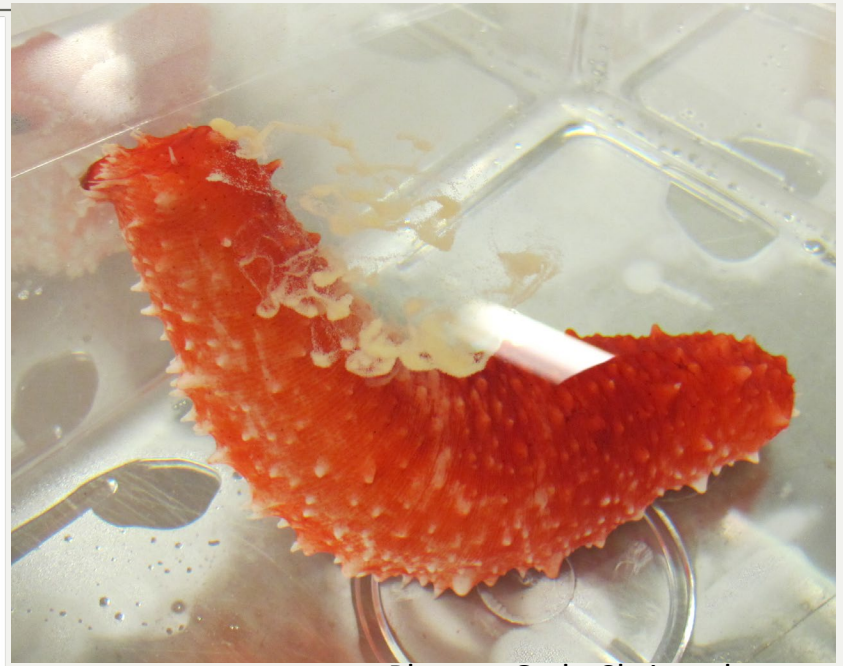


HATCHERY PRODUCTION

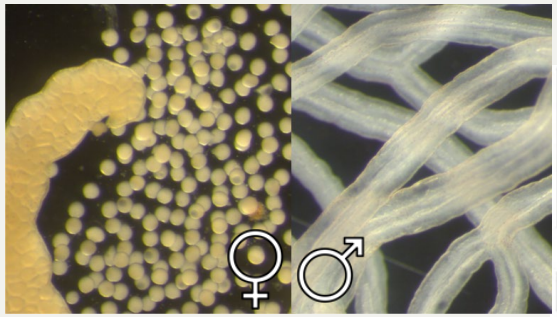
SANOCEAN project 288536

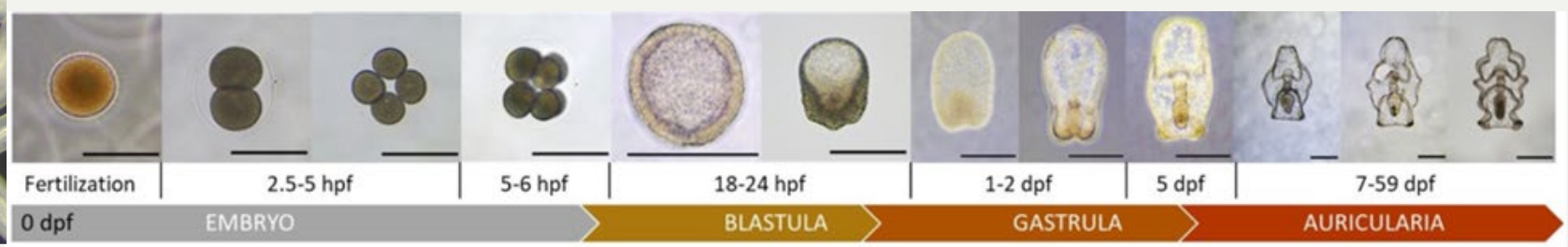






Photos: Gyda Christophersen





Scale bar
= 200 µm

From: Christophersen & Sunde, Poster, Aqaculture Europe 20

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA)

- Possible in the north?
- Suitable as IMTA species ?
- Can we adapt sea cucumber farming to already existing aquaculture infrastructure ?

