UJNR Scientific Symposium

Relationship Between Gametogenesis and Food Quality in Sea Urchin Gonads

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1. Gonadal structure and gametogenesis

CWW

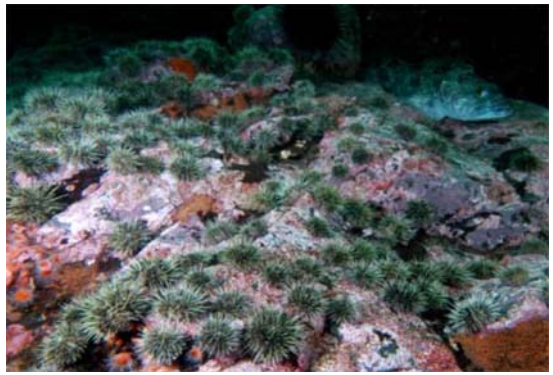
2. Relationship between gametogenesis and food quality

TU

3. Strategies to extend the season

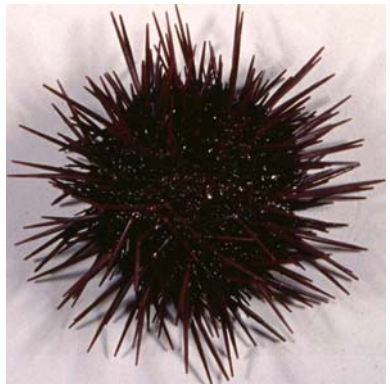
TU and CWW

CWW



Strongylocentrotus droebachiensis

TU

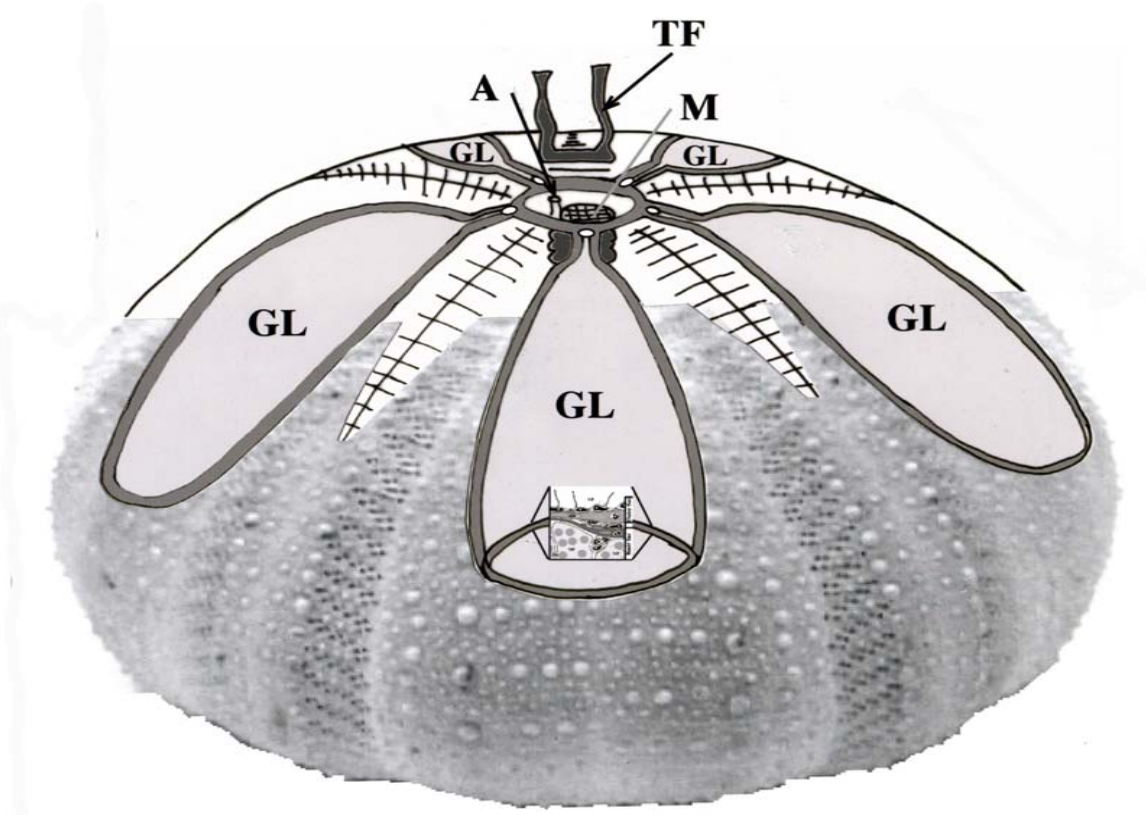


Pseudocentrotus depressus

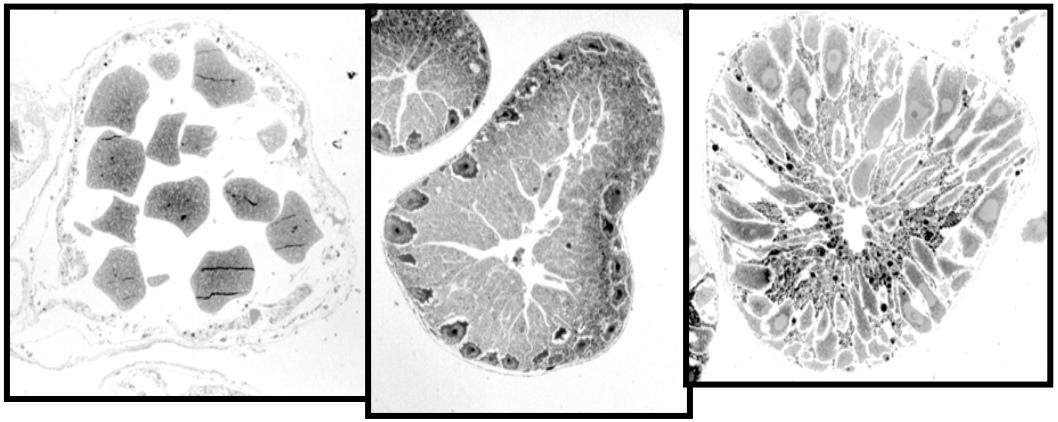
1. Gonadal structure and gametogenesis

2. Relationship between gametogenesis and food quality

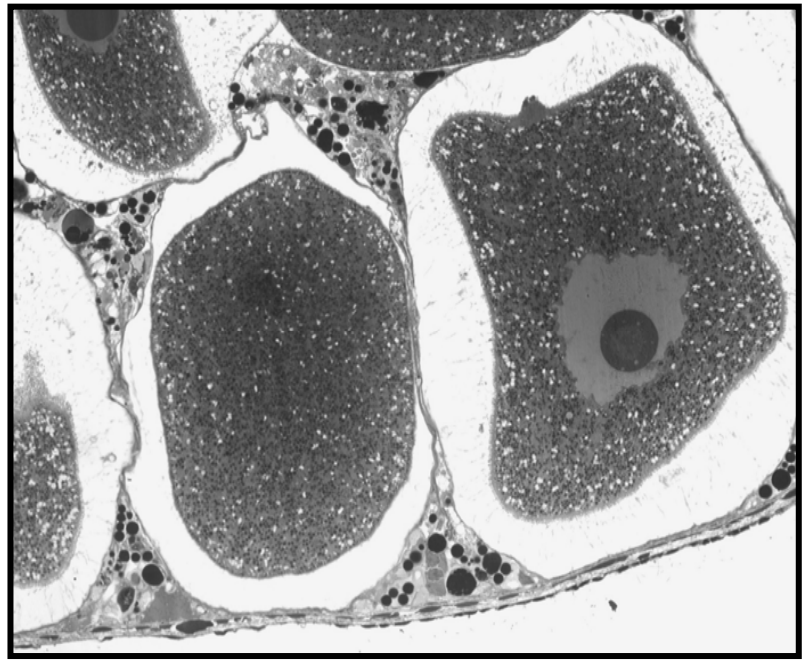
3. Strategies to extend the season

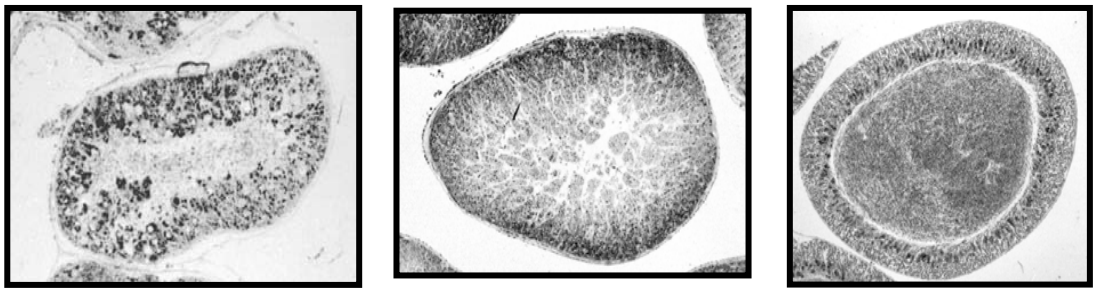


Gametogenesis in Sea Urchins

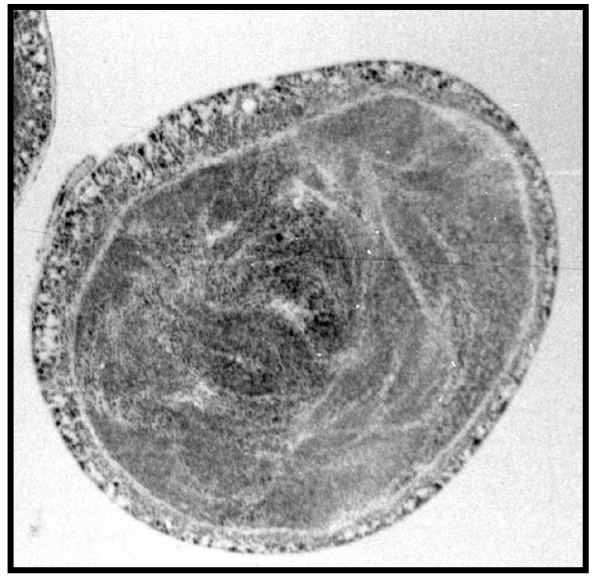


Female Gonad

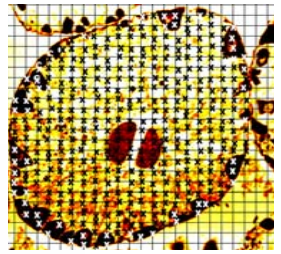


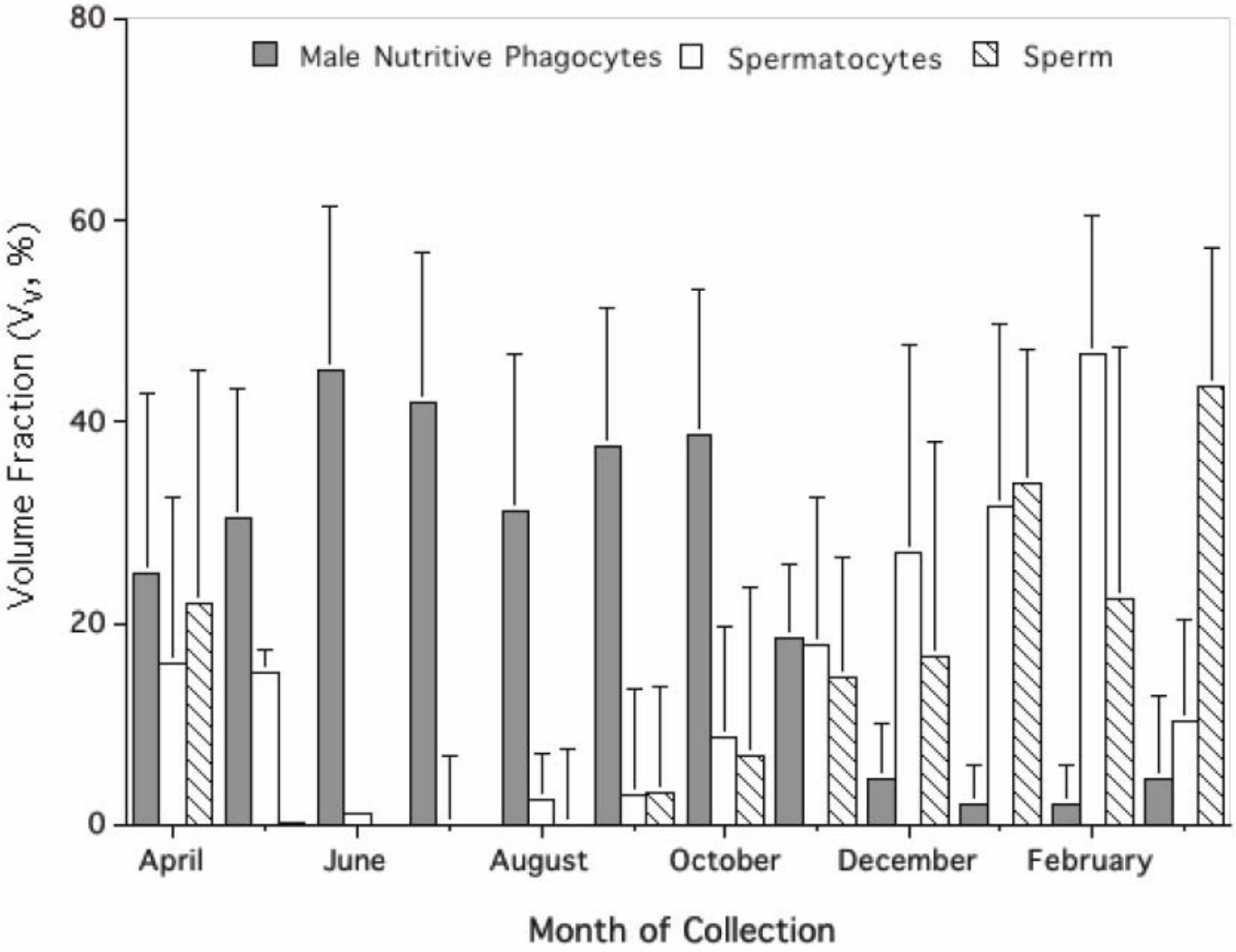


Male Gonad

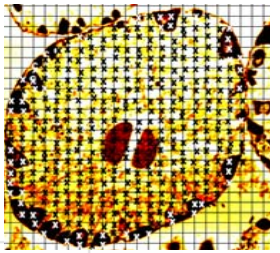


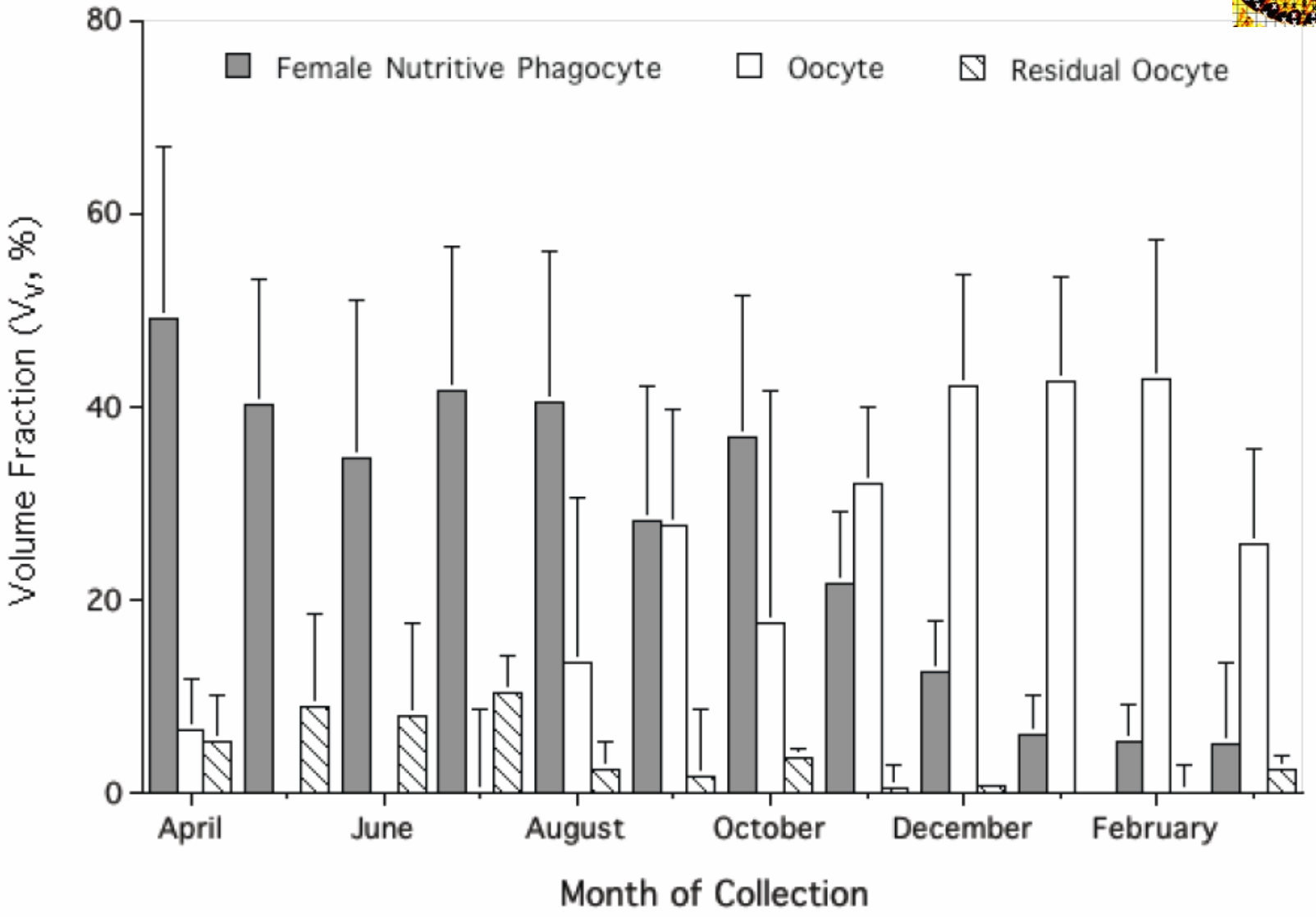
Stereology for Males





