2nd Meeting – 21 September 2015 (Odense Slot)

Odense Harbour Mussel Project

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A pilot project to assess the feasibility of cleaning sea water in Odense harbour by means of filter-feeding blue mussels on suspended nets

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NordShell Hav og viden

LINDØ PORT OF ODENSE

ODENSE KOMMUNE

UNIVERSITY OF SOUTHERN DENMARK

Outline

I	Goals & Study area
II	Environmental conditions
III	Local mussel population
IV	Recruitment
V	Larval settlement
VI	Mussel growth study
VII	*In situ* filtration rates
VIII	Conclusion & Outlook

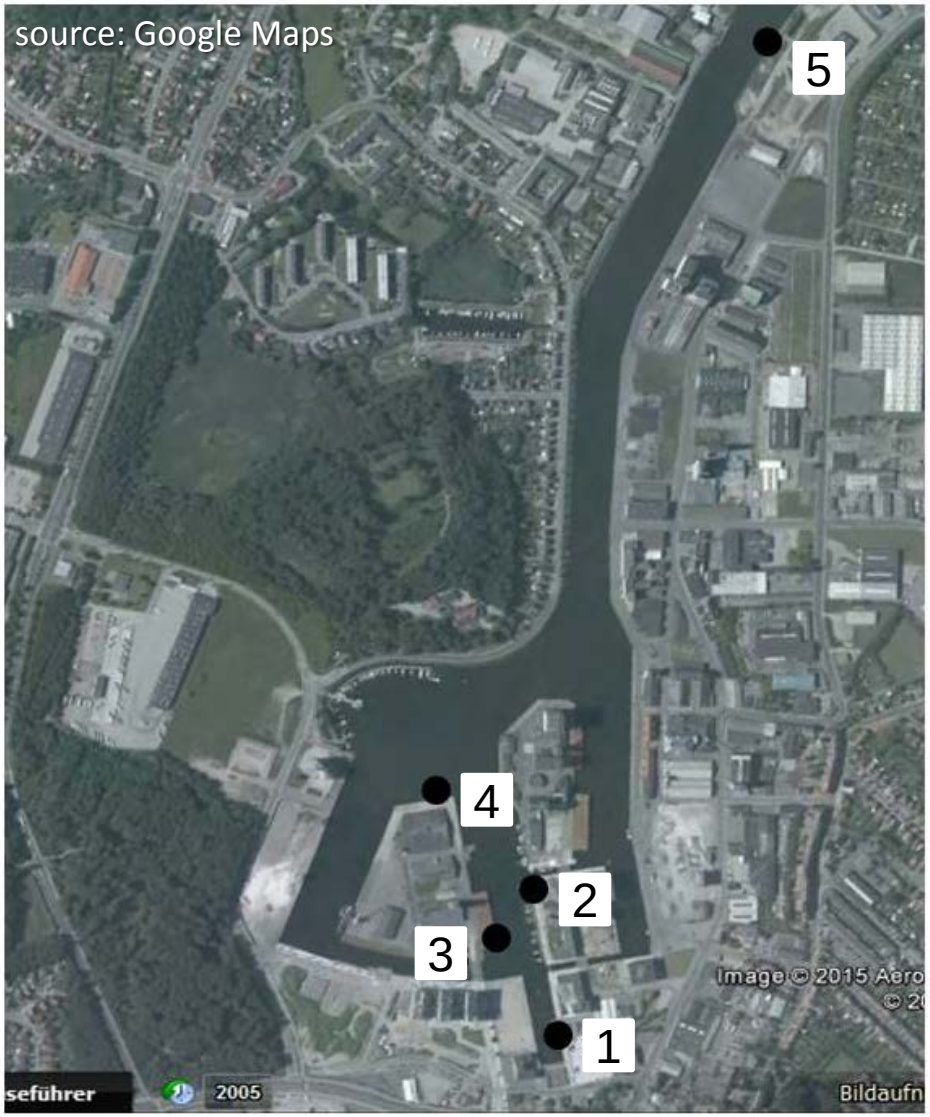
Goals

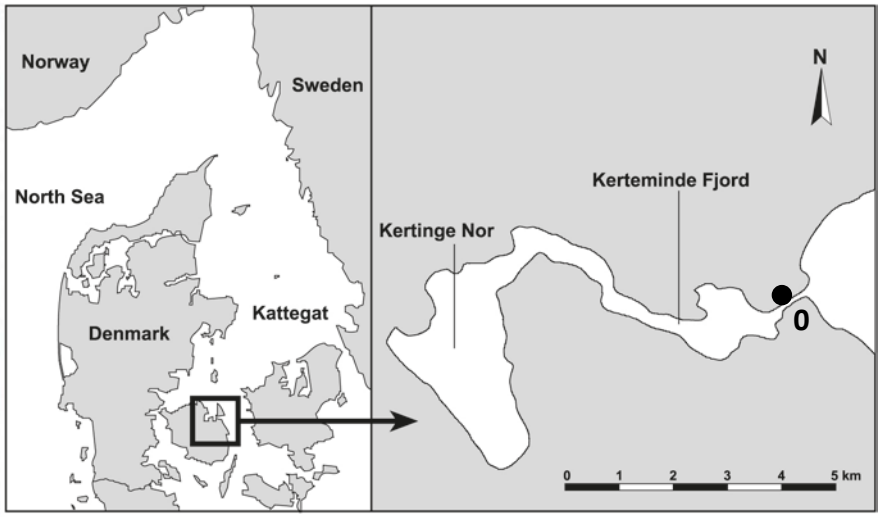
- developments in the harbour area but still a problem with eutrophicated and turbid water
- Odense Kommune asked for solutions to improve the water clarity (*Mytilus edulis* as bio-filter)
- evaluation of the environmental conditions, mussel offspring, settlement, filtration, and growth rates of blue mussels in the harbour area
- harsh growth conditions (changing salinities, high algal concentrations)

Goals

- Are the environmental conditions suitable for the growth of blue mussels?
- How big is the local ‘background’ mussel population?
- Is the recruitment sufficient for farming mussels on smart farm units?
- Are blue mussels realising their maximal growth and filtration potential in the Odense harbour?
- How many mussels are needed to control the algal population?

