An overview of applied research on kelp aquaculture in Québec, Canada

E.Tamigneaux[1], A.Licois[2] & G.Hersant[3]

[1] ÉPAQ, Cégep de la Gaspésie et des Îles
[2] Merinov
[3] Oleotek, Cégep de Thetford Mines

Outline of the presentation

1. Marine aquaculture in Québec
2. Portrait of the seaweed industry
3. Progress in kelp farming
4. Kelp product development
5. Industrial research chair grant

Dessin d'Adolphe Millot pour l'article "algue" du Larousse du XXe siècle (1931). Avec l'aimable autorisation des Éditions Larousse.\n1. Sargassum

1. Marine aquaculture in Québec

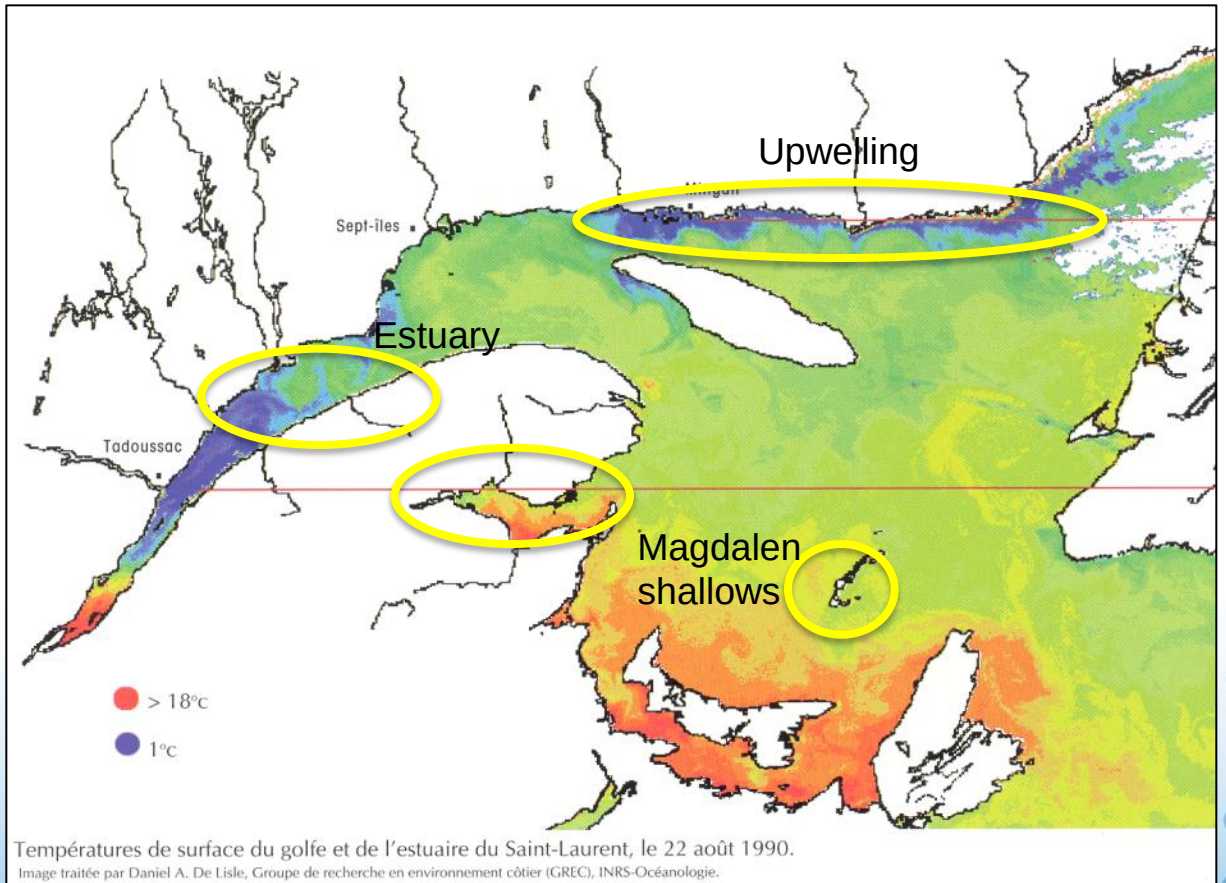
1.1 Playground

- **Large territory N-S**
- **Diversity of climates**
- **No pollution or eutrophication of coastal waters**

1. Marine aquaculture in Québec

1.1 Playground

Surface temperatures in the gulf of St Lawrence, on August 22 1990

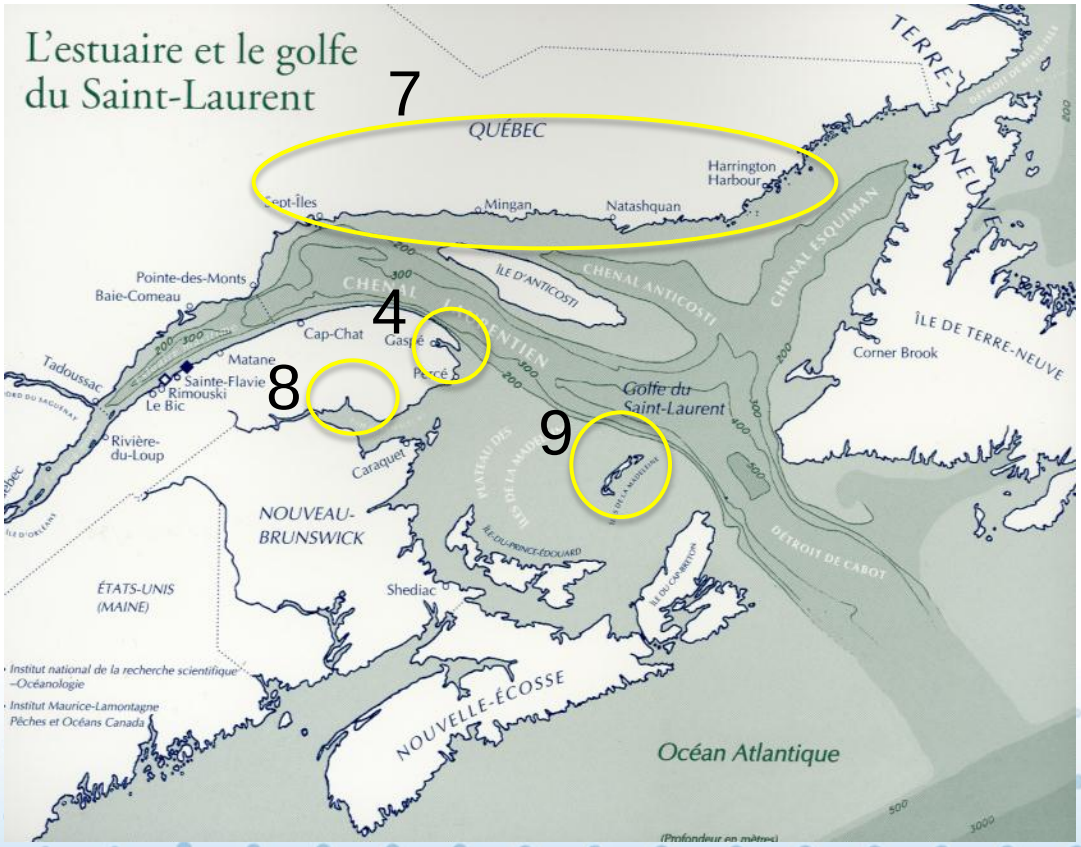


Températures de surface du golfe et de l'estuaire du Saint-Laurent, le 22 août 1990.
Image traitée par Daniel A. De Lisle, Groupe de recherche en environnement côtier (GREC), INRS-Océanologie.