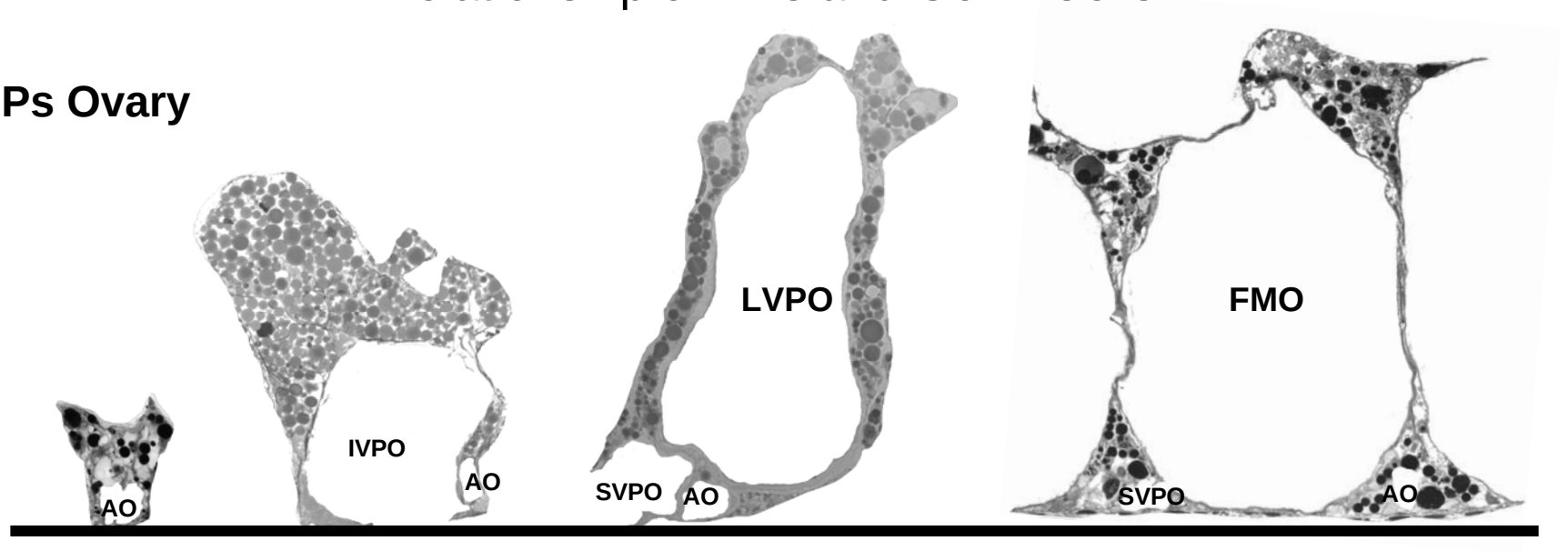
Stereology for Females





Relationship of NPs and Germ Cells

NPs Ovary



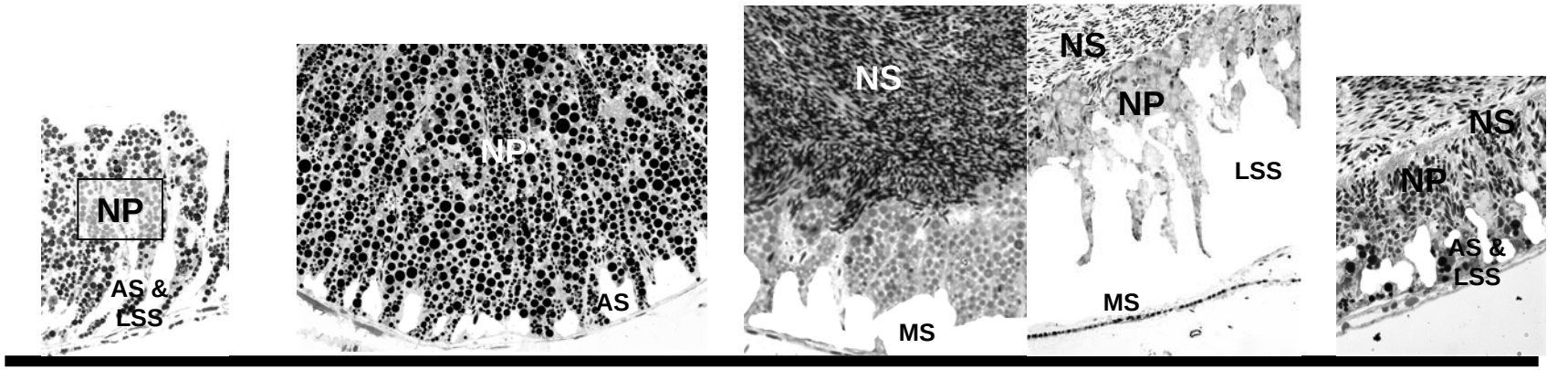
Inter-Gametogenesis and NP Phagocytosis

Pre-Gametogenesis and NP Renewal

Gametogenesis and NP Utilization

End of Gametogenesis, NP Exhaustion and Spawning

NPs Testis



Inter-Gametogenesis and NP Phagocytosis

Pre-Gametogenesis and NP Renewal

Gametogenesis and NP Utilization

End of Gametogenesis, NP Exhaustion and Spawning

Summary of Part 1

(1) Gametogenesis and nutrient storage and utilization are linked processes in sea urchin reproduction.

(2) Uniquely, sea urchin gonads grow in size not only because gametogenesis increases the size and/or numbers of gametes, but also because nutritive phagocytes store extensive nutrients before gametogenesis begins.

1. Gonadal structure and gametogenesis

2. Relationship between gametogenesis and food quality

3. Strategies to extend the season

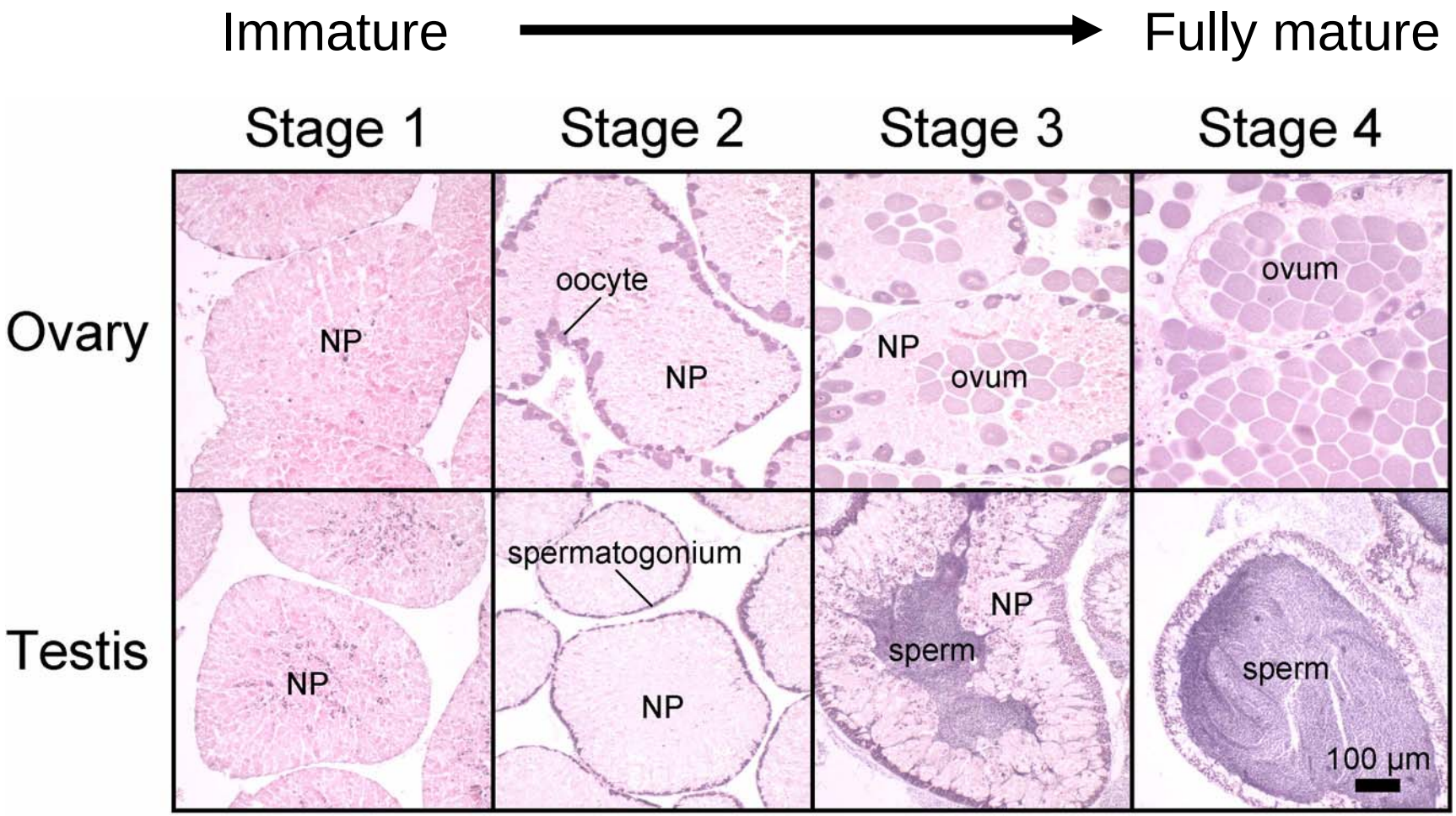
Commercial value varies with gonadal conditions