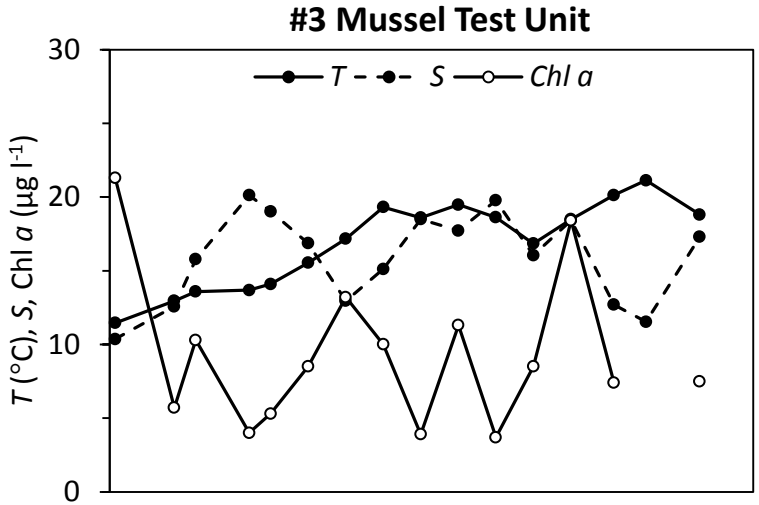
Study area

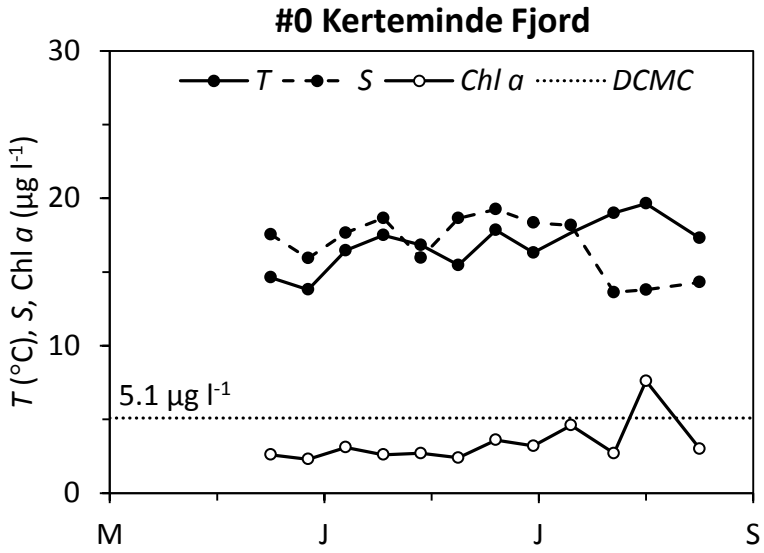


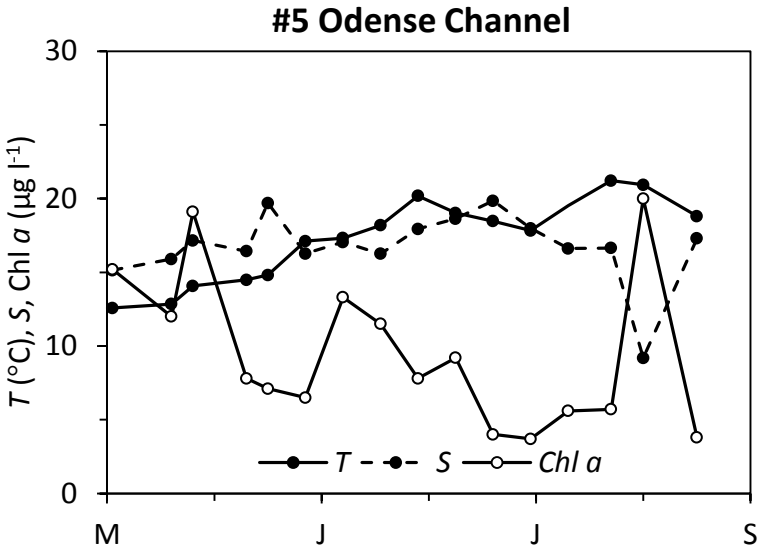


#0	Kerteminde Fjord
#1	Inner Harbour
#2	Middle Harbour
#3	Mussel Test Unit
#4	Ruslandkaj
#5	Odense Channel