1. Marine aquaculture in Québec

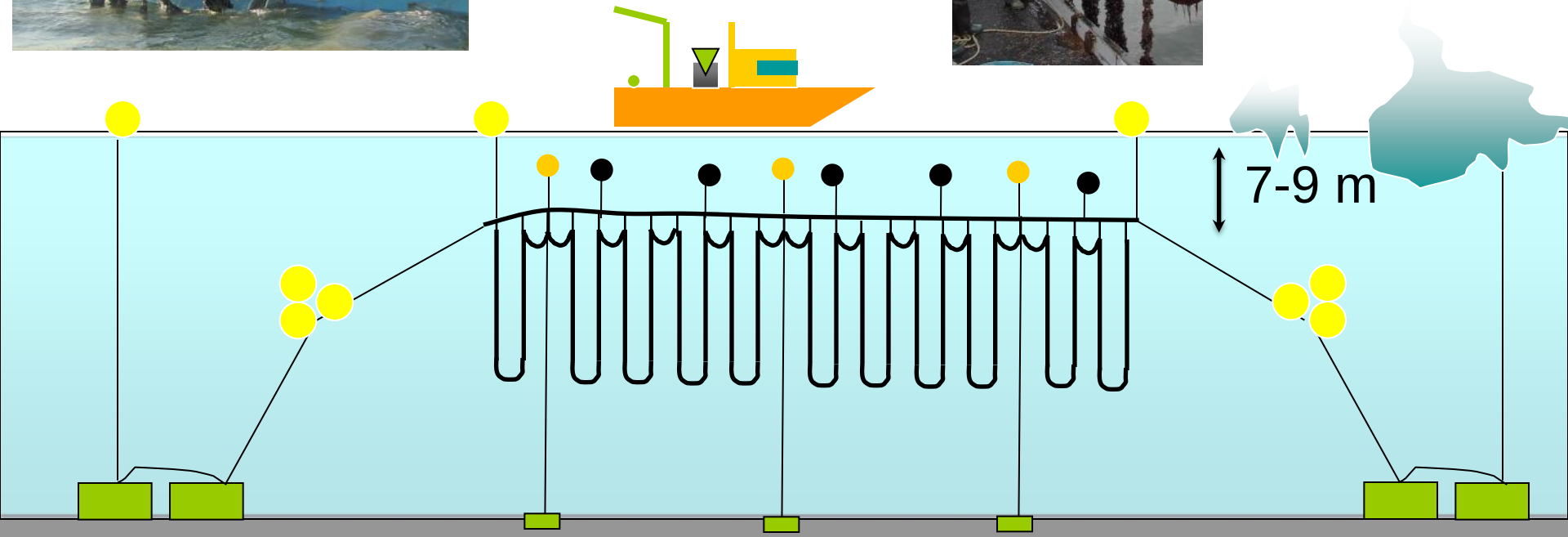
1.2 Marine aquaculture industry

- **20 small companies**
- **Shellfish producers**
  - **Mussels (11)**
  - **Scallops (4)**
- **500 tm/yr (mussels)**



1. Marine aquaculture in Québec

Submerged longlines



E. Tamigneaux

2. Portrait of the seaweed industry

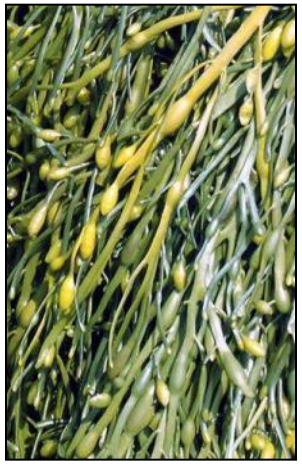
2.1 Which seaweeds are available ?

Green	*Ulva lactuca* (sea lettuce)	 
	Monostroma sp.	
	Enteromorpha sp.	 
Brown	***Ascophyllum nodosum* (knotted wrack)**	
	***Fucus* sp. (bladder wrack, etc.)**	 
	***Saccharina longicruris* (kelp)**	
	***Alaria esculenta* (dabberlocks)**	
Red	*Chondrus crispus* (Irish moss)	 
	Palmaria palmata (Dulse)	
	Porphyra (Nori)	

Subarctic province = brown seaweeds

2. Portrait of the seaweed industry

2.2 Which are commercially harvested ?



Ascophyllum nodosum

(Knotted wrack)

Fucus sp.

(Bladder wrack, etc.)

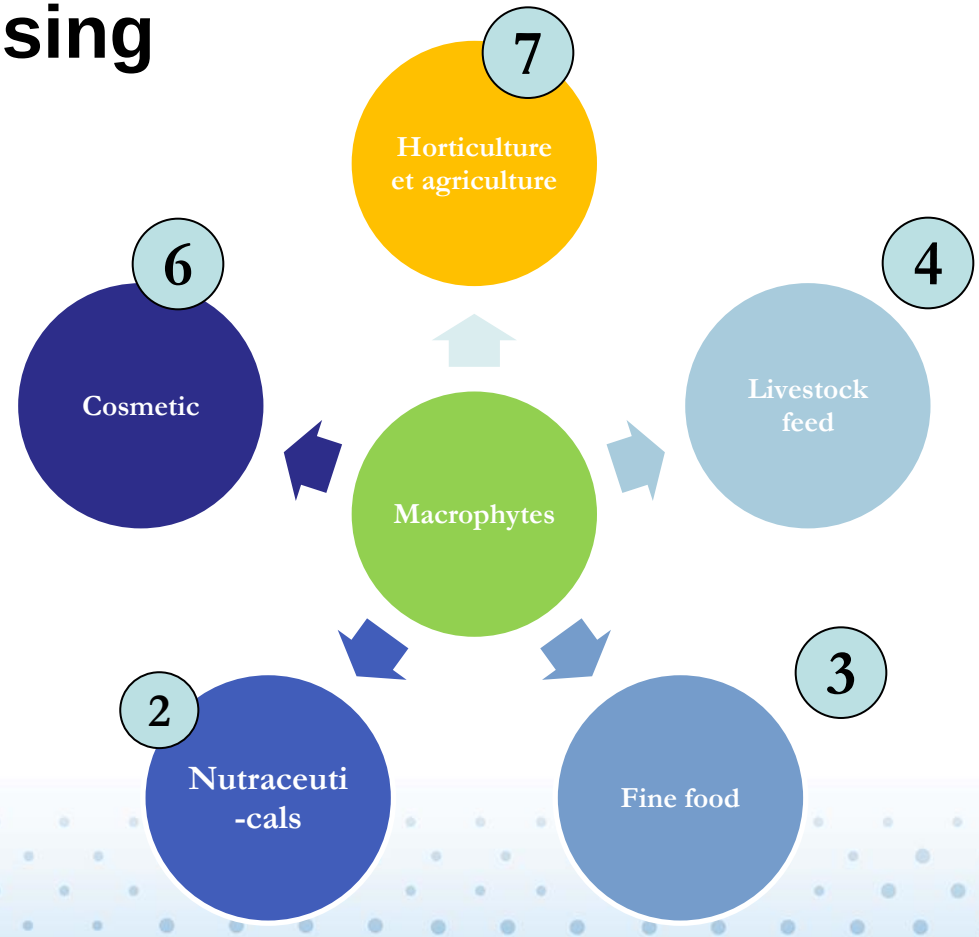
Saccharina latissima, S. longicruris

(Kelp)

2. Portrait of the seaweed industry

2.3 Harvest and processing

- 22 companies involved
- 4 companies harvest
- 100% wild ressources, (150 mt / yr)
- Fertiliser, cosmetical, nutraceutical, livestock feed, fine food



2. Portrait of the seaweed industry

2.4 Low value products

Compost, fertilizer, biostimulant

2. Portrait of the seaweed industry

2.5 High value products

Food

Cosmetic

Nutraceutical

2. Portrait of the seaweed industry

2.6 Limiting factors

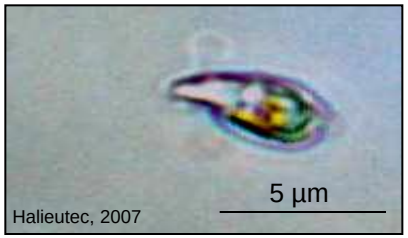
- Inventories geographically limited (1980)
- Access to the shoreline (truck)
- Harsh climate, exposed shoreline, depth, erosion of seaweed beds by drifting ice
- Overgrazing by green urchins
- Strict and complex regulations
- DFO in favour of cultivation

=> Should we turn towards seaweed aquaculture ?

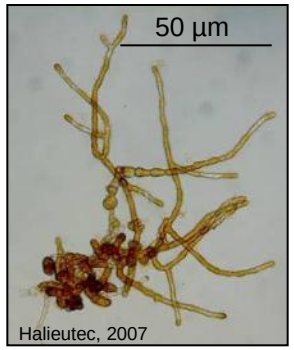
3. Progress in kelp farming

Seedling production in onshore facilities (hatchery)

Mature blade with sorus



Swimming zoospore with 2 flagella



Nylon ropes

Seedling embryo

Seedling (0,5 mm)

Plantlets production in the hatchery (30-40 days, 10° C)

3. Progress in kelp farming

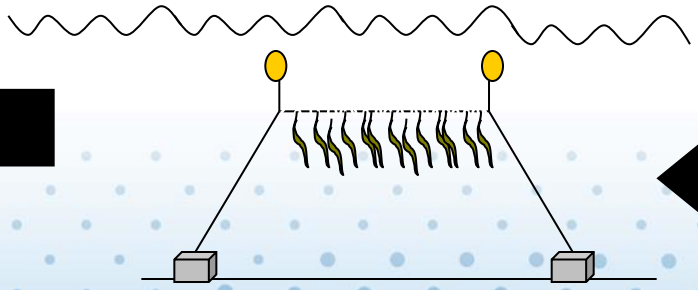
Outplanting at sea

Rope seeded with 2-4 mm plantlets

Outplanting on longlines

(Oct-Nov.)