Ovaries or testes

Removed from the test
Cleaned
Soaked in alum solution
Arranged in a tray

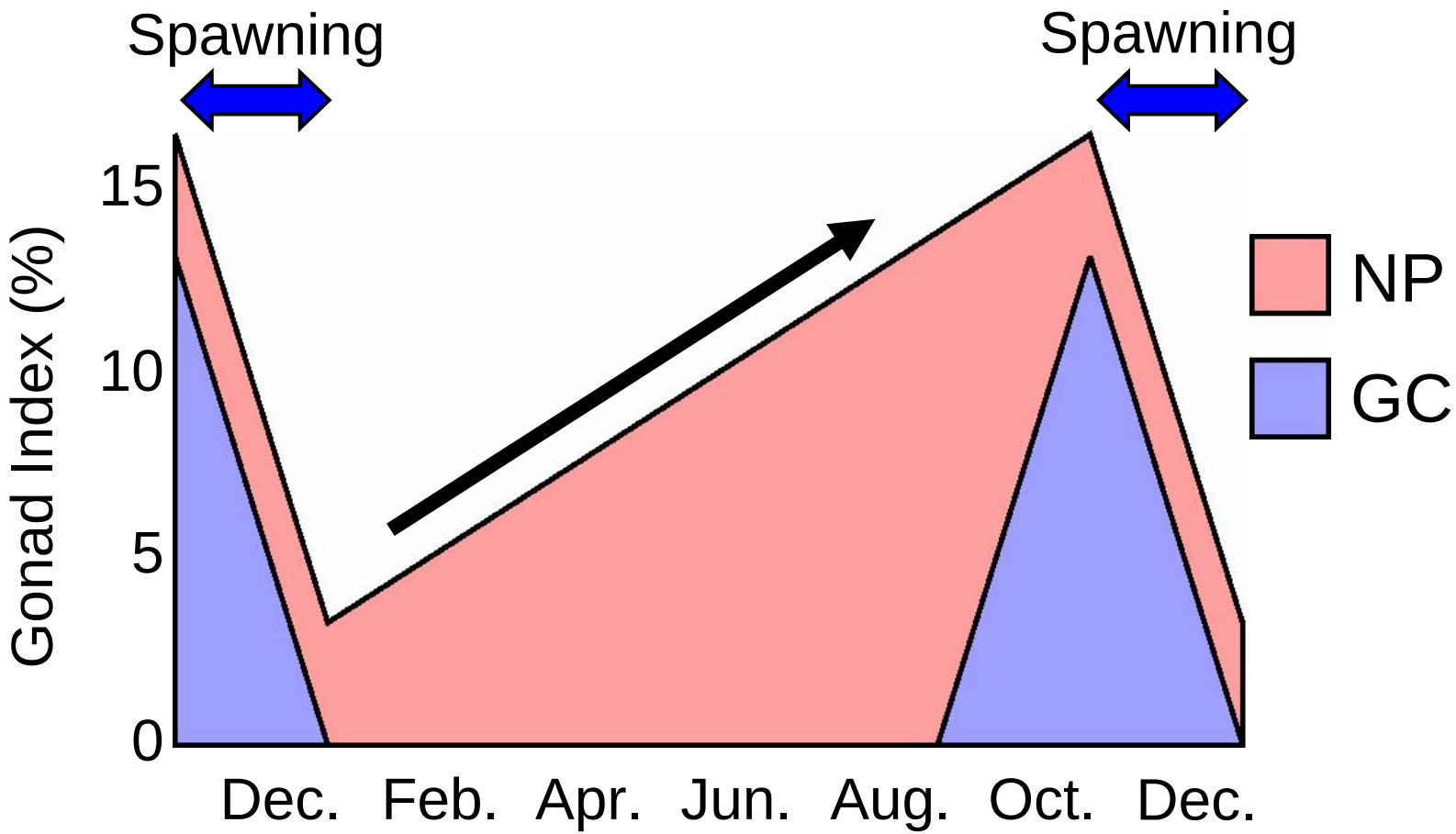
Superior quality gonads
US$250 / pkg

Classification of gametogenesis

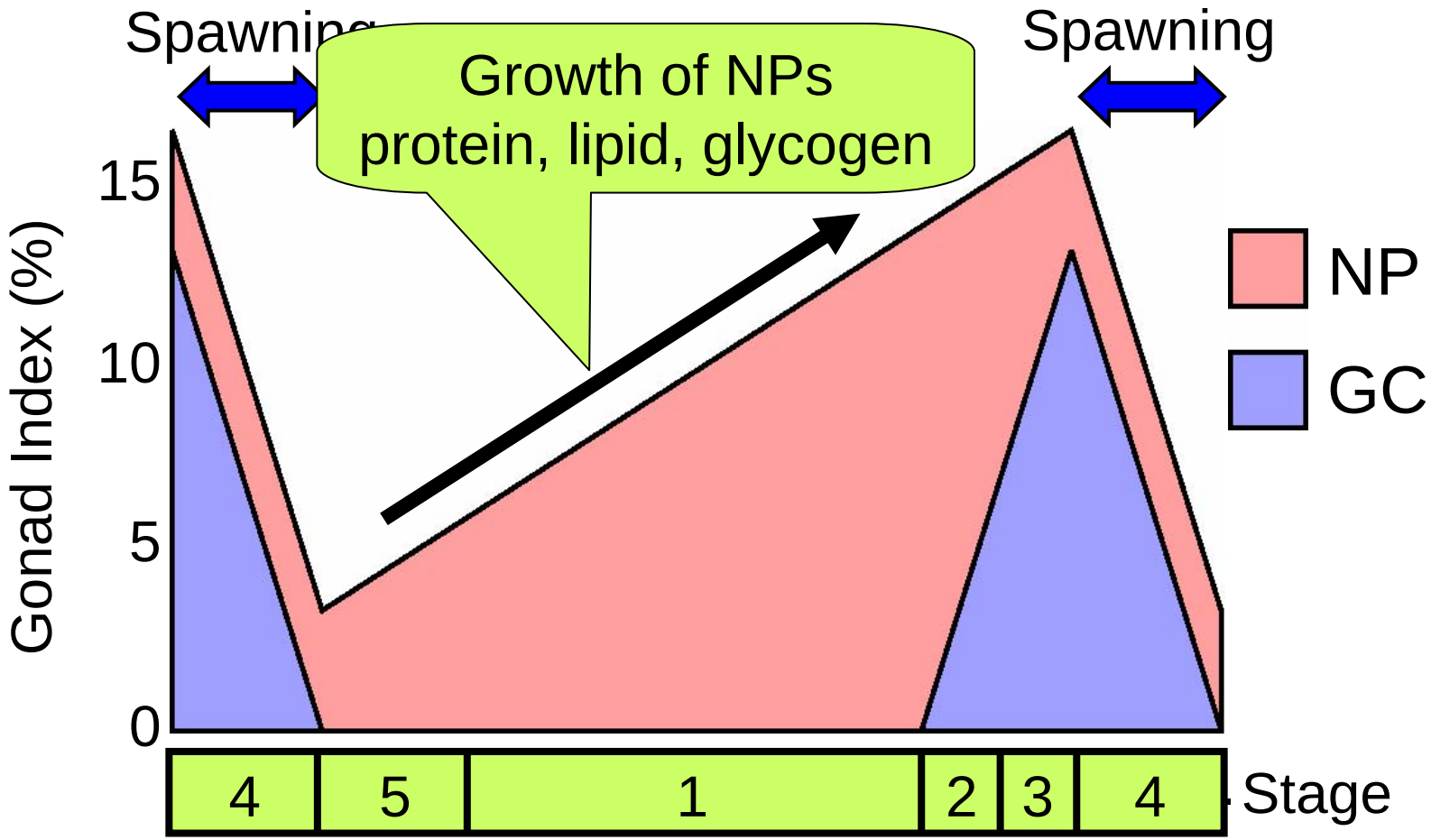


Stage classification of Fuji (1960) with modifications

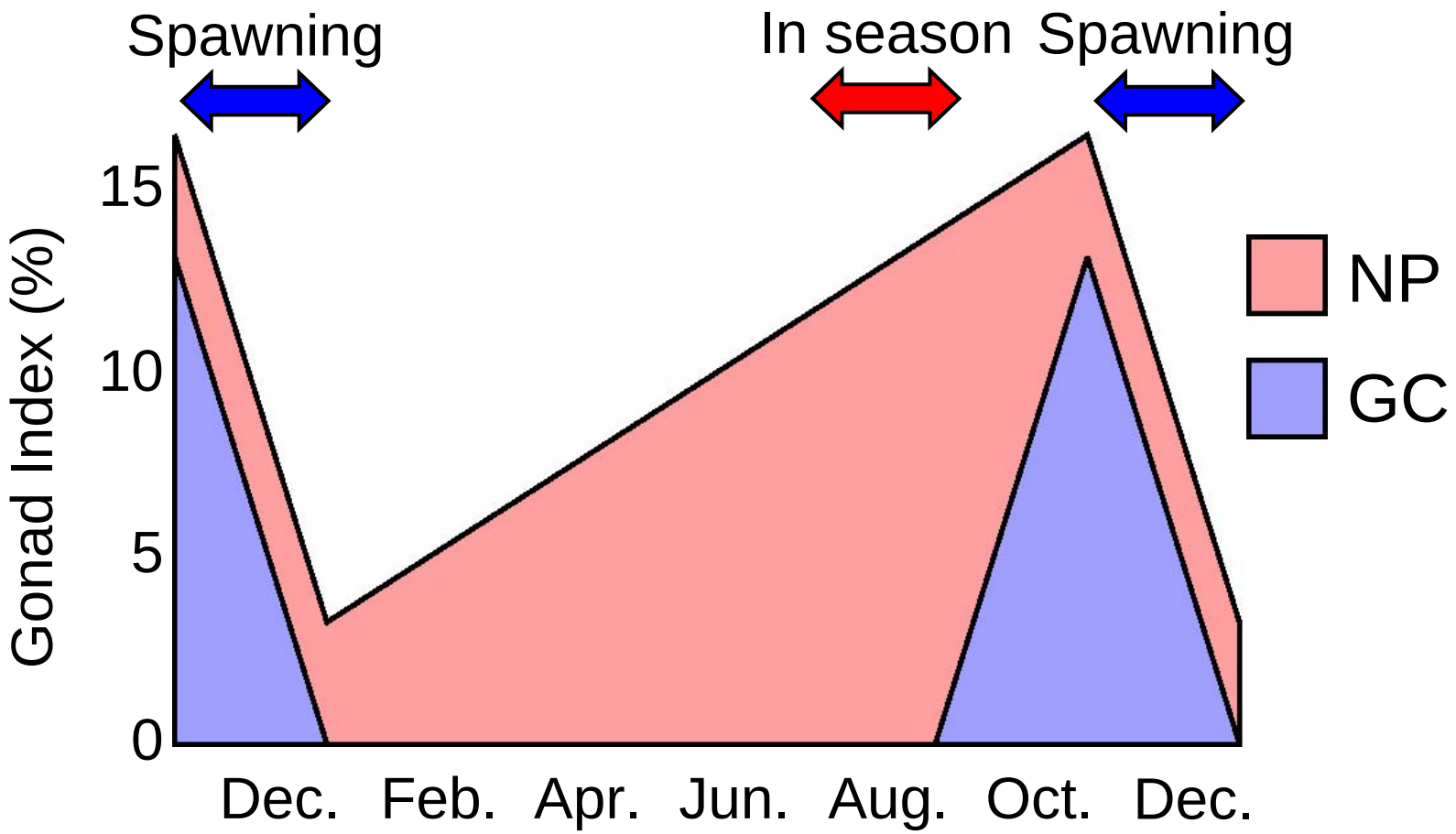
Seasonal changes in the gonad index and proportions of NPs and GCs