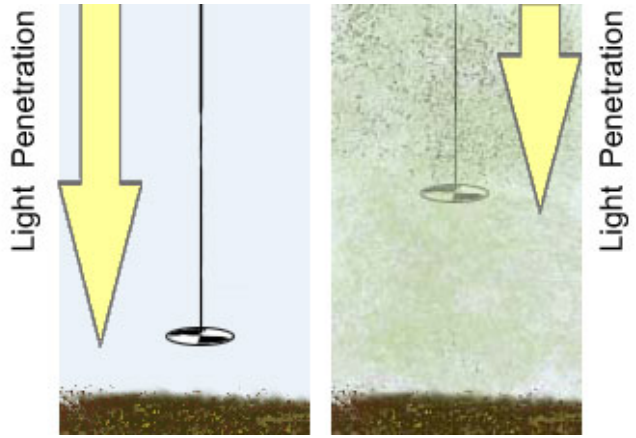
Environmental parameters



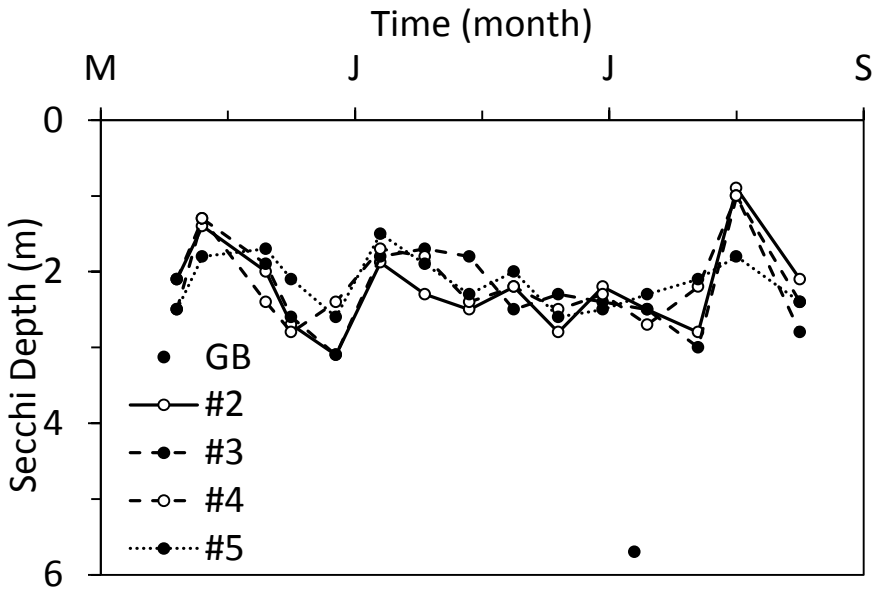


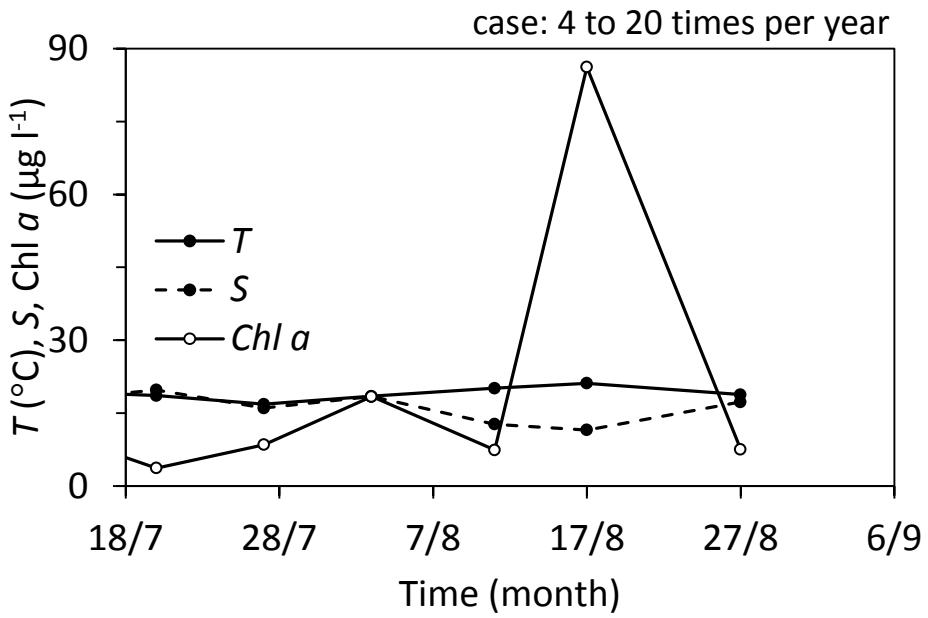