Kelp growing on the longlines



Marine farm

Harvest after 8-10 months

(June-July)

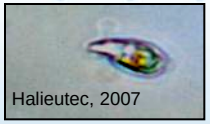
3. Progress in kelp farming

First trials allowed us to identify R&D themes (2006-2012)

1 Spore production

↓

Control of the sporogenesis in parent kelp



2 Seed stock and strains

↓

- Cultivation of gameto-phytes *in vitro*
- Selection of strains, hybridization

3 Sea farming

↓

- Production schedule ?
- Depth ?
- Seed density?
- Yields ?
- Upscaling ?

3. Progress in kelp farming

3.1 Availability of seeds

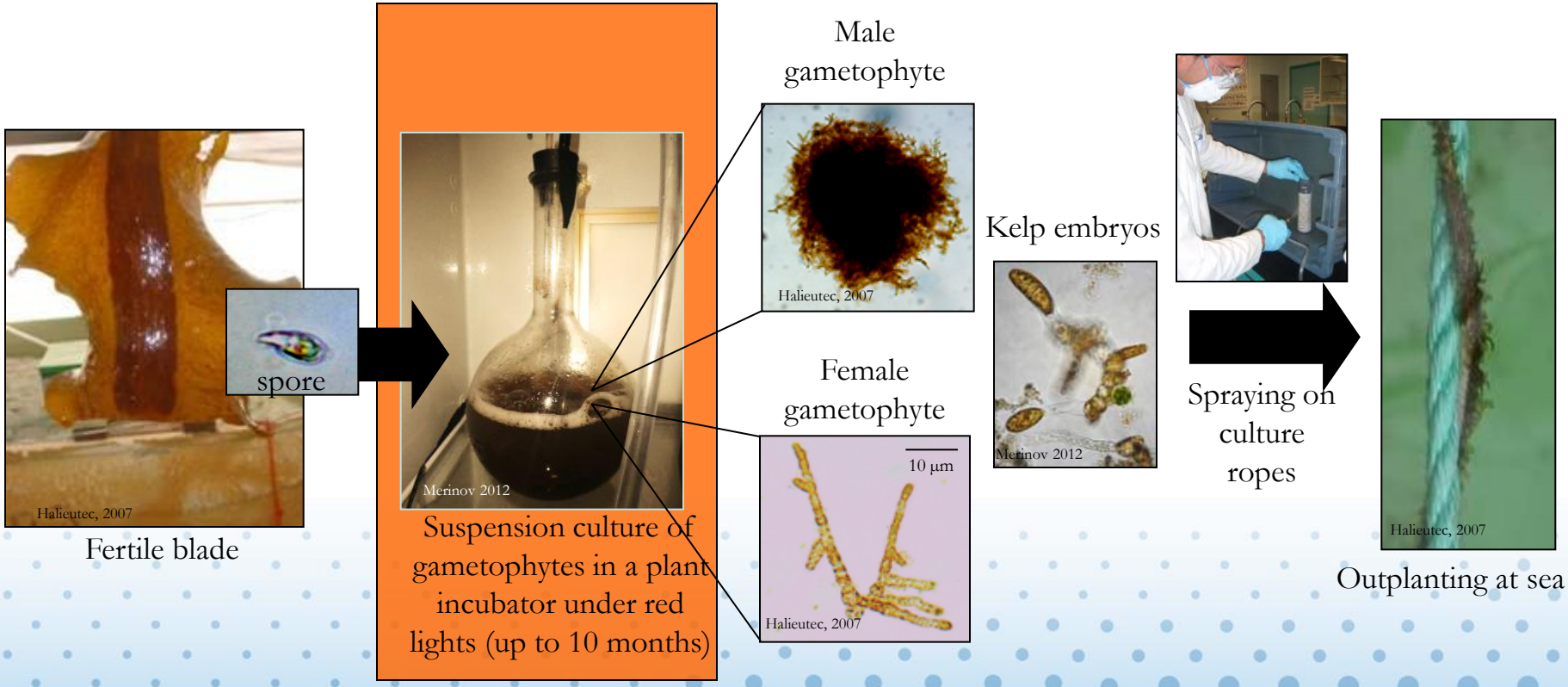
3.1.1 Artificial induction of sporogenesis (Pang and Lüning, 2004)

- Removal of the blade meristem area
- Constant short days (8:16) with fluo tubes
- 10-15 °C

3. Progress in kelp farming

3.1 Availability of seeds

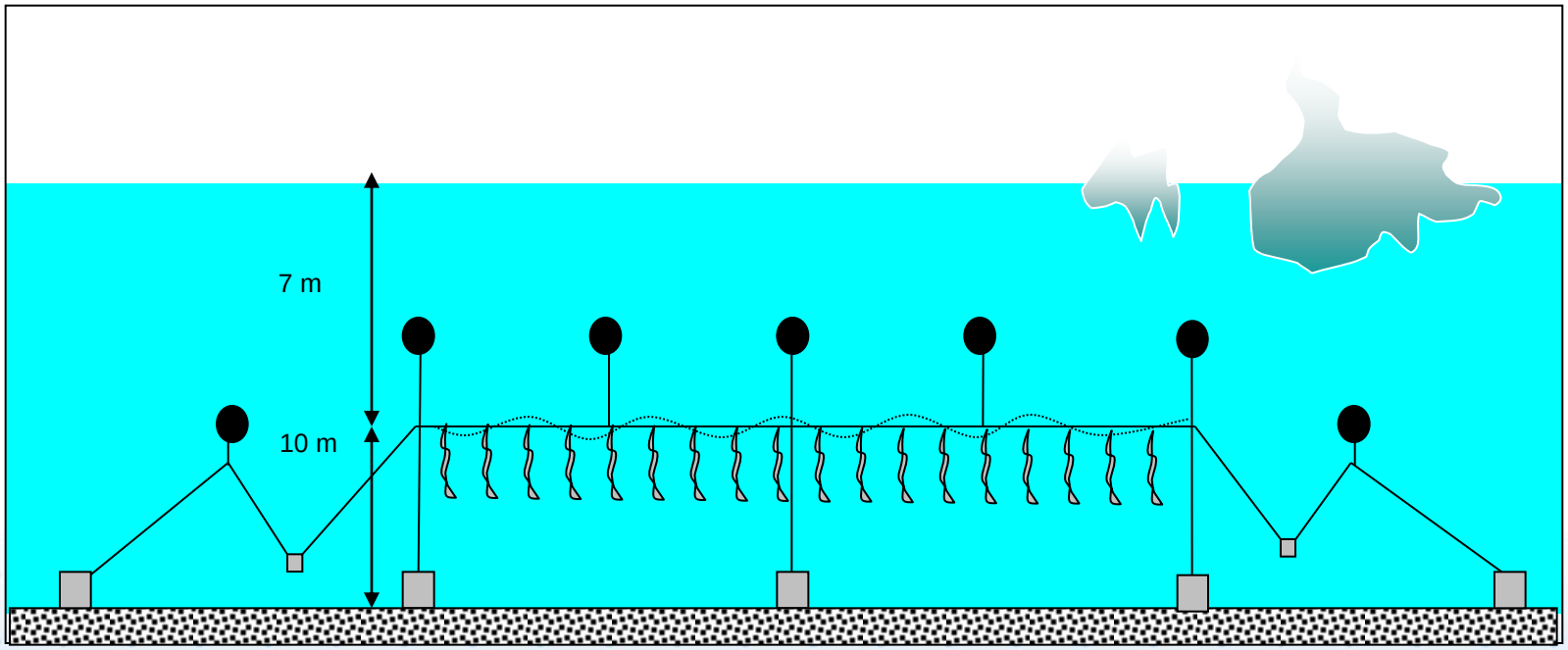
***In vitro* suspension culture of gametophytes (free-living)**