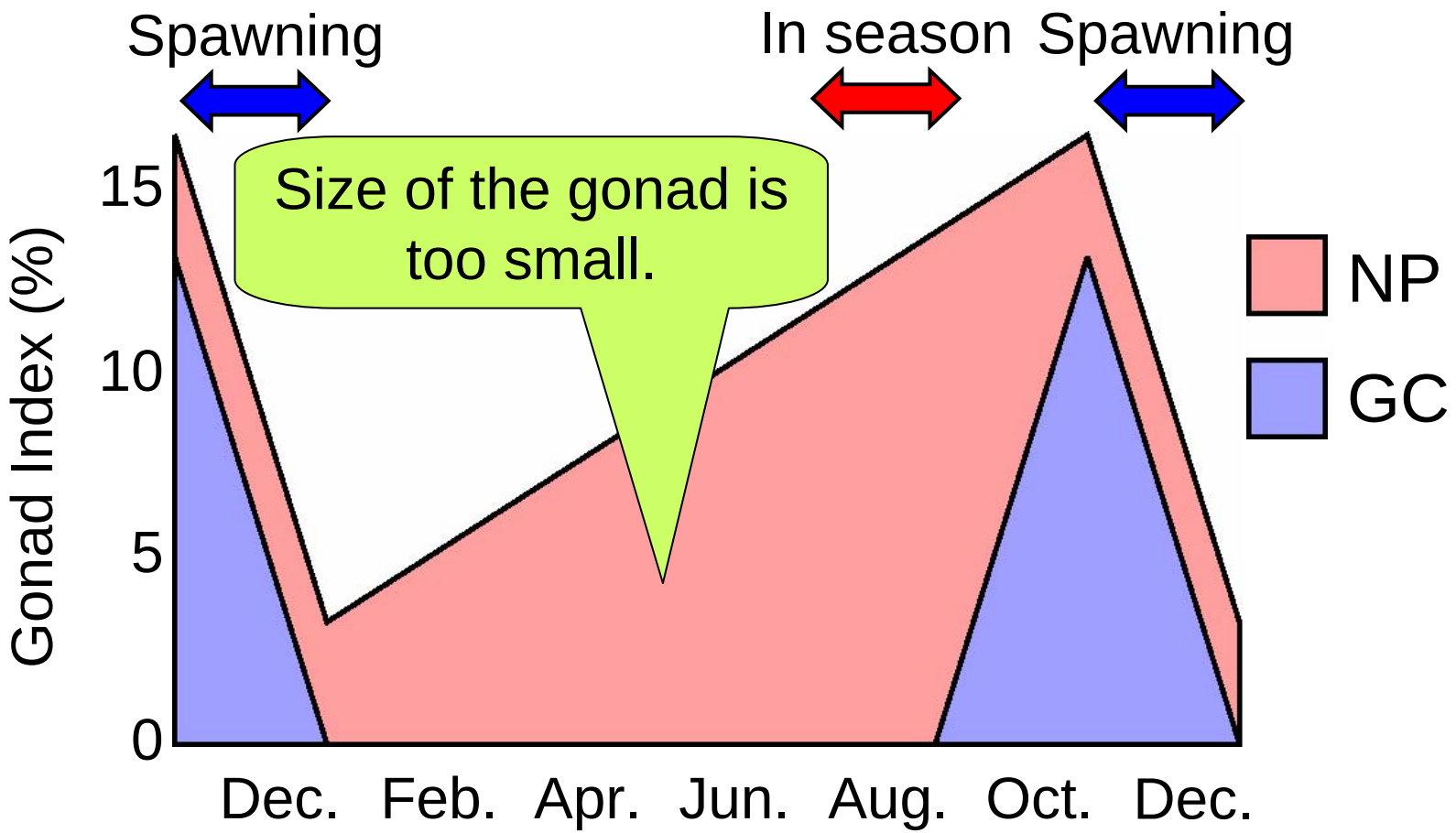
Seasonal changes in the gonad index and proportions of NPs and GCs



Season for sea urchin gonad as food



Season for sea urchin gonad as food



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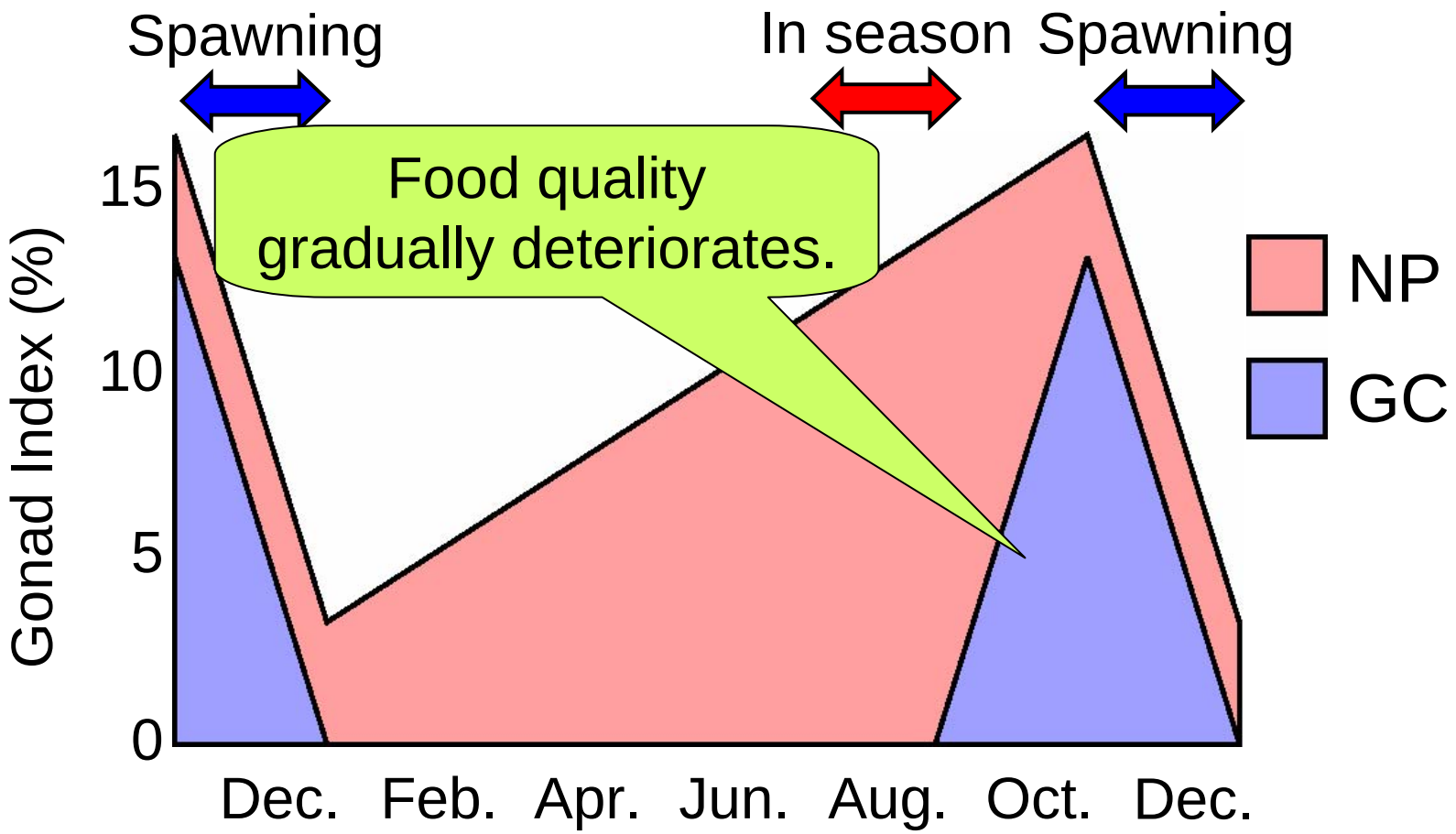
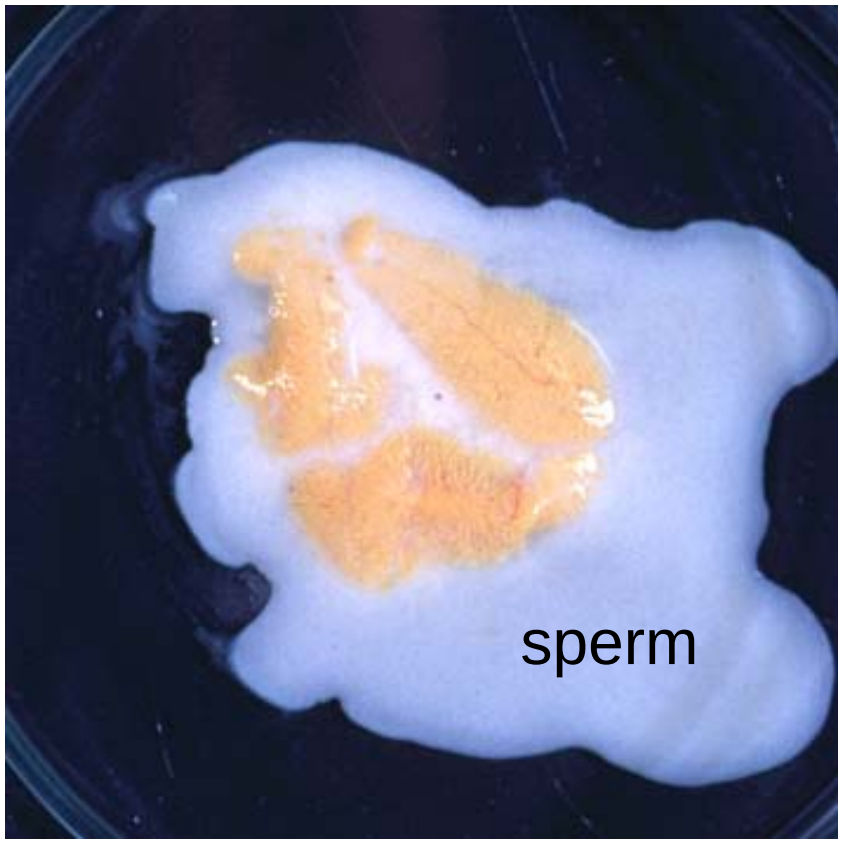


Problems associated with maturation
1. Oozing of gametes

Mature testis



Ovaries and testes of
all the edible sea urchins

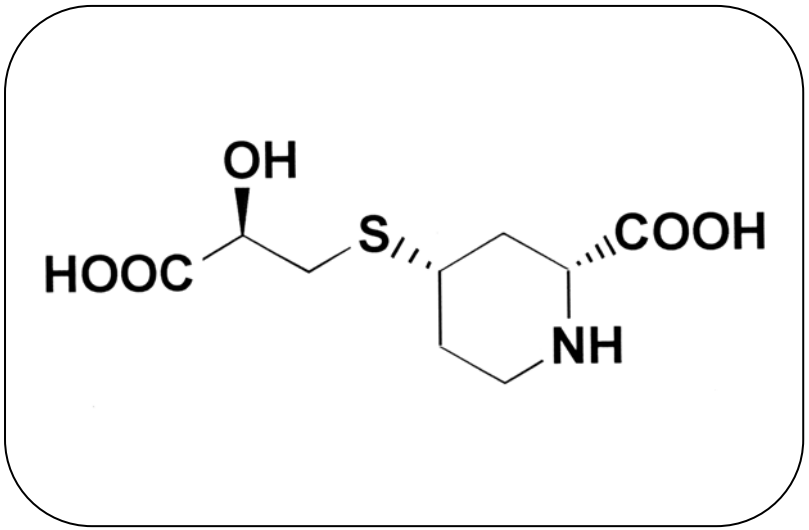
Suppressed with alum

⬇

Astringency

Problems associated with maturation
2. Bitterness of the ovary

Pulcherrimine



Murata & Sata 2000

Ovaries of some species

P. depressus
Hemicentrotus pulcherrimus

What stage is good for food?