Secchi Depth & heavy rainfalls

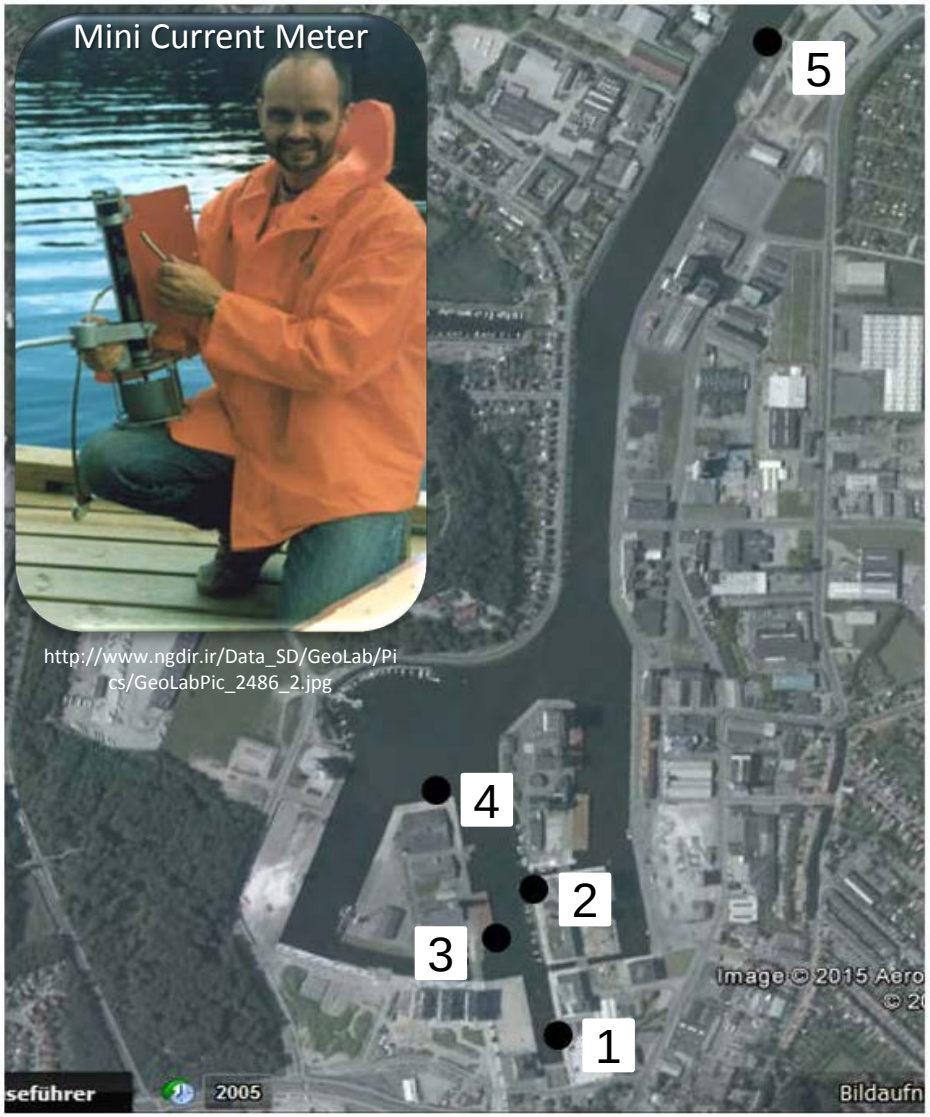


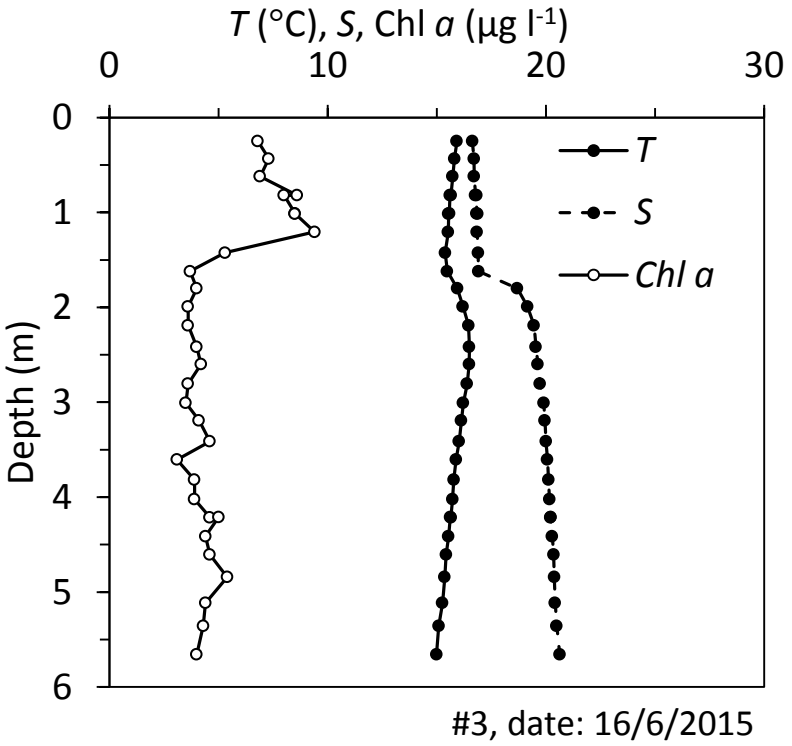
http://rmbel.info/wp-content/uploads/2013/04/Secchi_Graphic.jpg