3. Progress in kelp farming

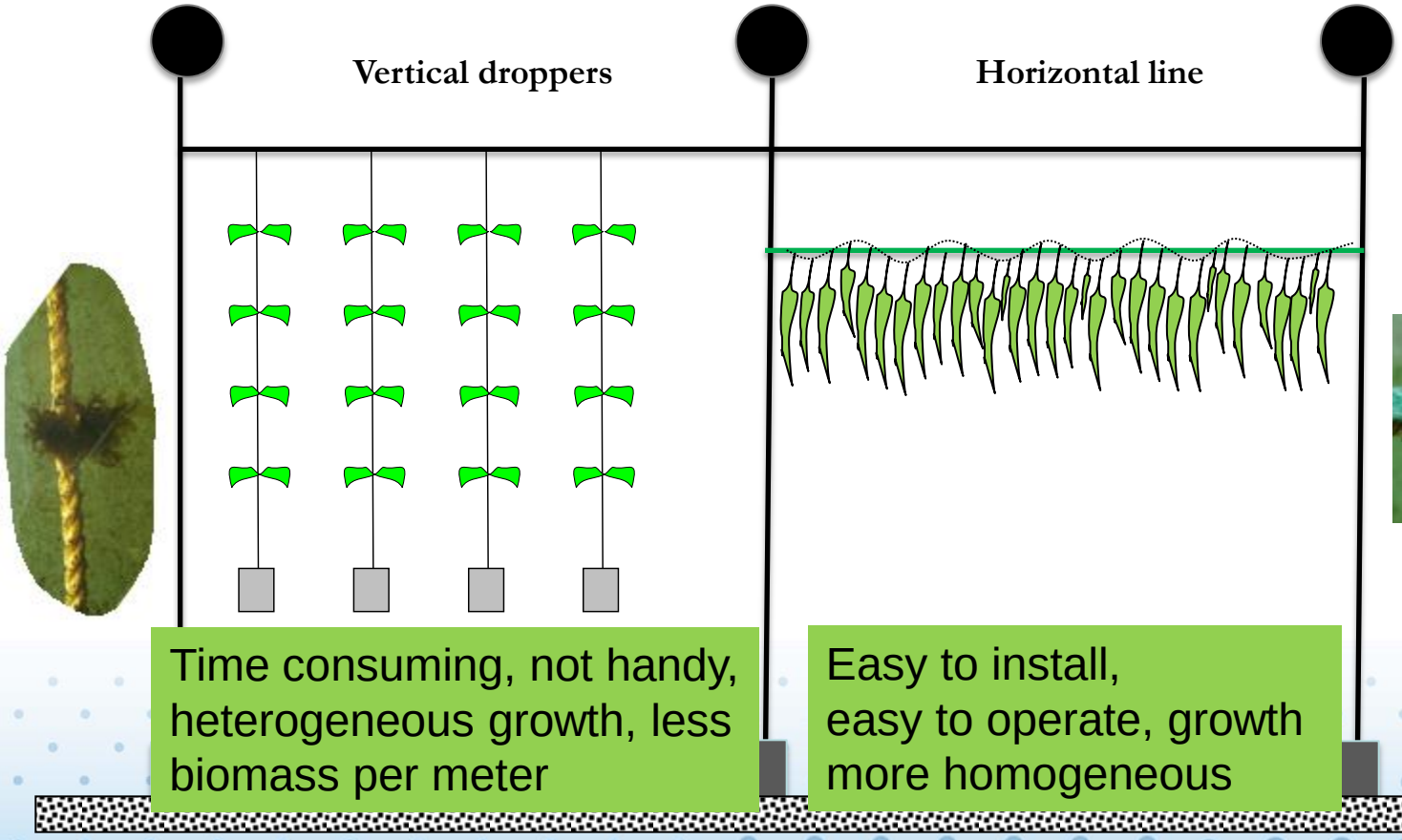
3.2 Culture gears

Adjustable submerged longlines: 7 m (winter) – 4 m (summer)



3. Progress in kelp farming

3.2 Culture gears



Time consuming, not handy, heterogeneous growth, less biomass per meter

Easy to install, easy to operate, growth more homogeneous

3. Progress in kelp farming

3.2 Culture gears

Double lines: main longline (move the boat using the starwheel winch)

+ culture line (support for kelp holdfast)