S. nudus
S. intermedius

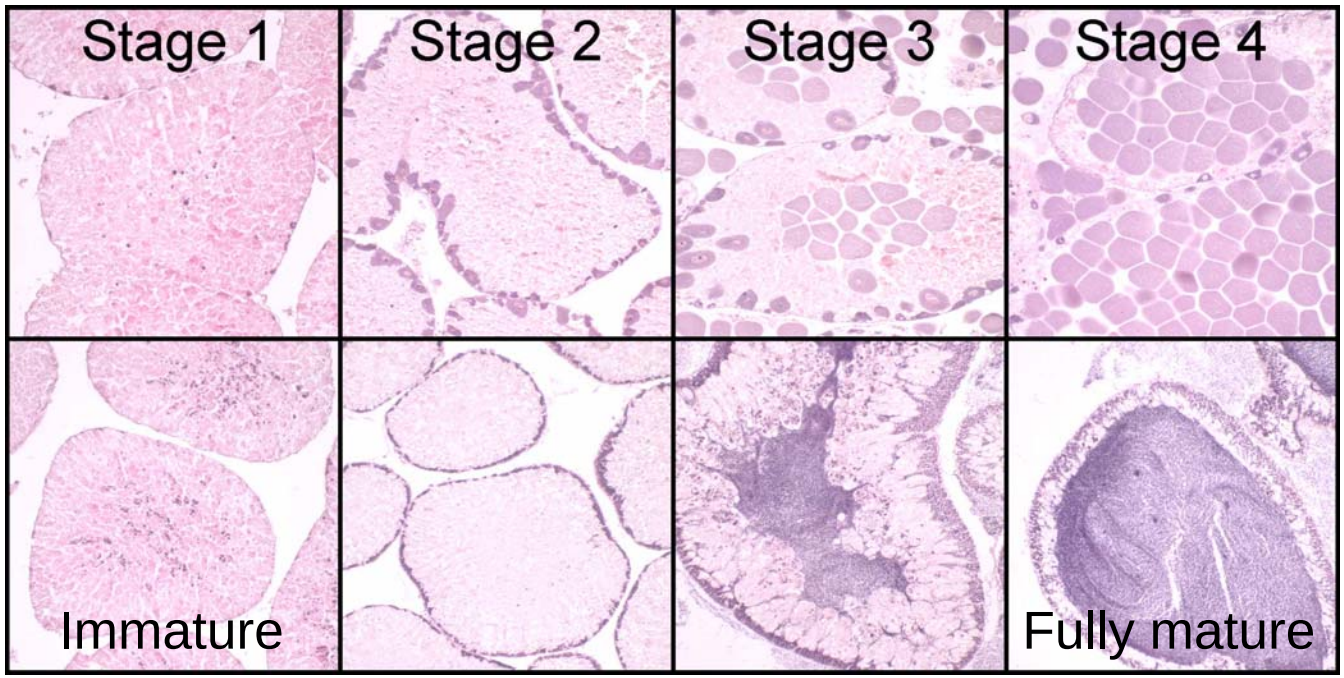
\+ + + −

P. depressus
H. pulcherrimus

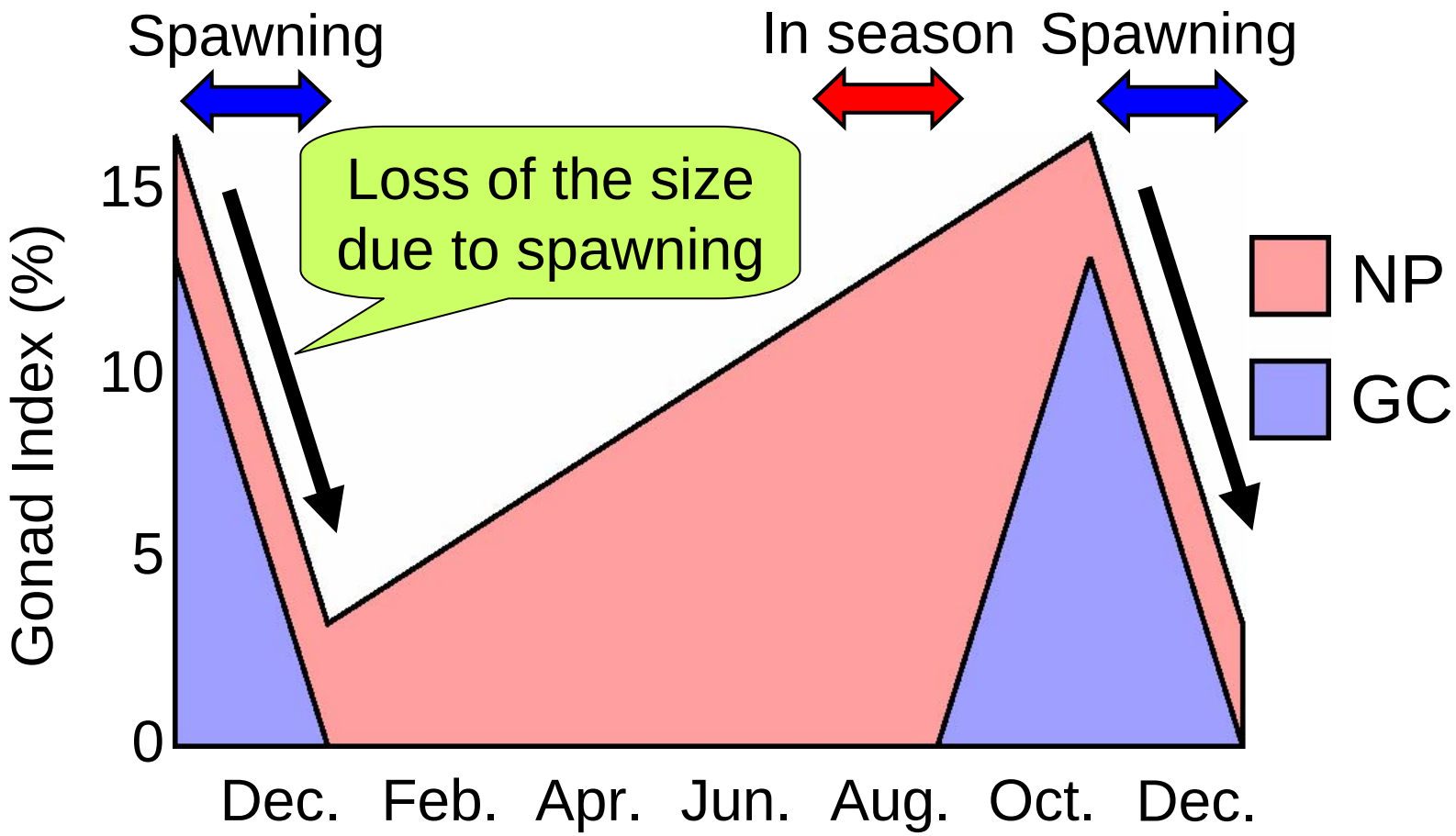
\+ −

Bitterness

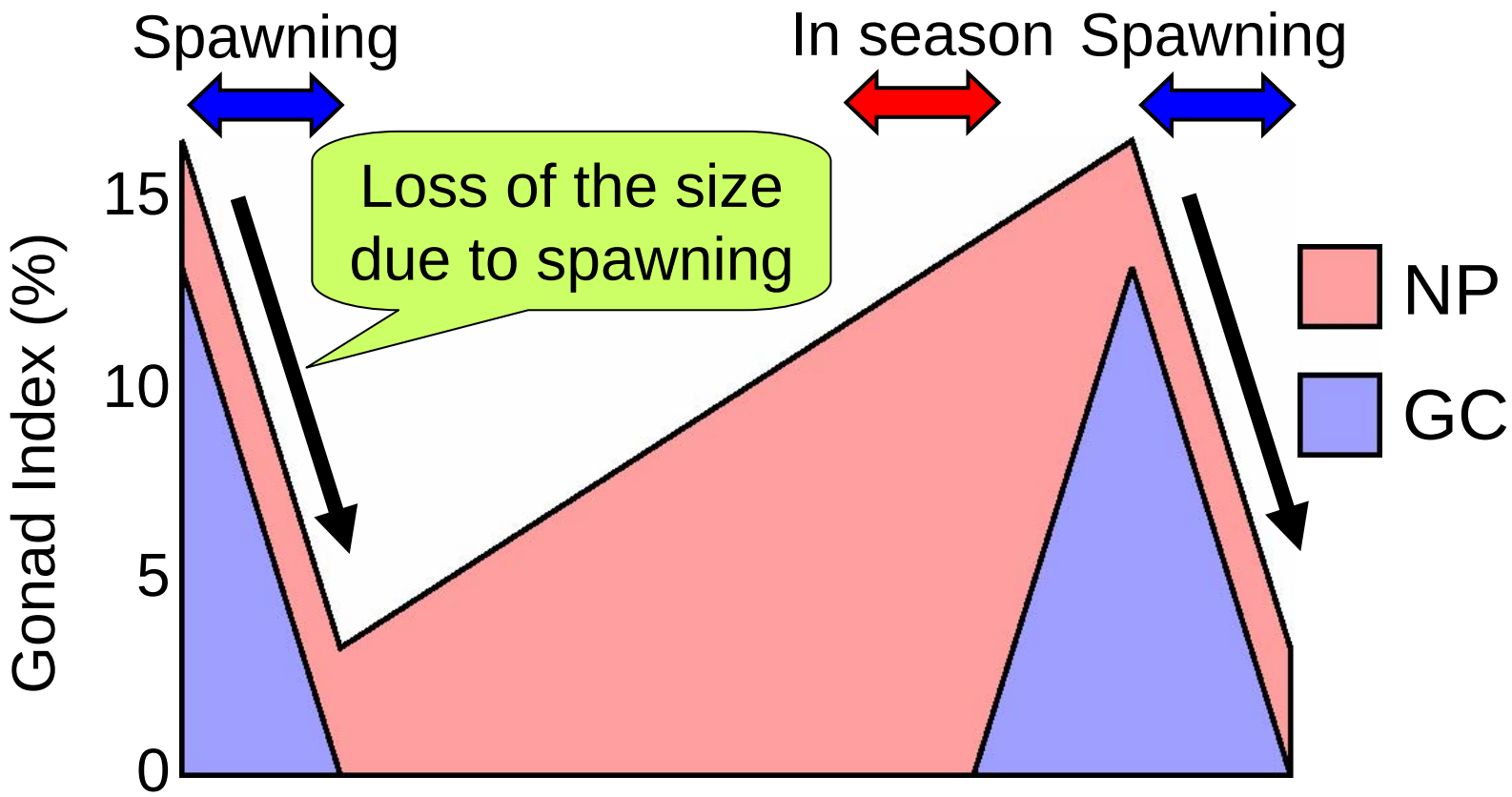
Gamete ooze



Season for sea urchin gonad as food is short because of gametogenesis

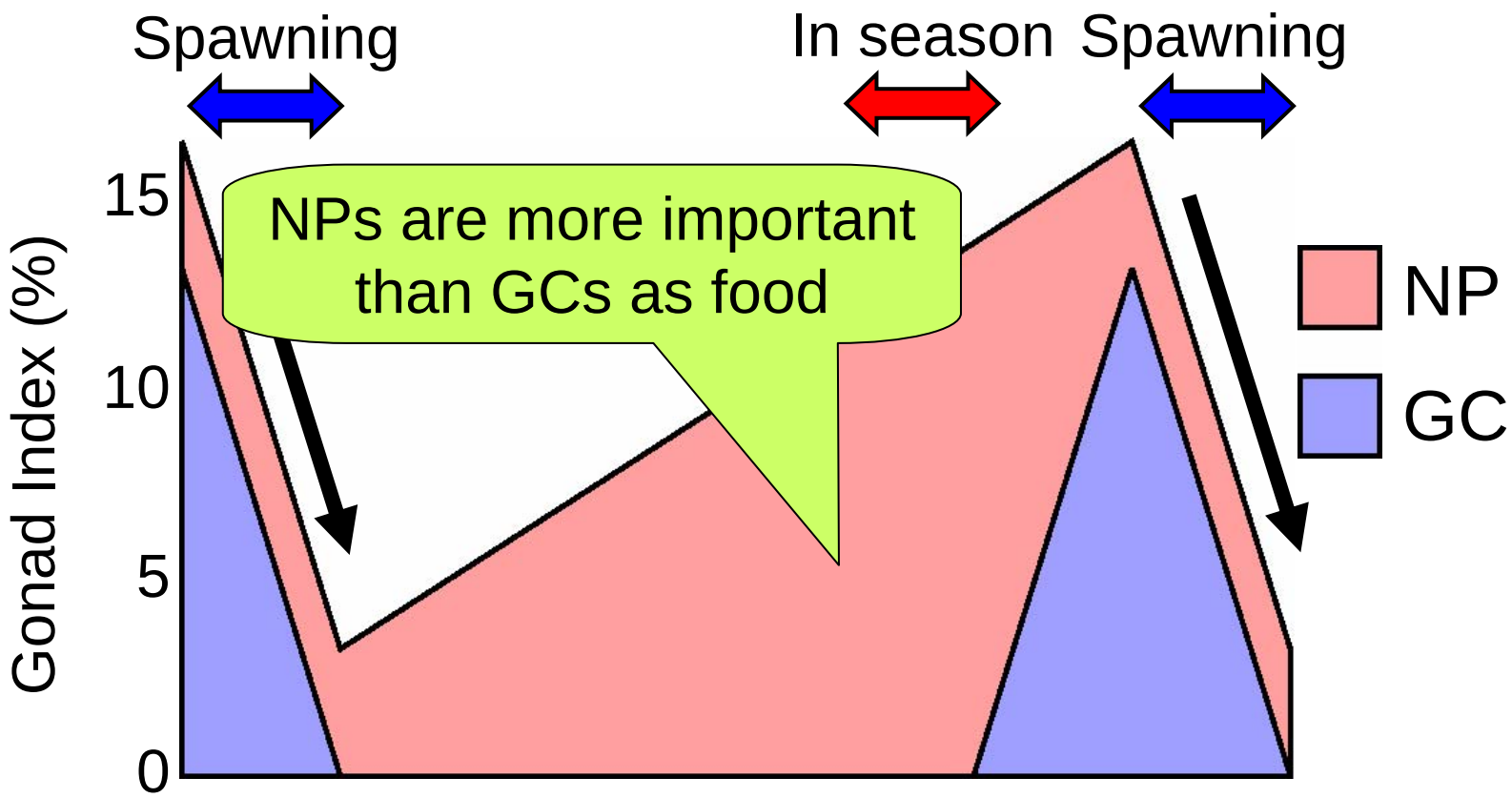


Season for sea urchin gonad as food is short because of gametogenesis



Gametogenesis and spawning are disadvantageous.