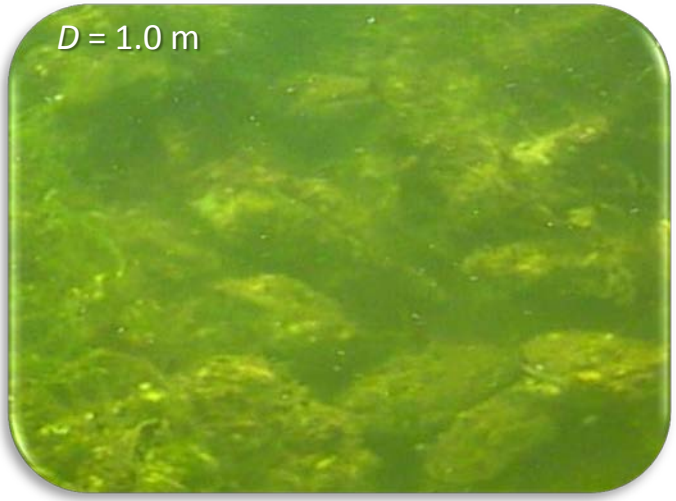
Vertical profiles & water movements

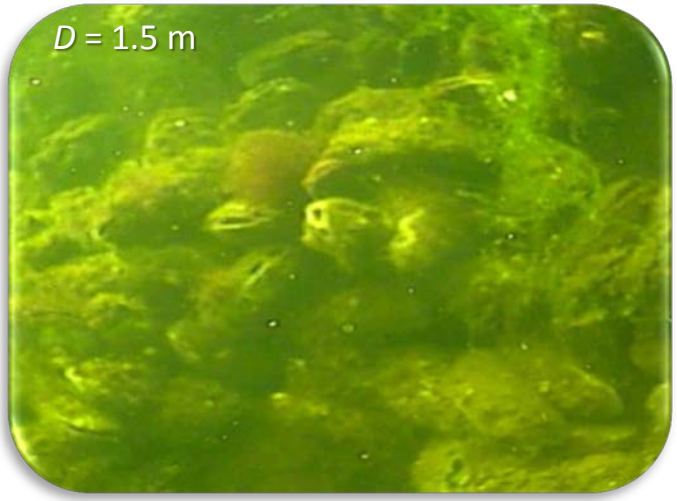


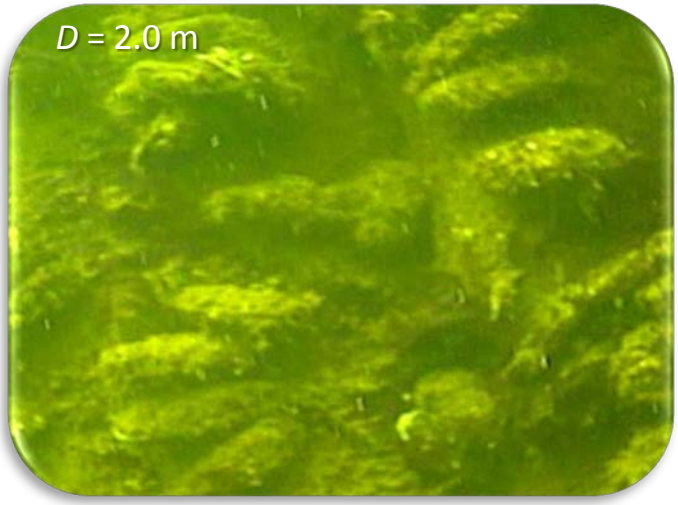


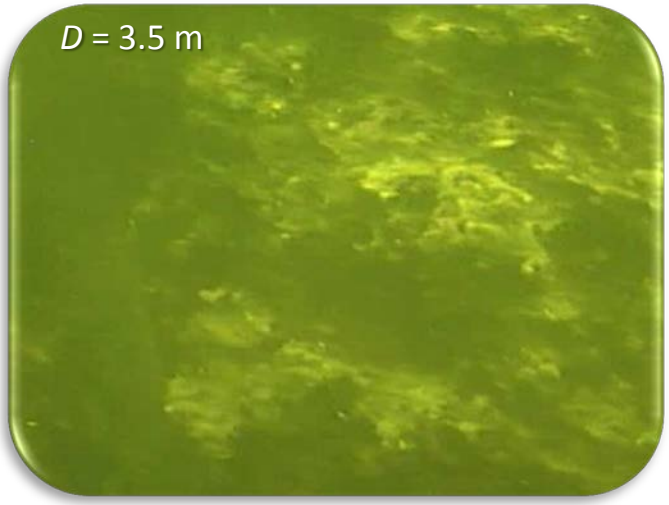
#3, date: 16/6/2015

Local mussel population – Walls





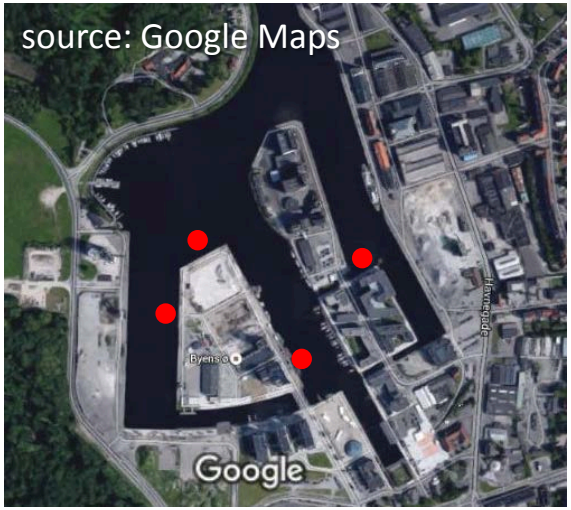




#3, *D* = 6.0 m

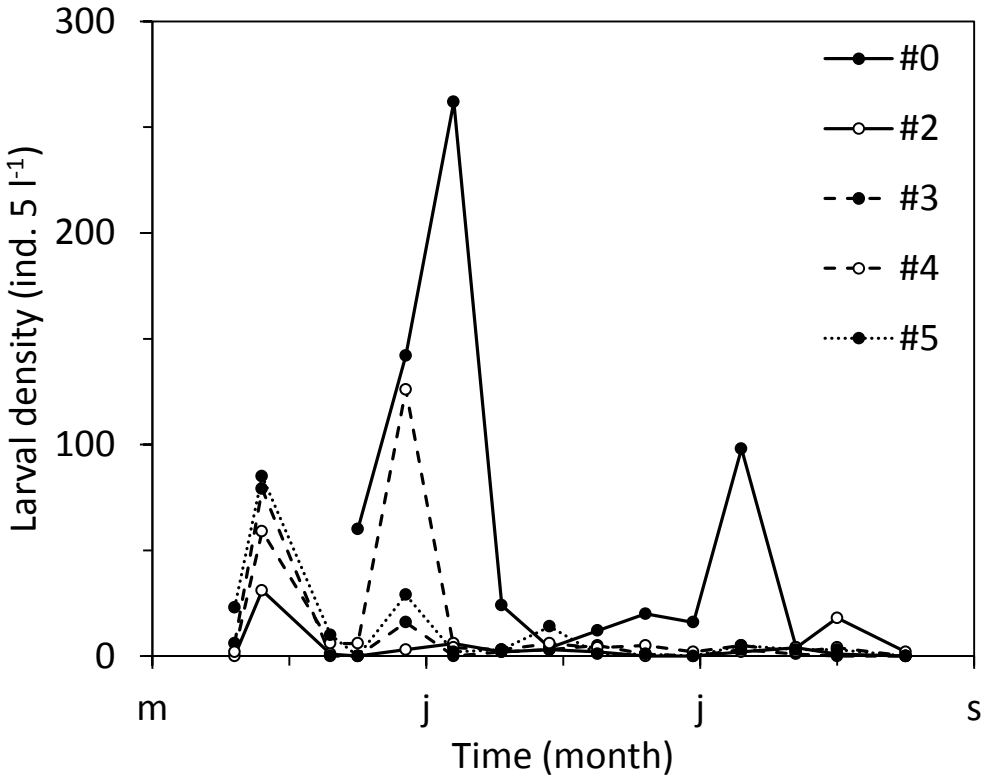
Local mussel population – Sea floor

http://arctic.cbl.umces.edu/Laurier2010/index/vanVeenout.jpg



Recruitment

http://www.molluscs.at/images/weichtiere/muscheln/mytilus_veliger1.jpg

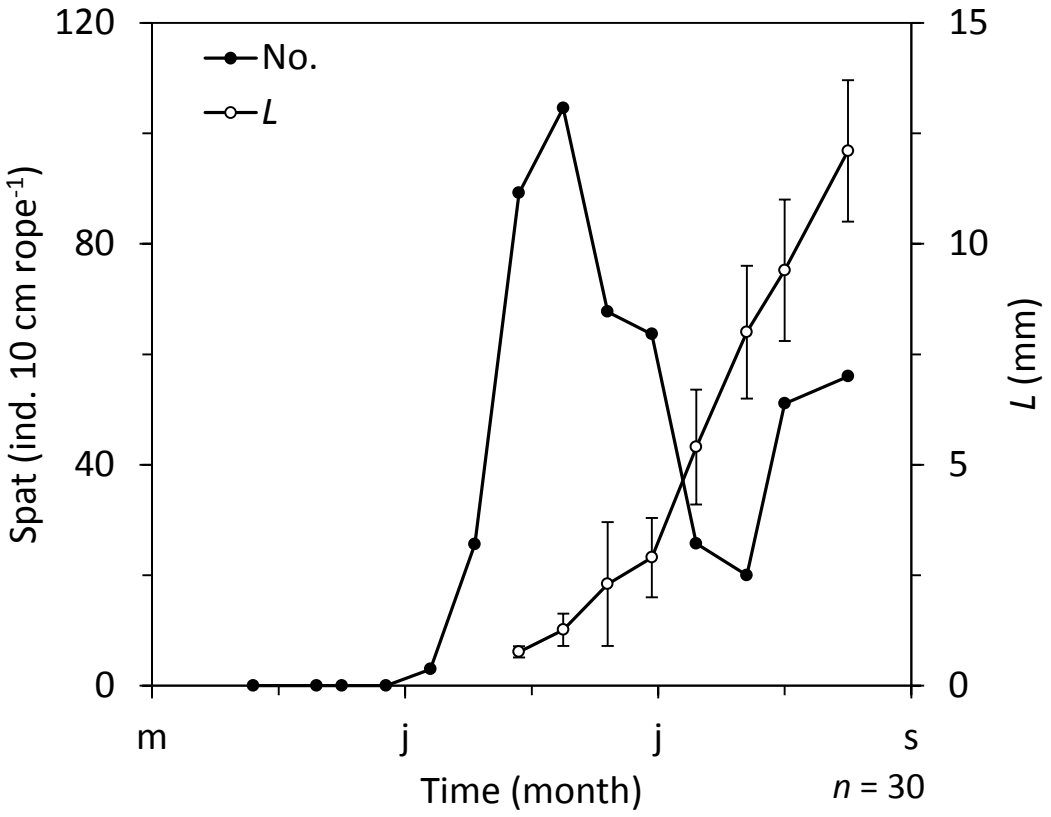


Predation of mussel larvae


Mnemiopsis leidyi


Aurelia aurita

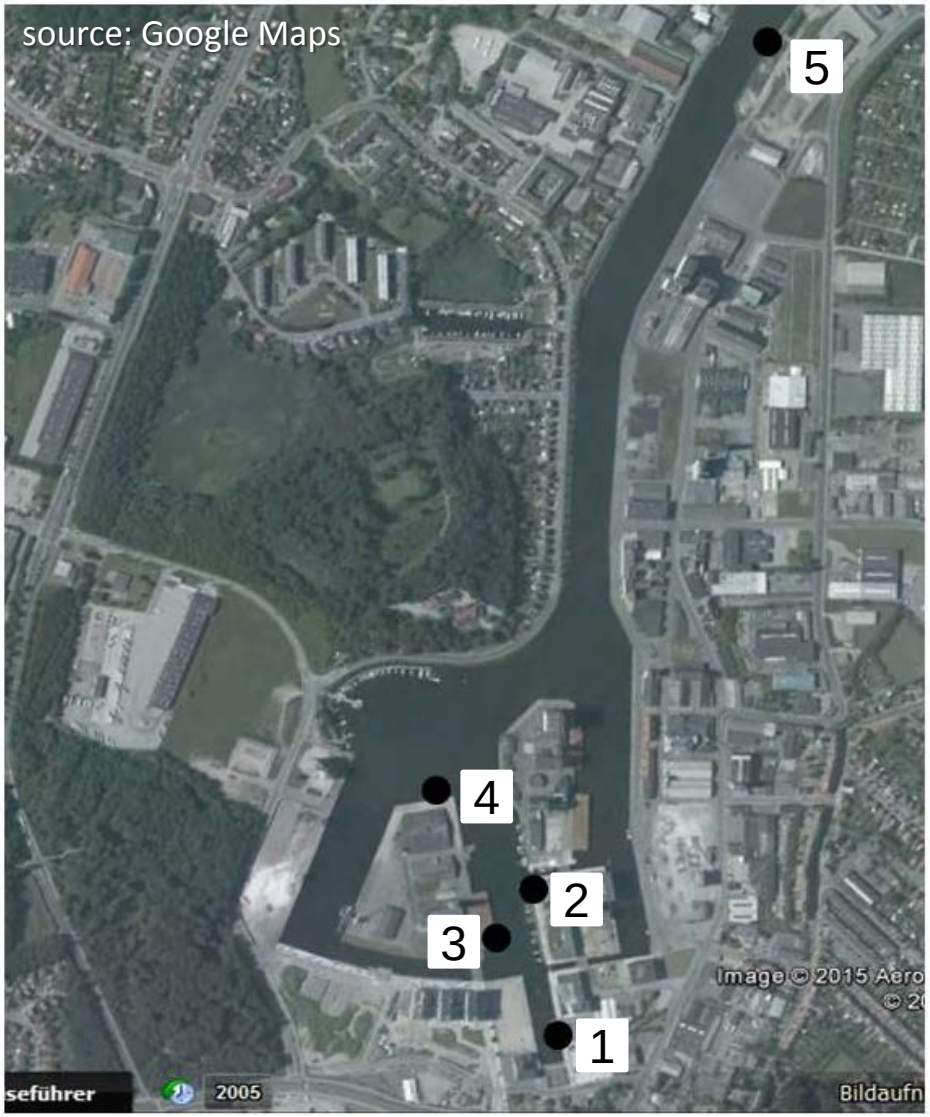
Larval settlement



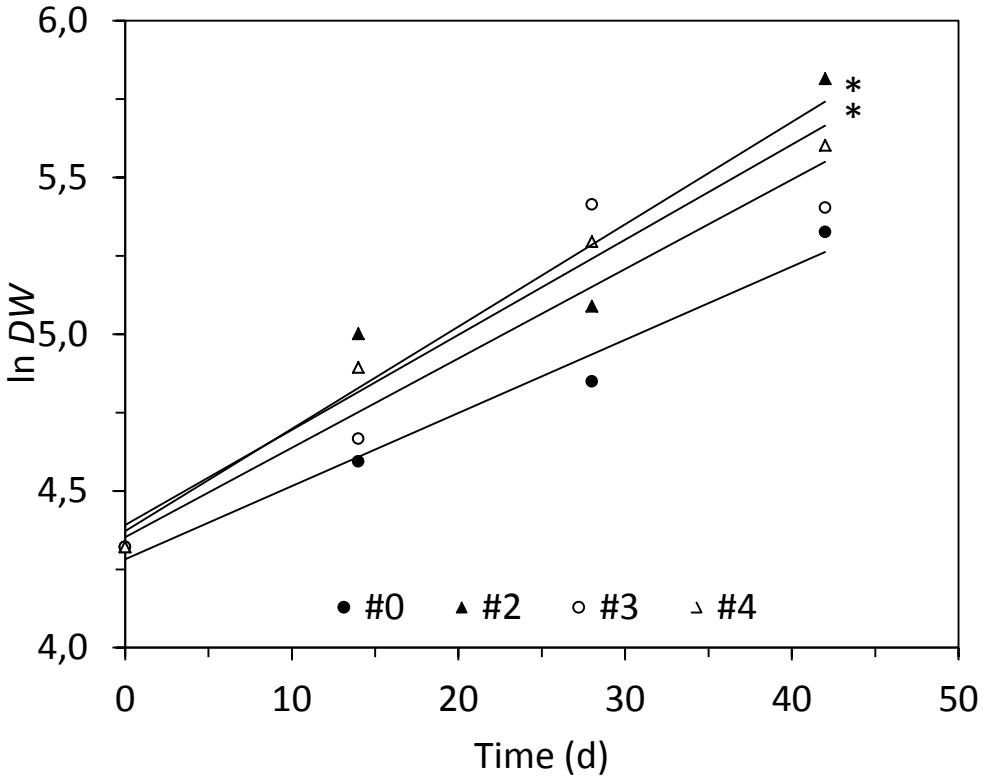
Larval settlement