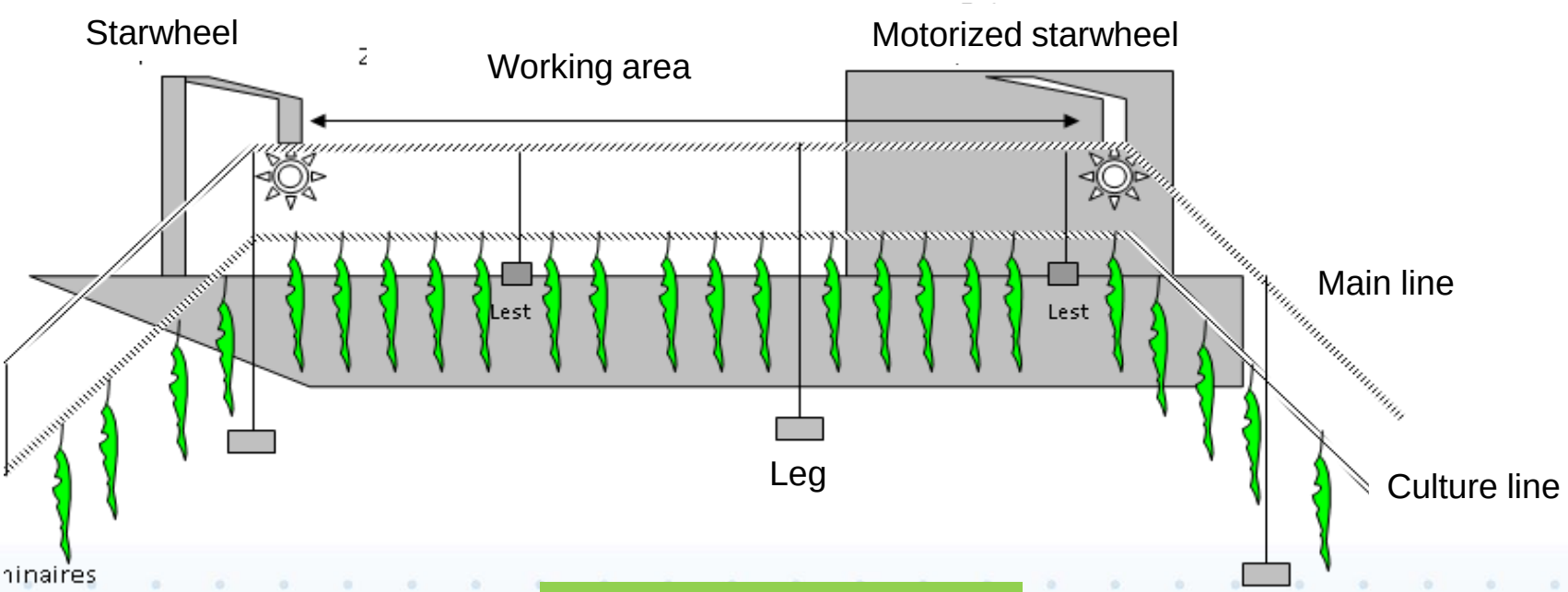
Set up

Installation of the seeded twine on the culture rope

Harvest

3. Progress in kelp farming

3.2 Culture gears

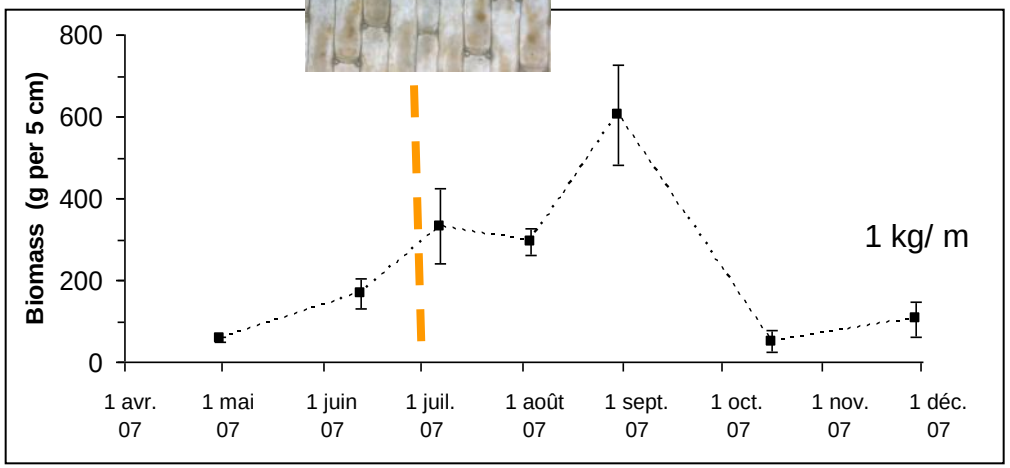


Quick, easy to operate

3. Progress in kelp farming

3.3 Schedule & yields, first trial (2007)

Colonial bryozoa:
Membranipora membranacea



August 2007

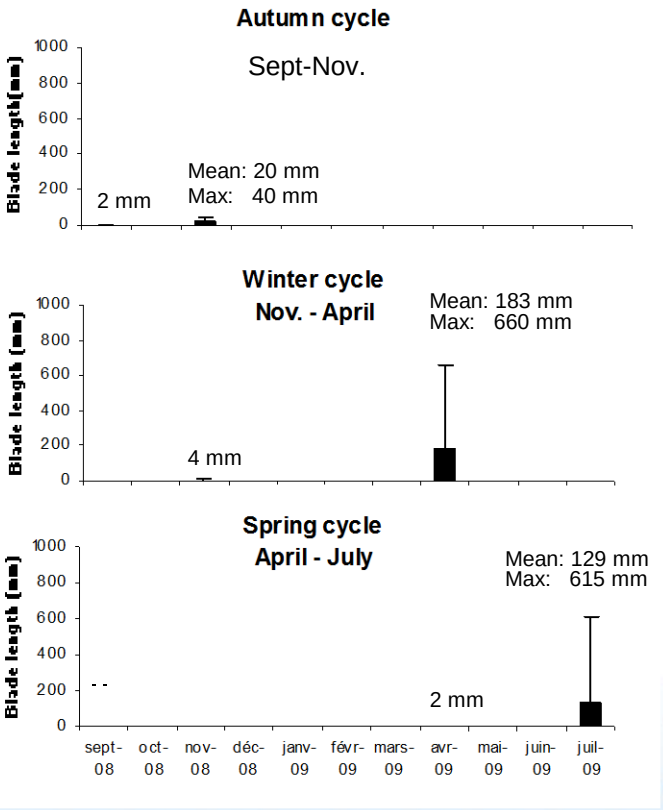
November 2007

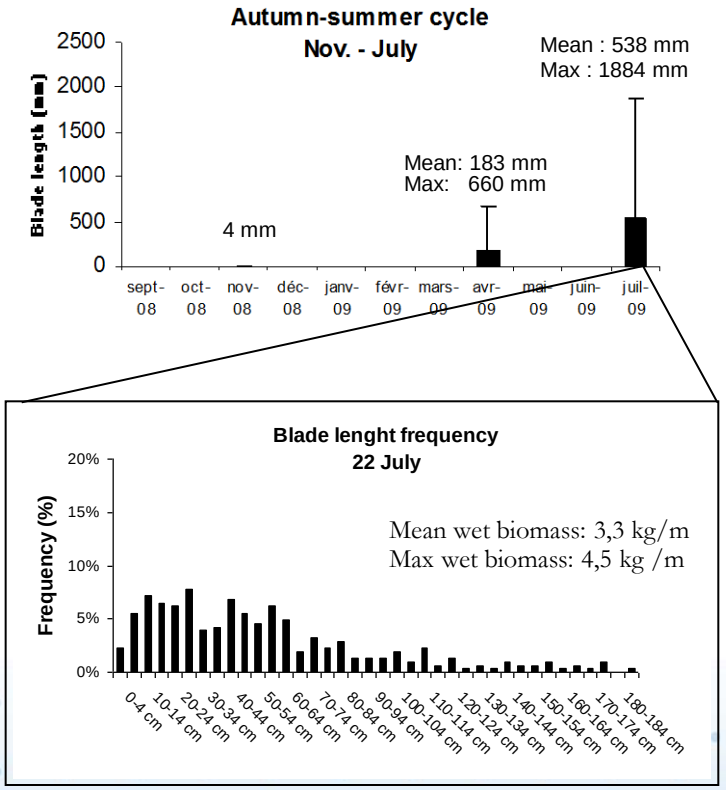
Subsurface longline (2 m deep)
October: **1 kg wet/m** (vertical dropper)

=> Harvest in late June-July

3. Progress in kelp farming

3.3 Schedule & yields (2009)

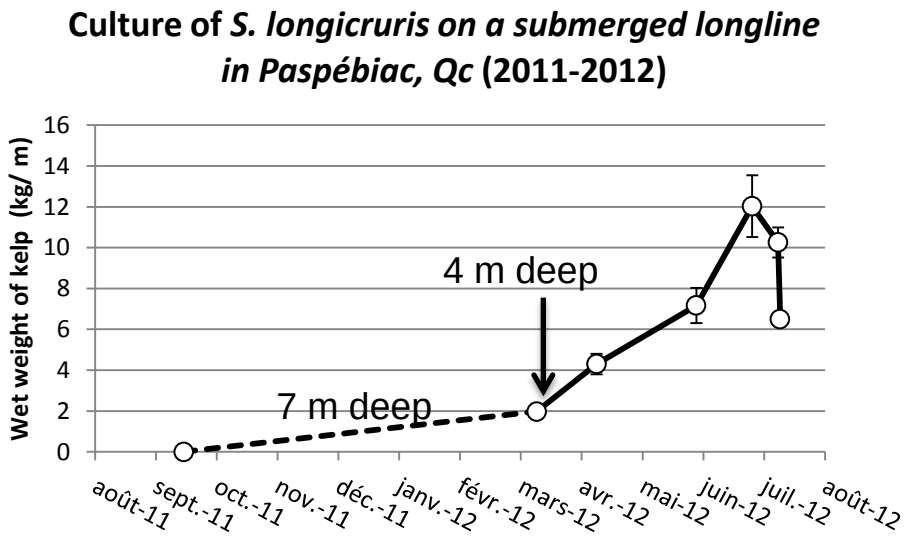


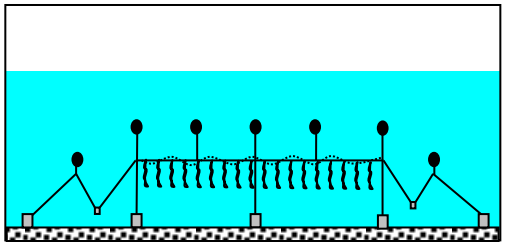


Submerged longline (7 m deep)
Nov. 2008 – July 2009 : **4,5 kg/m** (horizontal line)

3. Progress in kelp farming

3.3 Schedule & yields (2012)





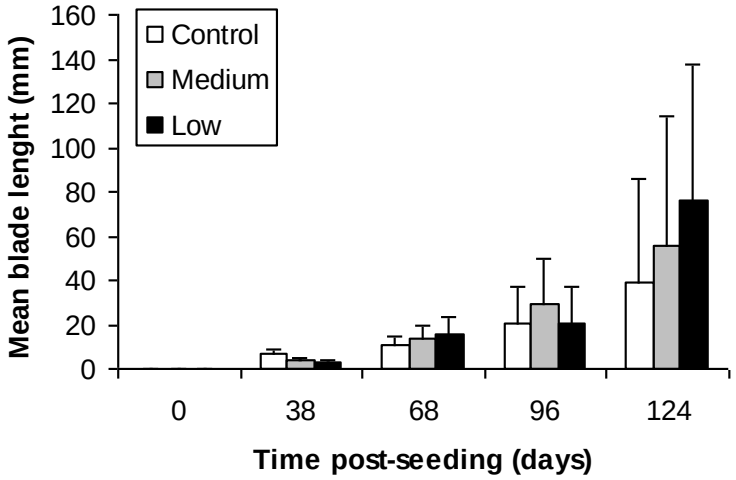
Adjustable longline; horizontal culture line

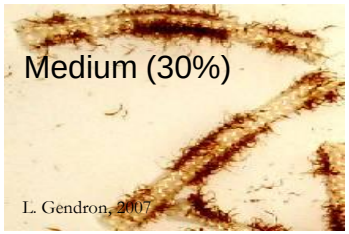
12 kg wet/m ; 250 cm (Oct 7, 2011 - July 18, 2012)

3. Progress in kelp farming

3.4 Adjustment of seedling density on ropes, in the hatchery

Spontaneous decrease of plant density observed on the culture ropes (auto-reduction?)



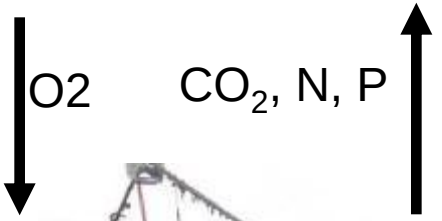


- **Medium & Low density > Control treatment (2 x; 90 days**)
- Can we still observe a difference on kelp when growing for 8 months on the marine farm (project in 2013)?