Season for sea urchin gonad as food is short because of gametogenesis



Gametogenesis and spawning are disadvantageous.

Summary of Part 2

(1) As gametogenesis proceeds, the food quality deteriorates from gamete oozing and bitterness.

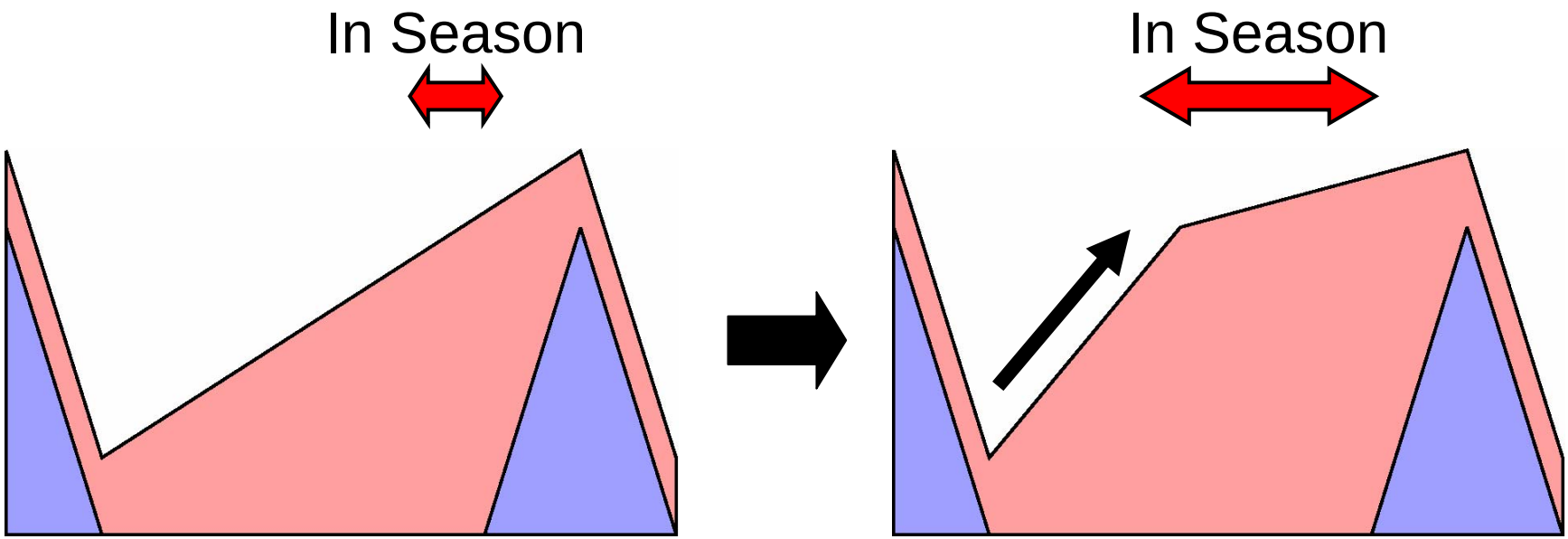
(2) NPs are more important than GCs as food.

1. Gonadal structure and gametogenesis

2. Relationship between gametogenesis and food quality

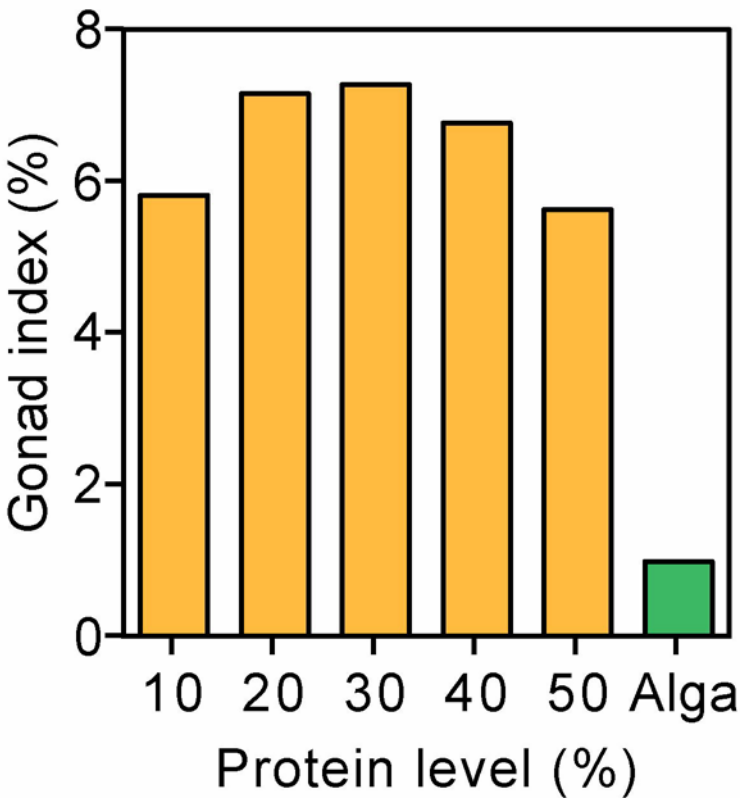
3. Strategies to extend the season

Strategies to extend the season
1. Acceleration of NP growth



If nutrient accumulation in NPs is accelerated, the gonads reach the marketable size early.

Formulated feed enhances the gonadal growth

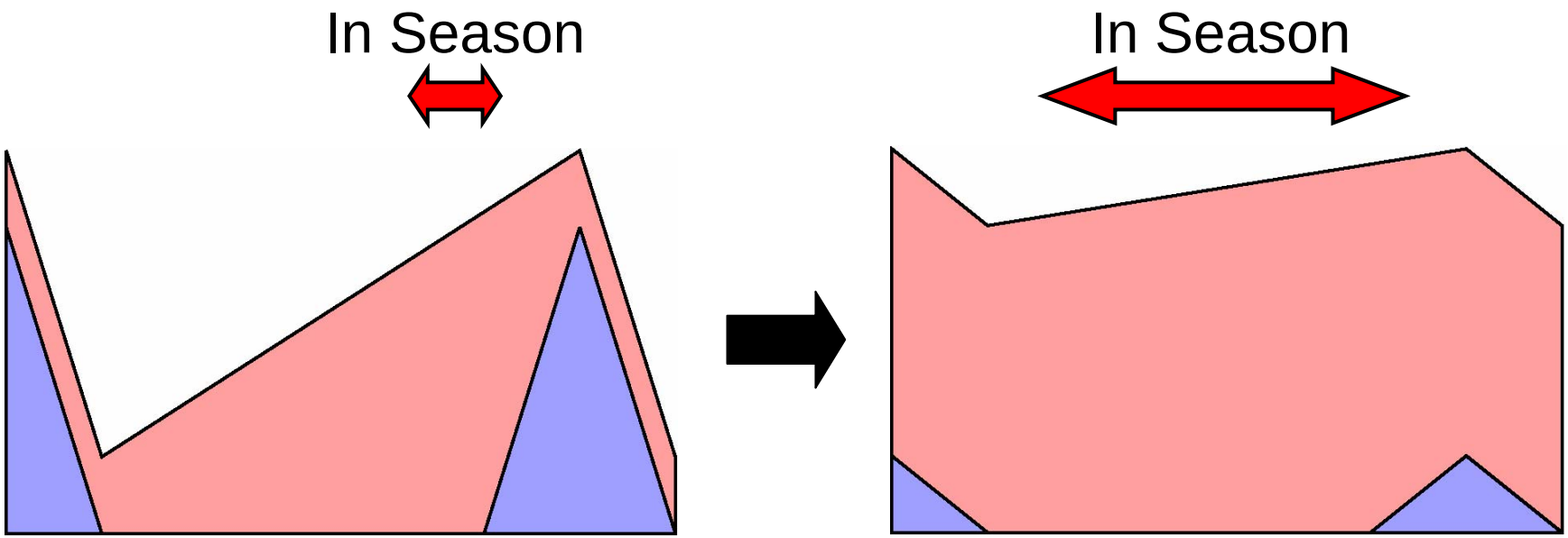


Drawn from Akiyama et al. 2001

Disadvantages

Bitter taste
Whitish gonad
Higher cost
Easy decay

Strategies to extend the season
2. Suppression of gametogenesis



If gametogenesis is suppressed, all the problems should be solved.

Loss of the gonad size, Melting appearance
Bitterness, Astringency

Manipulation of the environmental conditions

Gametogenesis is affected by temperature and photoperiod.

Temperature

P. depressus
H. pulcherrimus
Anthocidaris classispina

Photoperiod

S. purpuratus
S. droebachiensis
Euchidaris tribuloides

High energy cost should be overcome.

↓

Deep sea water
Effluent from power station

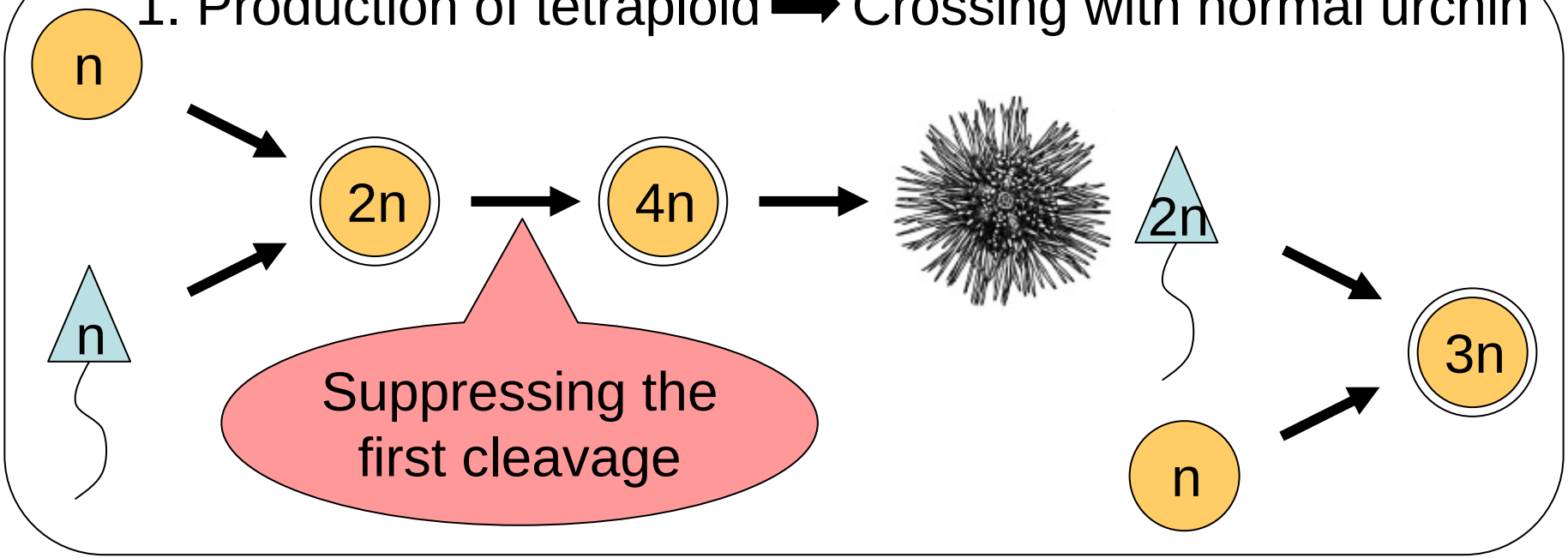
Generating triploid sea urchins

Meiotic divisions complete before spawning.

⬇

Retention of the polar body is impossible.