Location	t (d)	L_0 (mm)	Chl a (µg l^{-1})	ΔL (mm mo^{-1})	Reference
Laboratory	35	26.6 ± 0.8	2.4	4.7	Clausen and Riisgård 1996
Laboratory	15	19.5 ± 0.3	2.5	1.8	Riisgård et al. 2012b
Great Belt	21	14.8 ± 0.4	2.7 ± 0.6	5.0	Riisgård et al. 2014a
Great Belt	76	4.4 ± 1.6	3.1 ± 0.8	8.3	Riisgård et al. 2014b
Limfjorden	30	19.0 ± 0.1	17.6 ± 20.2	6.9	Landes et al. 2015
Nørrefjord	50	19.7 ± 0.4	17.2 ± 5.2	5.7	Landes et al. 2015
Odense Harbour	52	0.8 ± 0.1	18.4 ± 27.8	7.0	pilot study

Mussel growth study



Mussel growth study



* = repeated measures ANOVA (*P* = 0.01)

Mussel growth study

#	t (d)	Chl *a* (µg l^{-1})	*L* (mm)	*DW* (mg)	*CI* (mg cm^{-3})	*S* (ind.)	*µ* (% d^{-1})
Kerteminde Harbour							
0	0		22.5 ± 1.6	75.3 ± 24.9	6.9 ± 2.9	30	
	14		23.8 ± 1.8	98.9 ± 30.7	7.2 ± 1.5	29	