3. Progress in kelp farming

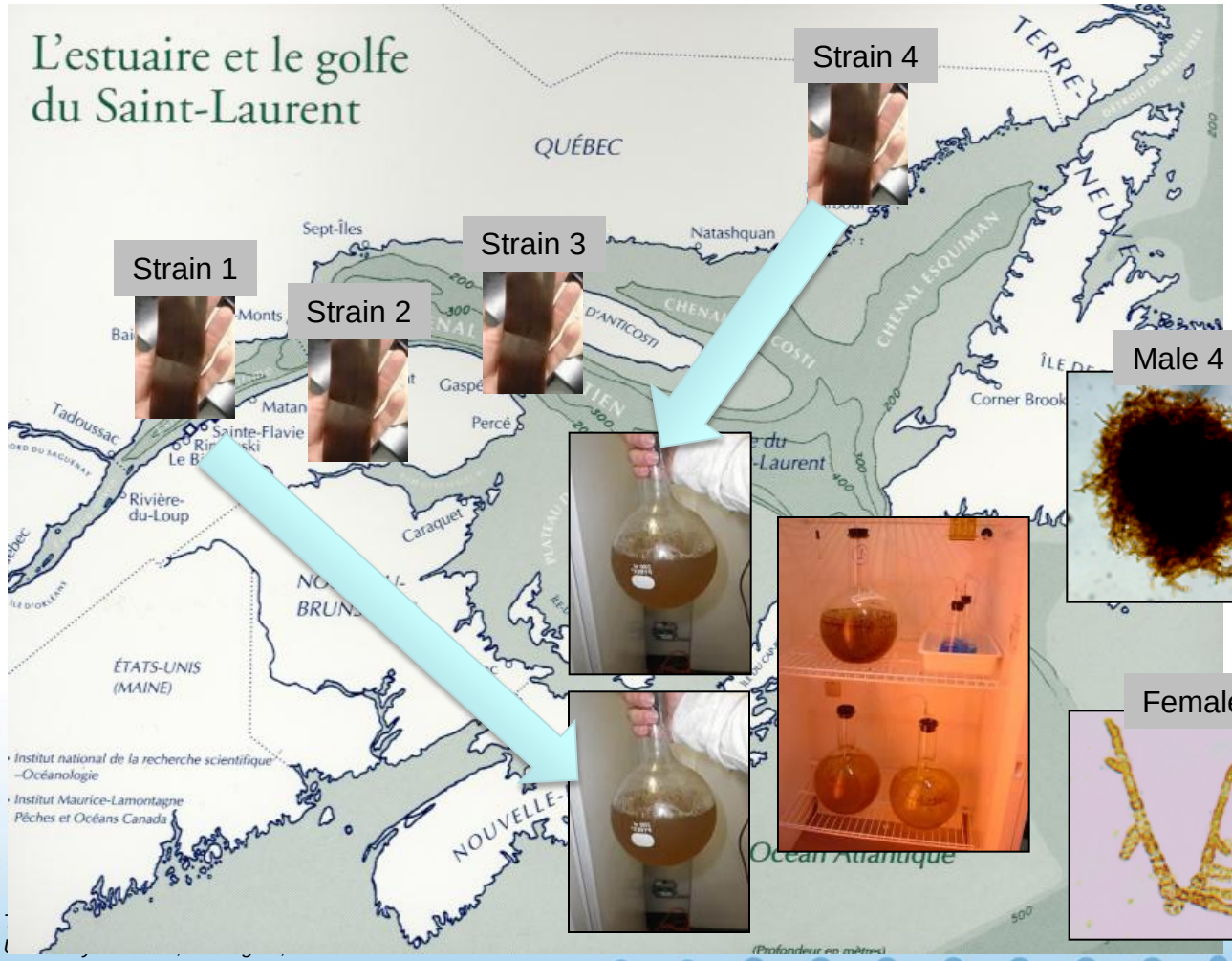
3.5 Polyculture shellfish-kelp

- *Diversification, empty longlines issue*
- *Trials on 2 mussel farms (2010 & 2011) and 1 scallop farm (running)*
- *Excellent kelp growth and quality in open waters, poor growth in marine lagoons*
- *Easy: same gears, same skills, less work*
- *Expect improved mussel /kelp growth and quality* *Scoggan et al. (éds). FAO Training Manual 89/5 (RAS/86/024)*



3. Progress in kelp farming

3.6 Selection of strains and hybrids (M.-H. Fournier, ÉPAQ)



Significant genetic differences between remote kelp beds ?

Comparison of growth performance of various hybrids

3. Progress in kelp farming

3.7 Diversification: adapt and master cultivation of other sp.


Merinov, 2012

Hollow stemmed kelp

(*Saccharina longicruris*)


Halieutec, 2010

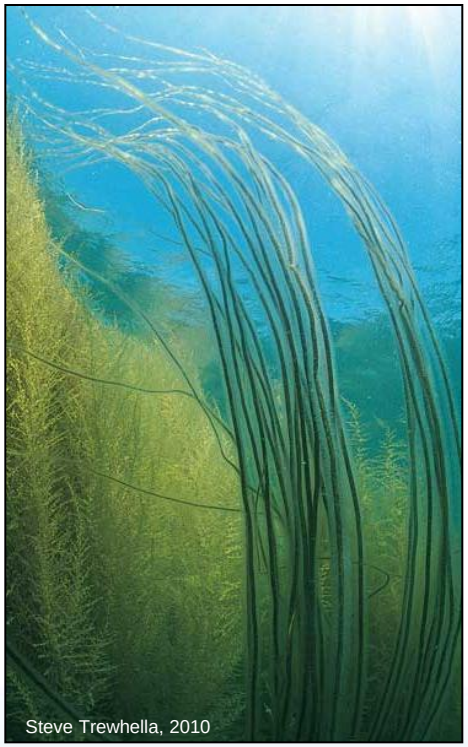
Sugar kelp

(*Saccharina latissima*)


Halieutec, 2006

Dabberlock

(*Alaria esculenta*)


Steve Trewhella, 2010

Sea lace

(*Chorda filum*)


Maeve Edwards, 2009

Dulse

(*Palmaria palmata*)

4. Product development: adding-value

1. ALHURE project

Species: *Saccharina longicruris*

Two parts: blade and stipe

(1) To extract lipids and characterize fatty acids.

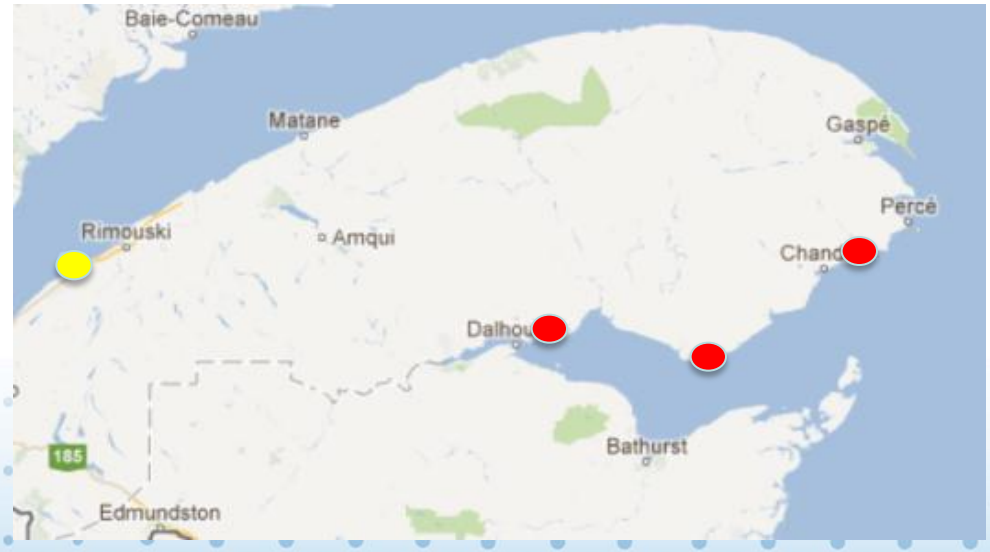
(2) To extract the mannitol (polysaccharide).

(3) To assess the potential of kelp fibers for the development of biobased composites.