1. Production of tetraploid ➡ Crossing with normal urchin

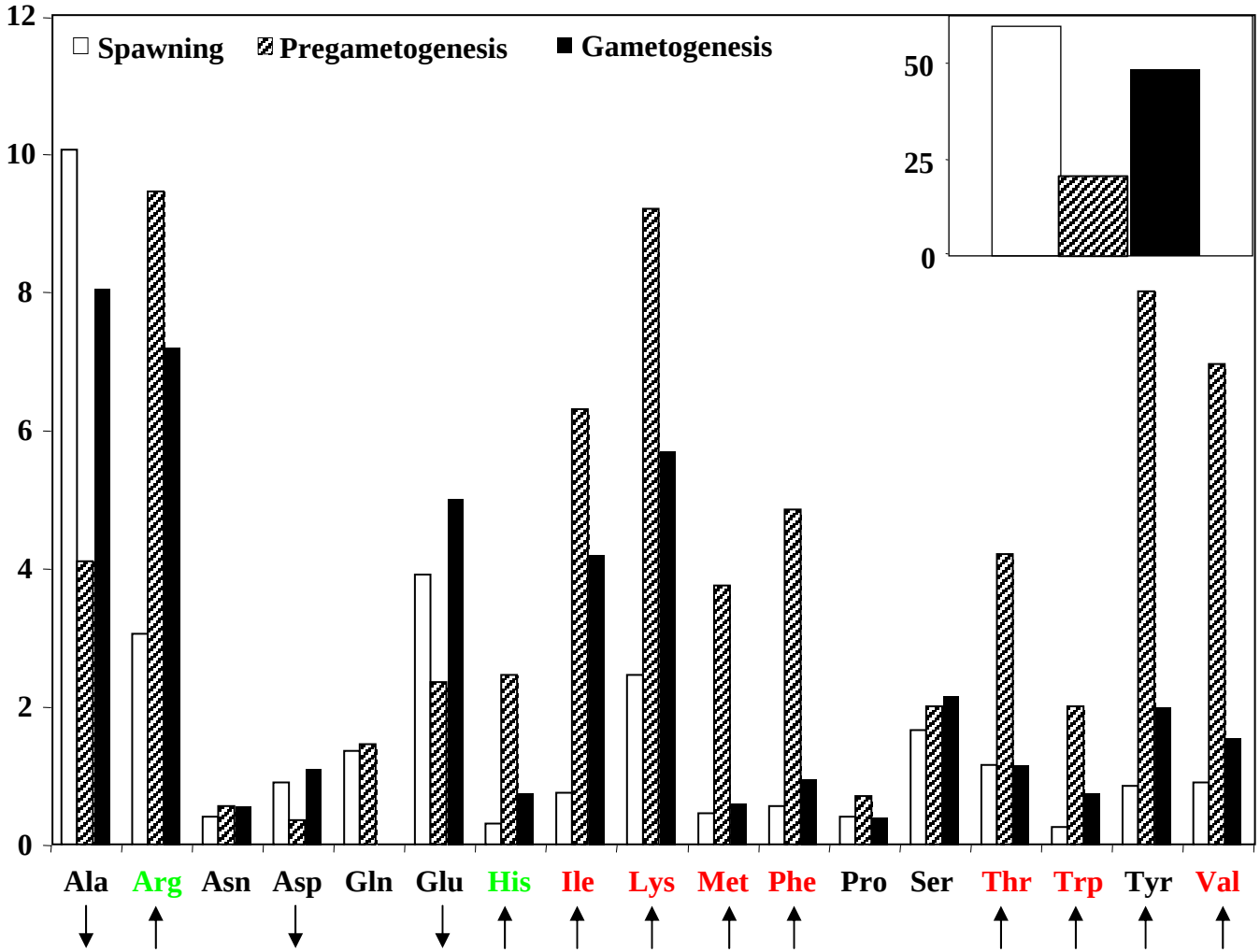


2. Fusion of two eggs ➡ Fertilization with normal sperm

A significant problem associated with edible sea urchin aquaculture is the production of large urchin gonads simultaneously characterized by consistently high quality sensory evaluations for taste, texture, color and firmness.

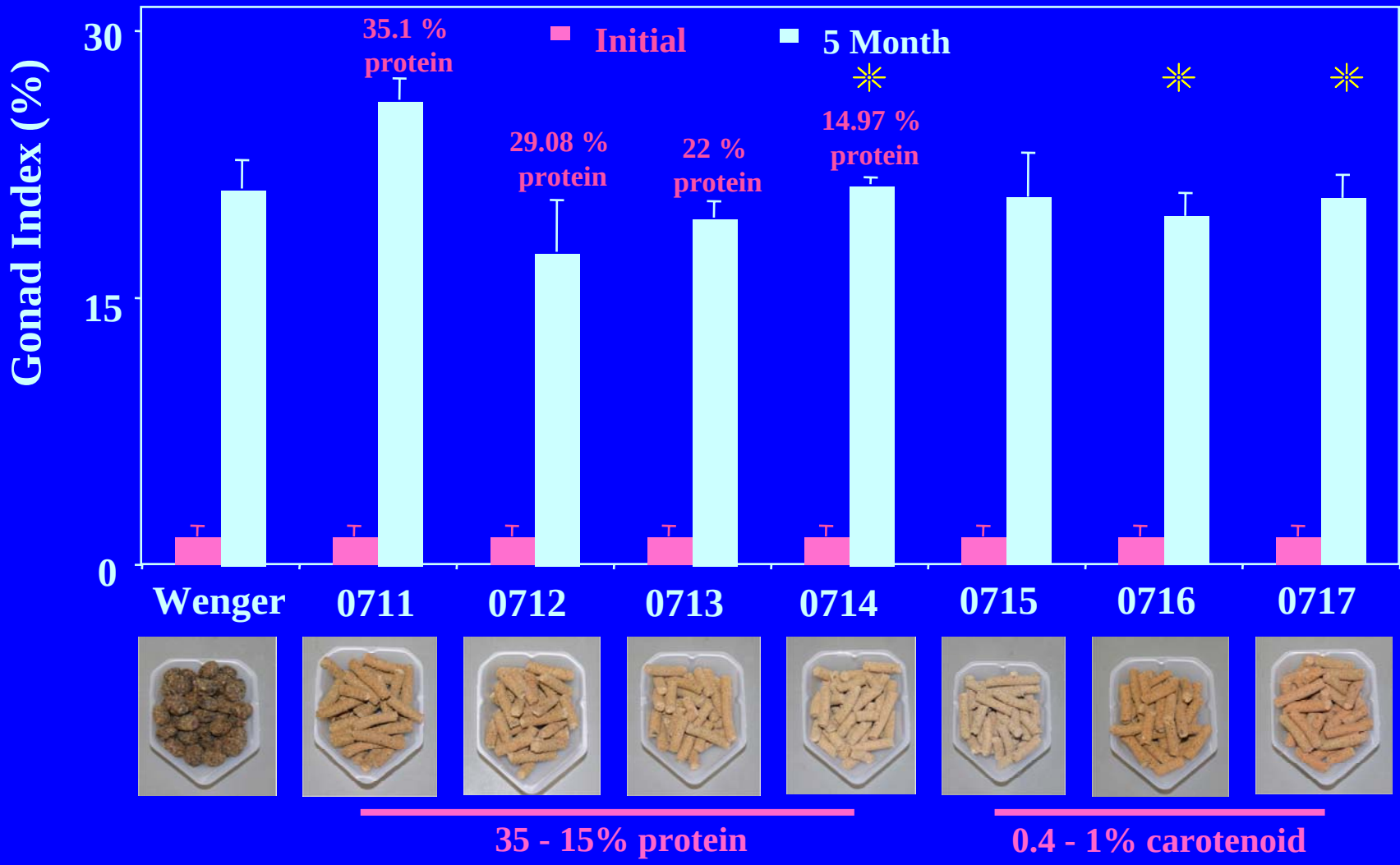
Consistent High Quality Sensory Evaluations

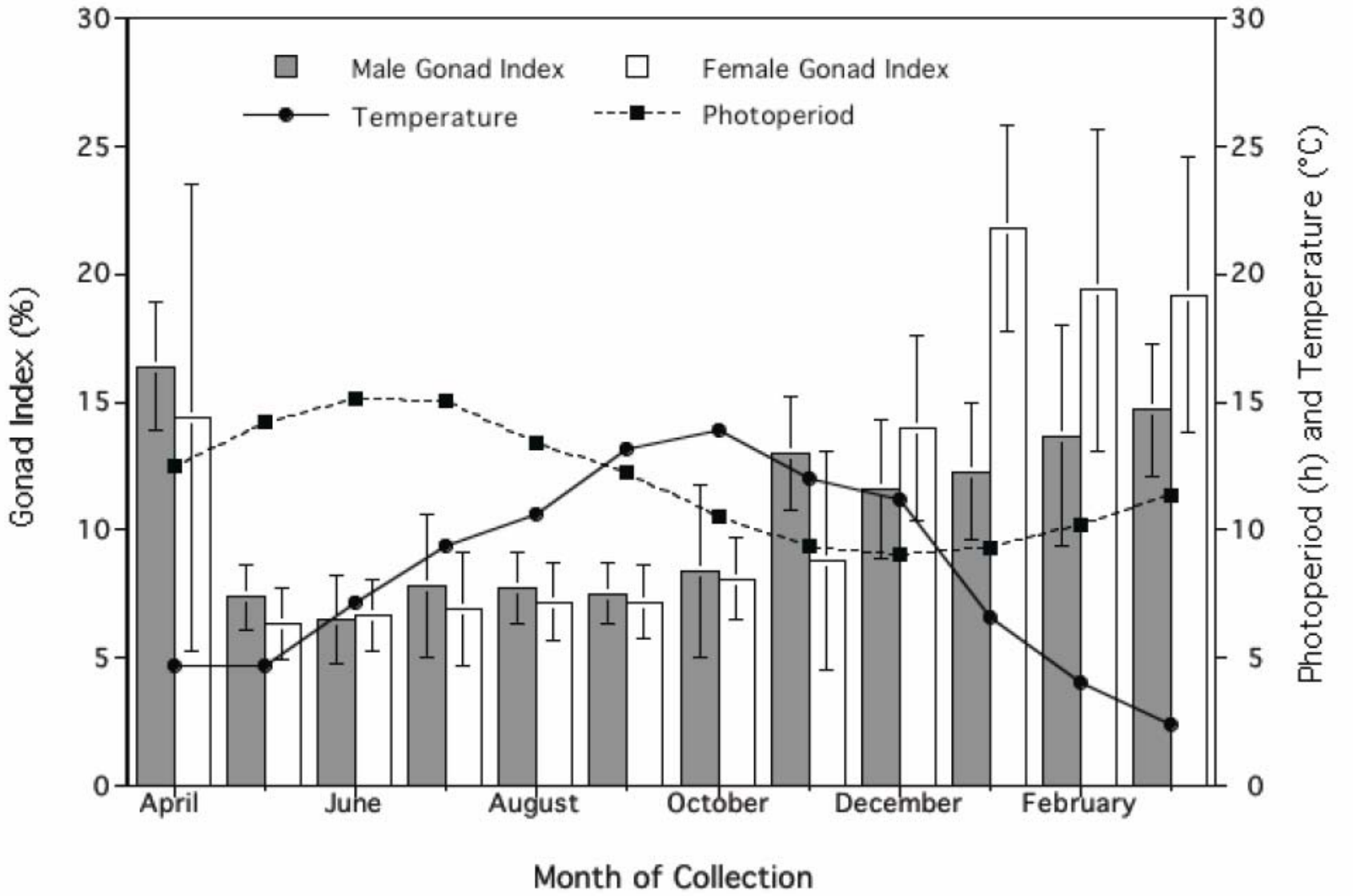
It is surprising that simultaneous determination of amino acid concentrations and thorough assessment of sensory parameters of green sea urchin gonads has been considered in only one study.