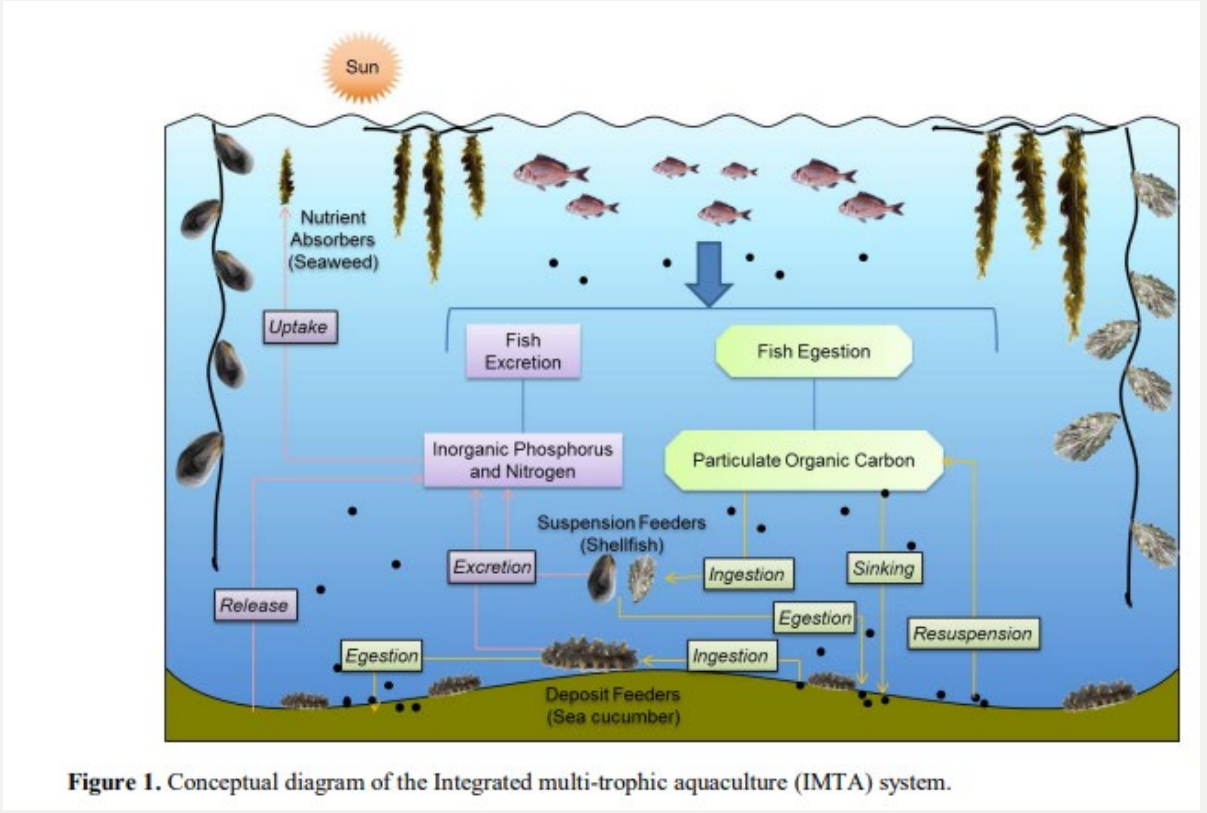


Figure 1. Conceptual diagram of the Integrated multi-trophic aquaculture (IMTA) system.

From: Zhang et al 2019. Bio-mitigation based on integrated multi-trophic aquaculture in temperate coastal waters: practice, assessment, and challenges. Latin American Journal of Aquatic Research, 47(2 Bio): - mitigation based on 212-223, 2019 IMTA in temperate coastal waters 1 DOI: 10.3856/vol47-issue2-fulltext-1

POSSIBLE PROSPECTS - NORWAY

- Highly developed salmon aquaculture infrastructure
- Waste - aquaculture sludge
- Potential new feed resource ?
- High in particulate matter
- High protein/energy content
- Current use - fertilizer or production of biogas
- Current legislation limits use

Photo: Jan Sunde

Photo: Jan Sunde

LIFE IN CAPTIVITY – SUCCESS FACTORS

- Reproduction
- Feed composition and conversion
- Environmental conditions
- Growth performance / biological constraints
- Rearing technology adapted for
  - - sea cucumber species
  - - life stages

FEED UTILIZATION – ONGOING STUDIES

SAFER-IMTA

SANOCEAN project 288536

- Feed composition/ingredients
- Formulated vs natural substrate?
- Digestibility of sludge
- Increase digestibility of sludge through processing?

Photo: Gyda Christophersen

SUMMARY – POTENTIAL AND OBSTACLES

- Biological knowledge gaps
- Growth rate – slow, seasonal variation (cessation of feeding ?)
- Stage specific adapted nutrition
- Species specific rearing technology
- Optimisation of water conditions
- Juvenile production – upscaling, industrialization
- Legislative obstacles (integrated farming, use of “waste” as feed)
- Disease/hygiene
- Processing industry
- Human and financial resources

ARE SEA CUCUMBERS POSSIBLE TO CULTIVATE IN NNA?