Parameters of the study

1. Wild and farmed seaweed
2. Harvest locations :
   - GR, P, C = kelp farms
   - Isle verte = wild beds

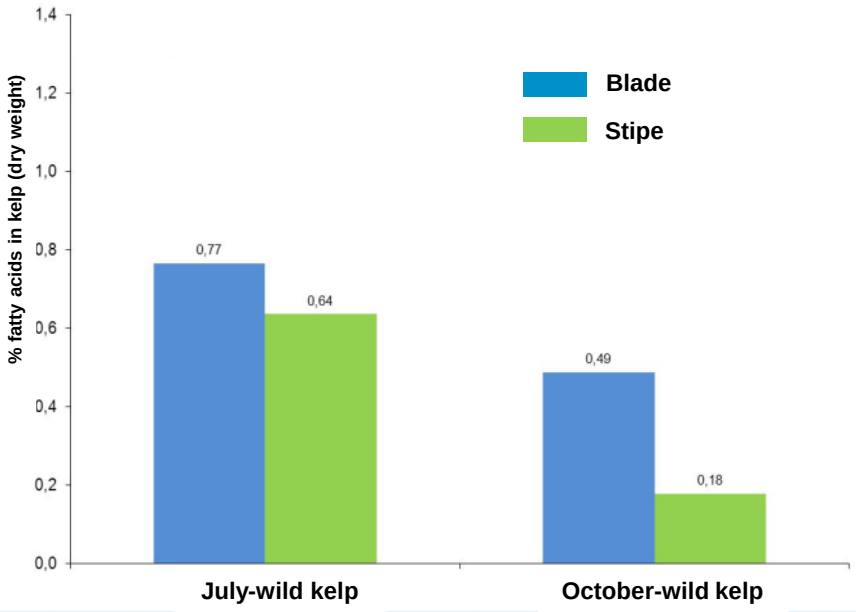
3. Methods
4. Particle size (541-3348 µm)
5. Extraction time
6. Water content



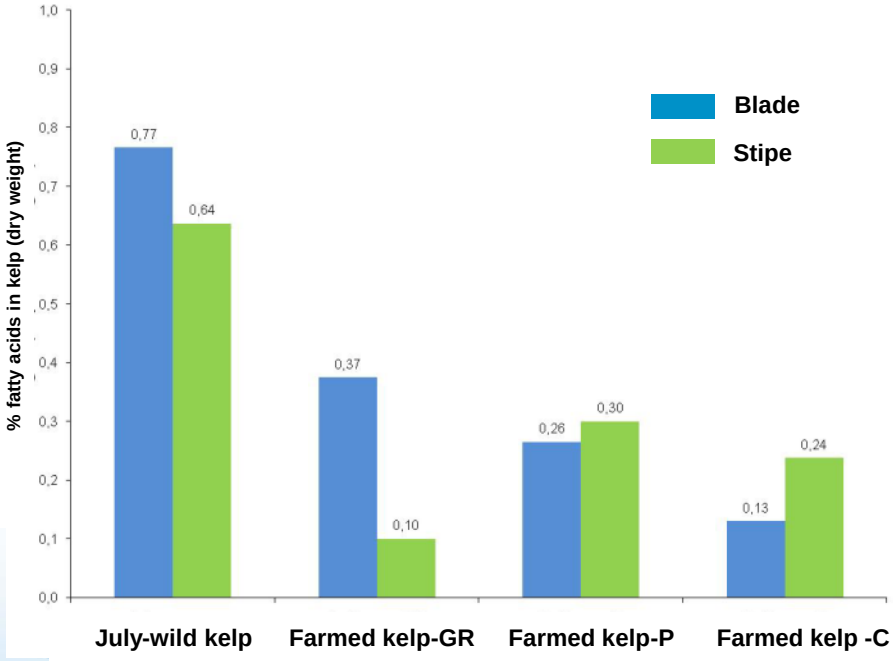
4. Product development: adding-value

Lipids in *S. longicruris*

a) Season



b) Wild vs cultured, 3 locations

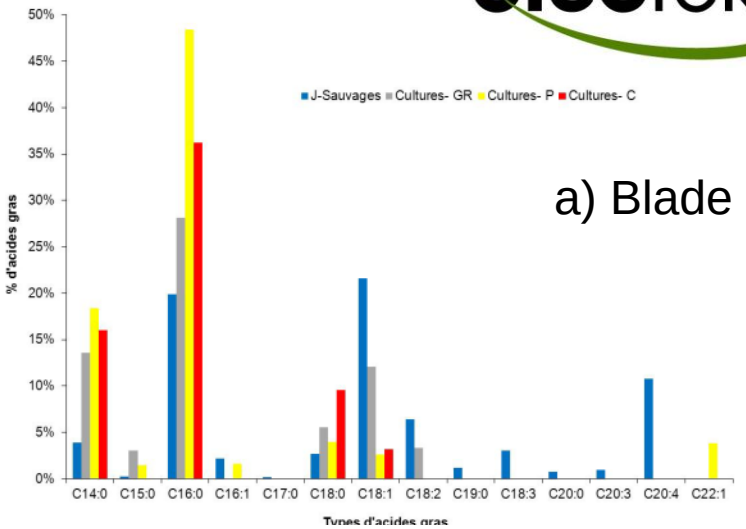


4. Product development: adding-value

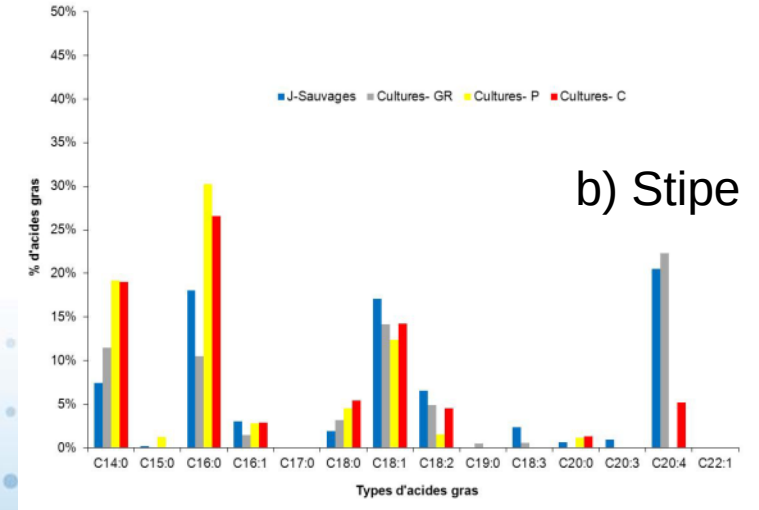
Fatty acids in *S. longicruris*

Wild vs cultured kelp, 3 locations

Chemical forms	July-Wild	GR-Farmed	P-Farmed	C- Farmed
C14:0	3,9%	**13,6%**	**18,4%**	**16,0%**
C16:0	19,9%	**28,2%**	**48,4%**	**36,2%**
C18:0	2,7%	5,6%	3,9%	9,6%
C18:1	**21,6%**	12,1%	2,6%	3,2%
C18:2	**6,4%**	3,3%	0,0%	0,0%
C20:4	**10,8%**	0,0%	0,0%	0,0%