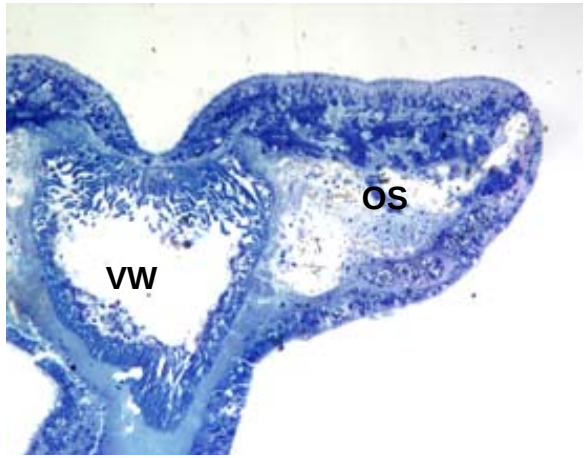
From Lee and Haard, 1982

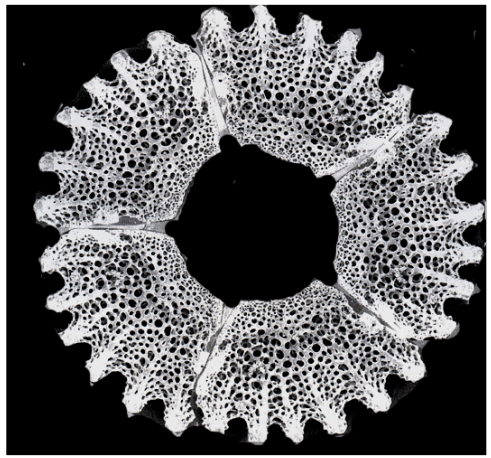
Formulated Feeds

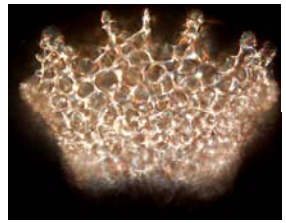


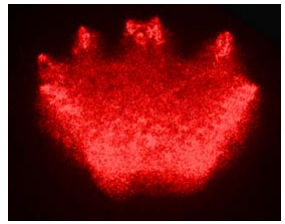

Male Gonad Index
Female Gonad Index
Temperature
Photoperiod
Gonad Index (%)
Photoperiod (h) and Temperature (°C)
0
5
10
15
20
25
30
April
June
August
October
December
February
Month of Collection

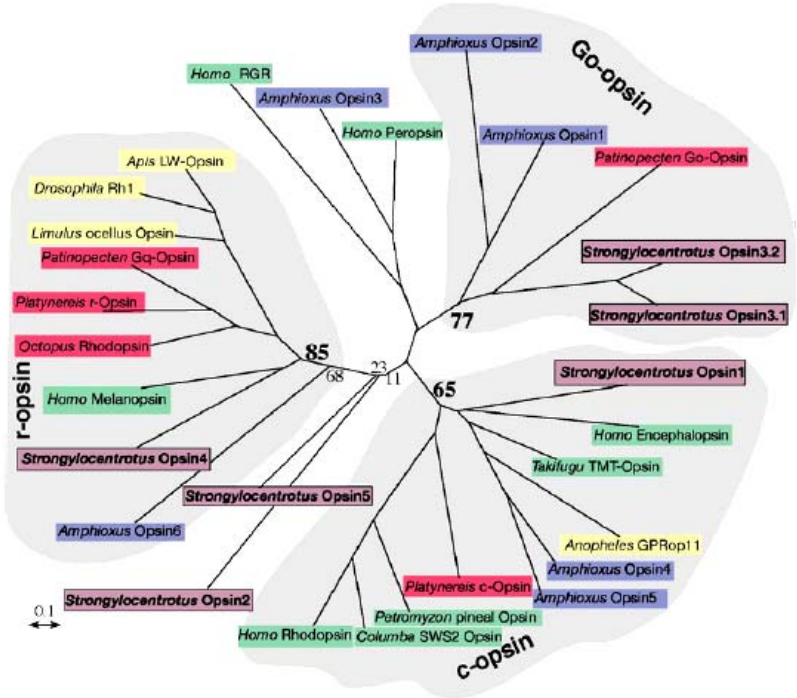
Detectors for Changing Photoperiod Light Regimes

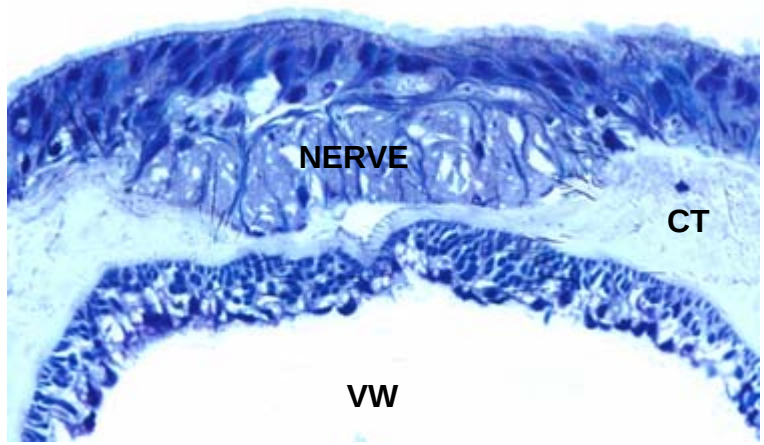




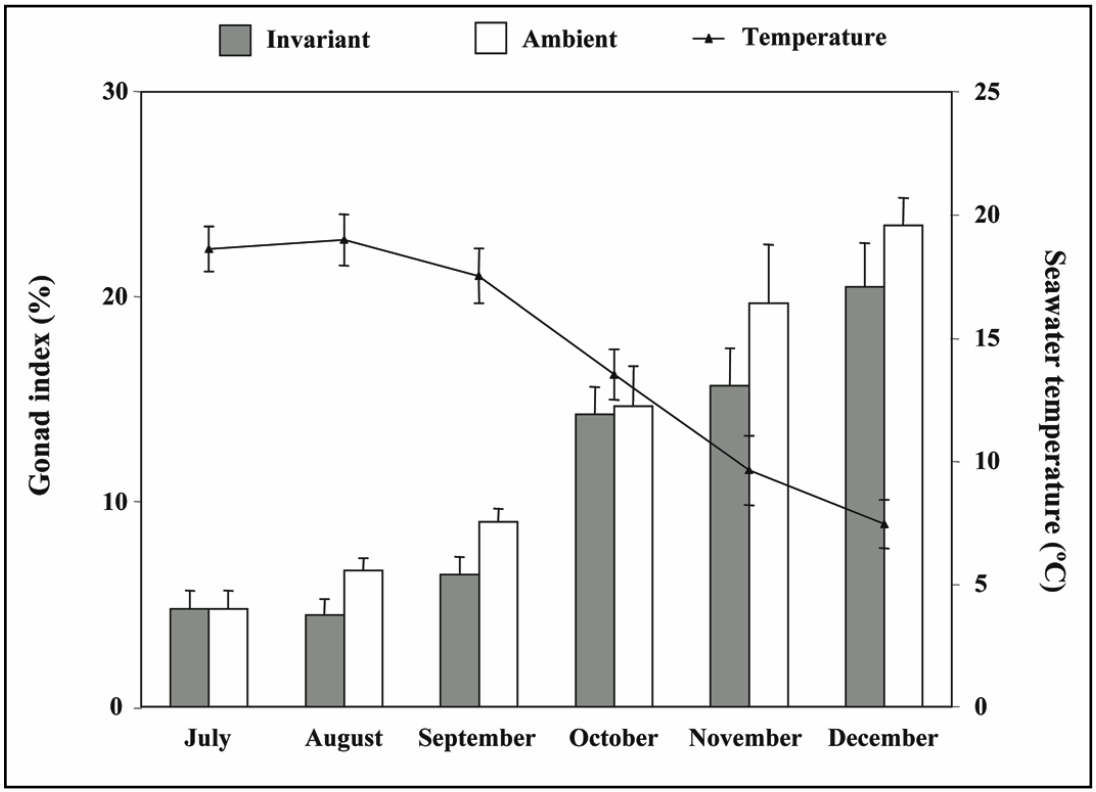


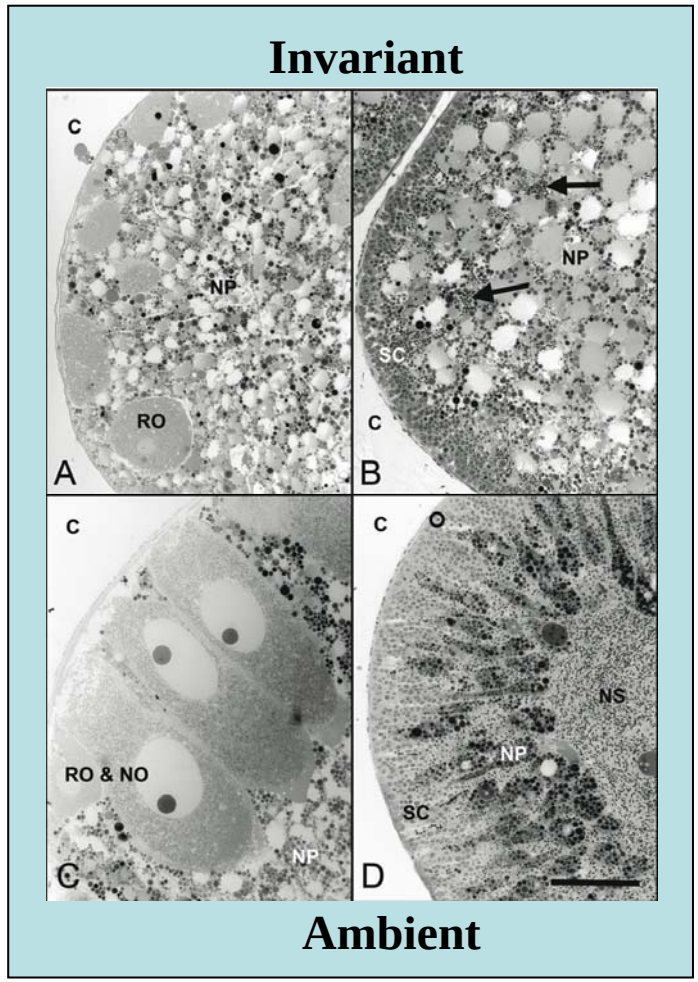






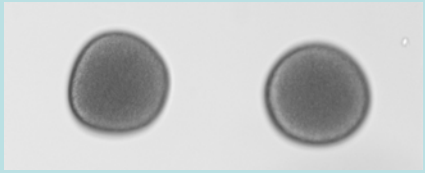
Large Gonads and Invariant Photoperiod

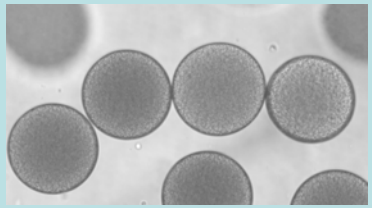


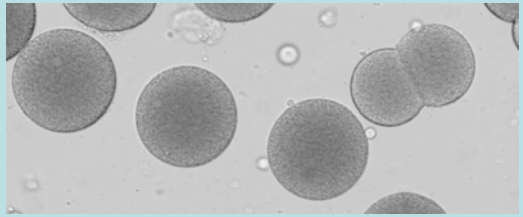


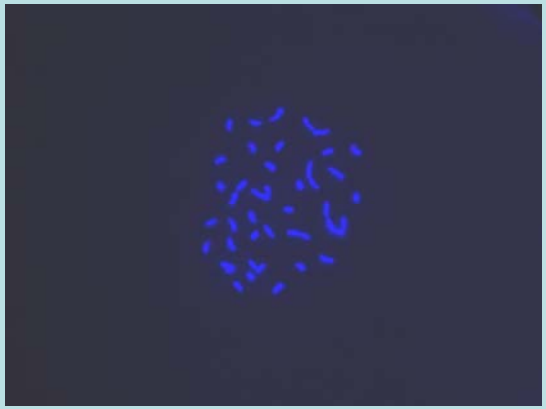
Böttger, Devin and Walker, (Aquaculture, 2007) Suspension of Annual Gametogenesis in North American Green Sea Urchins (*Strongylocentrotus droebachiensis)* Experiencing Invariant Photoperiod - Applications for Land-Based Aquaculture.

The First Triploid Sea Urchins

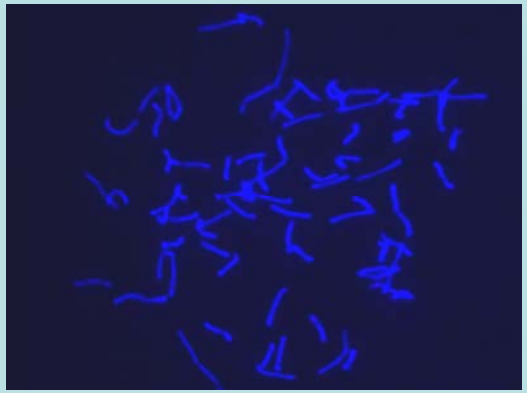




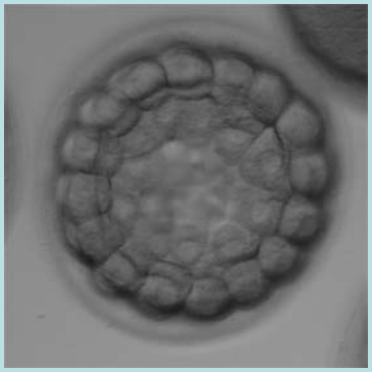


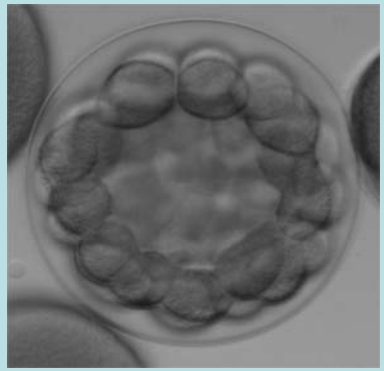


Diploid = 42



Triploid = 63





Böttger et al., (in prep for Aquaculture) Novel methodology for generating triploid green sea urchins - Applications for open-ocean aquaculture.

Summary of Part 3

(1) Promoting NP growth and suppressing gametogenesis are advantageous for aquaculture.

(2) It is desired to establish methods for generating infertile sea urchins.

Supported by USDA NRI-Competitive Grant (2002-35206-11631) and an NRAC grant (04-15), UNH and by Sea Grant SBIR Phase 2 to Peacock Cannery (Lubec, ME) and UNH to CWW.