	28		25.8 ± 1.7	127.6 ± 30.7	7.3 ± 1.3	27	
	42	2.8 ± 0.5	27.4 ± 1.9	205.5 ± 51.9	10.1 ± 2.9	28	2.33
Odense Harbour							
2	0		22.5 ± 1.6	75.3 ± 24.9	6.9 ± 2.9	30	
	14		25.8 ± 1.6	148.6 ± 34.6	8.6 ± 1.6	29	
	28		28.5 ± 2.0	162.3 ± 30.2	7.1 ± 1.5	28	
	42	10.4 ± 6.3	31.5 ± 2.9	335.1 ± 68.0	7.3 ± 1.8	28	3.26
3	0		22.5 ± 1.6	75.3 ± 24.9	6.9 ± 2.9	30	
	14		25.1 ± 1.9	106.3 ± 29.4	6.7 ± 1.6	30	
	28		28.9 ± 1.8	224.5 ± 51.5	9.4 ± 2.0	28	
	42	8.0 ± 3.8	31.4 ± 2.7	222.1 ± 42.8	10.9 ± 2.6	26	2.85
4	0		22.5 ± 1.6	75.3 ± 24.9	6.9 ± 2.9	30	
	14		25.3 ± 1.8	133.5 ± 39.0	8.2 ± 2.3	27	
	28		28.2 ± 2.6	199.4 ± 48.9	9.0 ± 2.2	29	
	42	10.9 ± 5.1	31.8 ± 2.2	271.2 ± 56.6	8.5 ± 2.0	24	3.03

Condition index

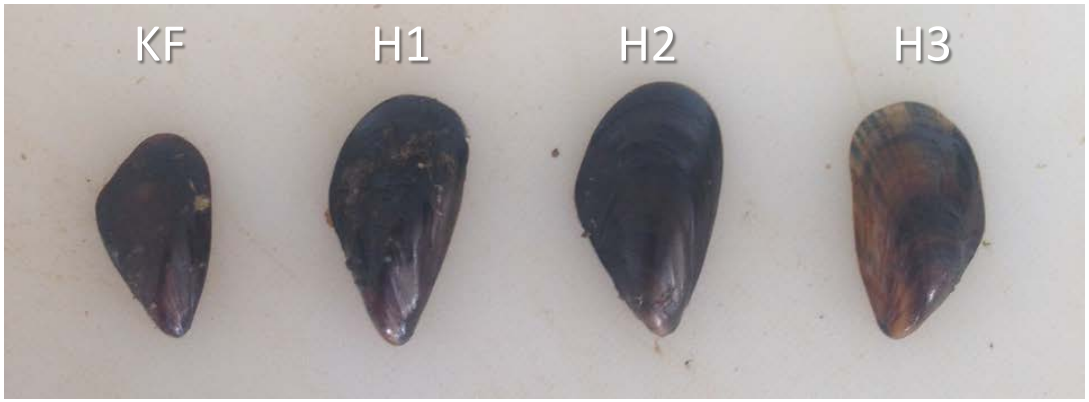
$$CI = \frac{DW}{L^3}\left(\frac{mg}{cm^3}\right)$$