a) Blade

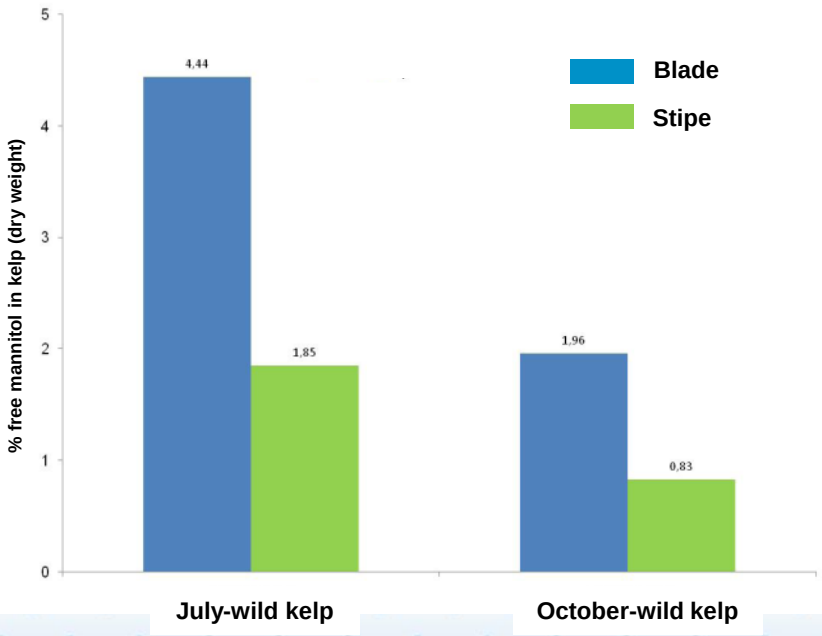


b) Stipe

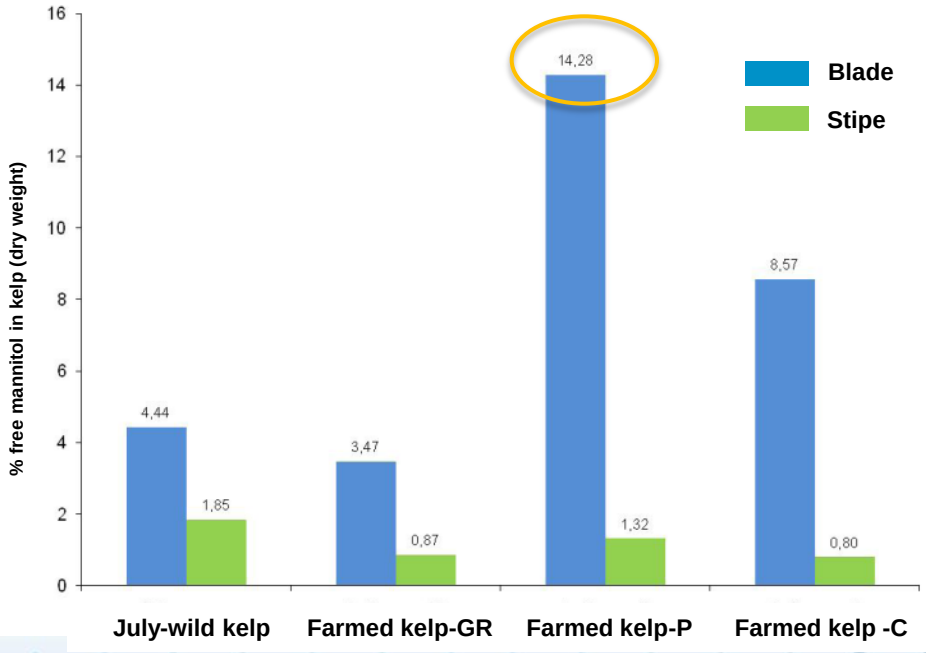
4. Product development: adding-value

Free mannitol content in *S. longicruris*

a) Season



b) Wild vs cultured, 3 locations



4. Product development: adding-value

Why to develop fully biobased composites ?

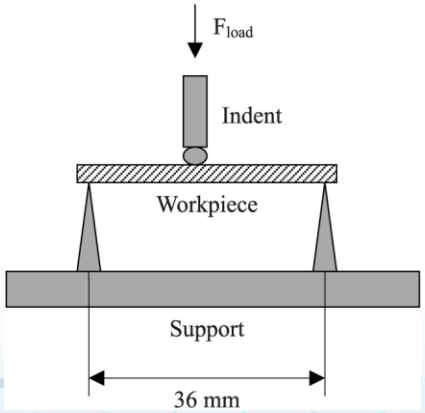
How to make seaweed composites:

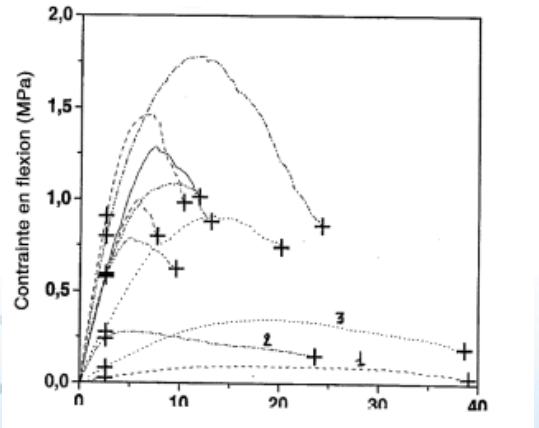
Modified vegetable oil resin

Seaweed powders
60 to 80 (% w/w)

- Radical initiator
- Δ (25 to 180°C)
- t = 12 h

→ Seaweed composites





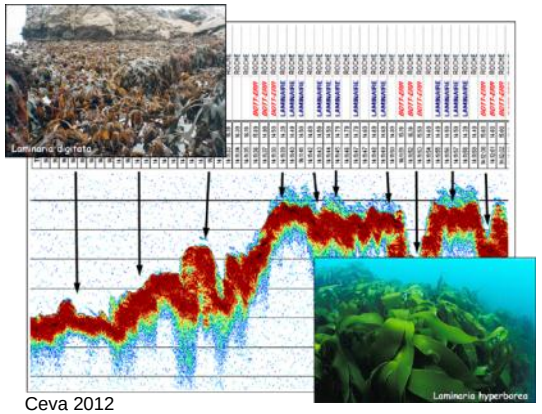
Bending tests (standard BNQ-3805)

Preliminary results: same performance as plywood

5. Industrial research chair

Industrial Research Chair Grant from NSERC on seaweeds

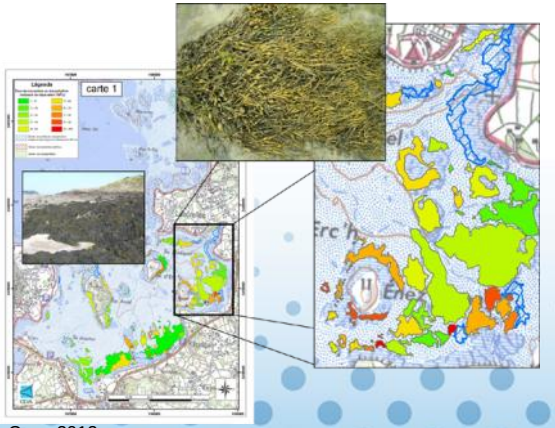
1. **Harvest of wild resources**
   a. *Gather available data on seaweed beds*
   b. *Import acoustic detection techniques*
   c. *Develop new tools for seaweed harvest*



Ceva 2012

2. **Cultivation on marine farms**
   a. *Optimization and scaling up*
   b. *Co-cultivation shellfish-seaweeds*
   c. *Master cultivation techniques for more sp.*

3. **Processing and product development**
   a. *Food industry*
   b. *Nutraceuticals / pharmaceuticals*
   c. *Composite biomaterials*



Ceva 2012

PAPERS AND REPORTS

- Licois A., Hersant G., Tamigneaux E. & Bernier R. (2012). *Projet ALHURE. Valorisation des huiles et des fibres d'une algue brune (Saccharina longicruris) pour le marché des biomatériaux*. Ministère de l'éducation du loisir et du sport, rapport PART2010N035, 36 pages.
- Gendron L., Tamigneaux E., Leroux C. & Leblanc M.-J. (2010). *Ajustements du calendrier de culture de la laminaire à long stipe (Saccharina longicruris) en Gaspésie (Québec) pour éviter la colonisation des frondes par le bryozoaire Membranipora membranacea et augmenter le nombre de récoltes annuelles*. Rapport technique canadien des sciences halieutiques et aquatiques 284 : vii+53 p.
- Gendron L. & Tamigneaux E. (2008). *Expériences de culture de l'algue brune Saccharina longicruris en 2007 : essais en bassin et en mer au large de Paspébiac et de Grande-Rivière (Québec*). Rapport technique canadien des sciences halieutiques et aquatiques 2820 : x+48 p.
- Leblanc M.-J., Tamigneaux E. & Larrivée, M.-L. (2008). *Amélioration des techniques de culture des algues marines : culture in vitro de semences de la laminaire à long stipe et ensemencement de cordes de culture*. Programme d'aide à la recherche technologique. Ministère de l'éducation du loisir et du sport, rapport PART2007N003, 52 p.
- Tamigneaux E. (2012). Essais préliminaires de culture de l'algue rouge *Palmaria palmata* (Linnaeus) Weber & Mohr. Rapport final PART2009N004, MÉLS : vi + 28.
- Tamigneaux E., Leblanc, M.-J. & Larrivée M.-L. (2011). *Amélioration des techniques de culture des algues marines: comparaison entre les rendements de Saccharina longicruris et d'Alaria esculenta*. Rapport final PART2009A019, MÉLS : vi + 32.
- Tamigneaux E., Leblanc, M.-J. & Larrivée M.-L. (2009). *Amélioration des techniques de culture des algues marines: test de faisabilité de trois récoltes annuelles pour la laminaire à long stipe (*Saccharina longicruris*).* Rapport final PART2007N004, MÉLS : vii + 40.

How to join us:

General manager
Patrice Element, CEO
Gaspé (Québec)
Tél. 418 368-7638
patrice.element@merinov.ca

Project coordinator & chairholder
Éric Tamigneaux, Ph.D.
Grande-Rivière (Québec)
Tél. : 418 385-2241, poste 4108
etamigneaux@cegepgim.ca

Project manager
Aurélie Licois, M. Sc.
Grande-Rivière (Québec)
Tél. : 418 385-2241, poste 4123
aurelie.licois@merinov.ca

info@merinov.ca **www.cevam.qc.ca**