Weight-specific growth rate

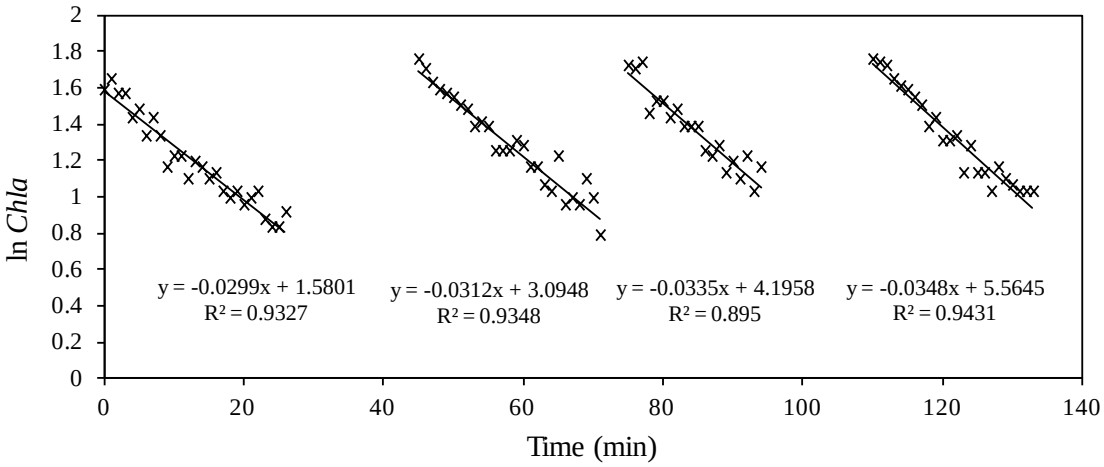
$$\mu = ln\left(\frac{W_t}{W_0}\right) \times t^{-1}(d^{-1})$$

Mussel growth study

Location	t (d)	L_0 (mm)	Chl a (µg l^{-1})	μ (% d^{-1})	References
Laboratory	35	26.6 ± 0.8	2.4	1.90	Clausen and Riisgard 1996
Great Belt	21	16.5	2.7	7.00	Riisgard et al. 2014a
Great Belt	69	21.1 ± 0.2	3.0 ± 0.2	3.05	Riisgard et al. 2014b
Limfjorden	41	21.0 ± 0.1	3.4 ± 0.2	4.15	Riisgard et al. 2014b
Nørrefjord	50	19.7 ± 0.4	17.2 ± 5.2	3.80	Landes et al. 2015
Odense Harbour	42	22.5 ± 1.6	2.8 ± 0.5	3.05	pilot study
Kerteminde Fjord	42	22.5 ± 1.6	9.8 ± 5.0	2.33	pilot study



In situ filtration rates



Filtration rate

$$F = \frac{V \times b}{n}\left(\frac{l}{ind \times h}\right)$$

In situ filtration rates

#	Chl *a* (µg l^{-1})	*L* (mm)	n_m	n_e	Prey item	F_{ind} (l h^{-1})
pre-study	5.3 ± 0.3	63.6 ± 2.5	10	4	*Rhodomonas salina*	6.9 ± 0.5
study	86.2 ± 0.0	48.4 ± 2.2	1	6	natural sea water	0.5 ± 0.2
study	4.8 ± 0.9	63.6 ± 2.5	10	3	natural sea water	1.7 ± 1.5
post-study	3.1 ± 0.6	63.6 ± 2.5	10	6	*Rhodomonas salina*	5.6 ± 1.8

Conclusion

$$V_{total} = \Sigma A_{Basin} \times D_{Basin} = \underline{867{,}578\ m^3}$$

$$V_{total}/F_{ind} = 867{,}578 \times 10^3\ l/84\ l\ d^{-1} = \underline{10.3 \times 10^6\ ind.}$$

$$t_{1/2} = V_{total}/F_{pop} \times \ln 2 =$$
$$867{,}578 \times 10^3\ l/(84\ l\ d^{-1} \times 10.3 \times 10^3\ ind.) \times \ln 2$$
$$= \underline{0.69\ d}$$

$$n_{local} = 2\ m \times 4{,}032\ m \times 200\ ind.\ m^2 = \underline{1.6 \times 10^6\ ind.}$$

$$n_{SFU} = n_{total} - n_{local} =$$
$$10.3 \times 10^6\ ind. - 1.6 \times 10^6\ ind. = \underline{8.7 \times 10^6\ ind.}$$

Standard mussel:
L = 40 mm, F = 84 l d^{-1}
(Riisgård et al. 2011)

Conclusion

- Odense harbour is a highly dynamic systems
- growth conditions for mussels are reasonably good
- weight-specific growth rates of transplanted mussels are comparable to other marine areas
- local mussel population is mainly situated above 2 m depth, the bottom is almost completely dead
- natural recruitment is sufficient for rope farming
- natural thinning due to intra-specific competition for space between newly settled mussels
- filtration rate is reduced under extremely high phytoplankton concentrations
- blue mussels can take part in the cleaning process of highly eutrophicated sea water


Smart farm unit (SFU)

Outlook

- improvements in local mussel population characteristics
- nutrient loads (P + N), bacterial concentrations, heavy metal loads
- dissolved oxygen concentration in the water column and close to the sediment
- Chl *a* concentrations before and after entering the vertical mussel bed


Mytilus edulis

References

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Per Andrup
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Thank you for your attention!

NordShell
Hav og viden

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