SEMI-EXTENSIVE PRODUCTION OF TURBOT FRY FED ON COPEPODS

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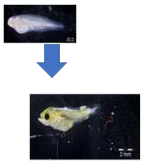
Master plan

Turbot (*Psetta maxima*) juveniles have been reared on copepods at Venøsund Fisk og Skaldyr Aps, Denmark during the last 20 years for restocking purposes or for export.

In the semi-extensive production system, a succession takes place during each larvae production initiating with a bloom of small diatoms. After a crash in the diatom bloom, small algae cells and sometimes-filamentous bacteria take over. Nutrients are taken up very quickly, often depleted as to be immeasurable within few days. Usually P is in excess. The blooms in this system are closely monitored, and to a certain extent regulated. Well-nourished adult copepods are added to the production system before introducing the fish larvae. The adult copepods produce eggs that hatch into nauplii and develop into older stages of nauplii or copepodites unless eaten by the larvae.

From 3 mm to 15 mm in 3 weeks



At Venøsund Fisk og Skaldyr Aps larvae productions were monitored with the aim to describe all trophic levels including primary producers, secondary producers and fish larvae during different seasons. The final survival and quality of the fry was related to their early life in the semi-extensive enclosure ecosystems.

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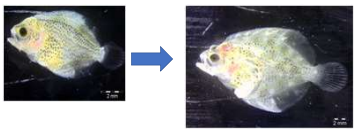
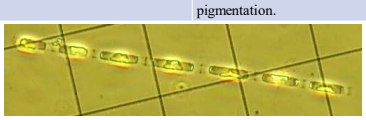


Phytoplankton throughout the year

Spring productions	Late summer productions	Fall productions
Huge bloom of diatoms (***Skeletonema costatum***, maximum 100 mill/l). **Filamentous bacteria** became numerous (max 150 mill/l) by the end of the production resulting in **low oxygen**. At this point the lagoons had to be harvested quickly.	Productions initiated by a bloom of diatoms (***Dactyosolen fragillissimus***, maximum 10 mill/l), and ***Leptocylindricus danicus.*** Productions were successful and **dynamic** with a balanced algae community, sustaining the copepod production during the whole production and a low density of filamentous bacteria (40 mill/l).	Initiated by a quick, weak bloom of ***Dactyosolen fragilissimus*** (4 mill/l) and ***Leptocylindricus danicus*** but very quickly small flagellates and ***Prorocentrum minimum*** (7 mill/l), a potentially ichthyotoxic dinoflagellate took over. By the end of the production **filamentaous bacteria** (max 70 mill/l) dominated entirely, resulting in low oxygen levels and stressed fish with black pigmentation.



Copepod production throughout the year

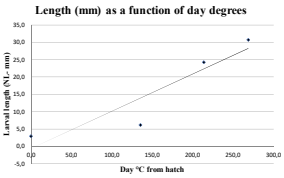
- Copepods are small, free-living crustaceans and the main diet of wild turbot larvae.
- During spring *Acartia spp*. dominated the copepod population. During late summer and fall *Acartia spp.* and *Centropages hamatus* were present in the lagoons.
- Normally up to 50-100 eggs per litre per day is produced by the copepods in the 1200 m^3 large lagoons during a production season.
- During fall, egg production decreased resulting in low densities of nauplii and copepodites and possibly also in low fish larval survival during "first feeding". Most likely decreasing temperatures were the main reason for the reduced copepod egg production.

Performance and harvest, industry scale

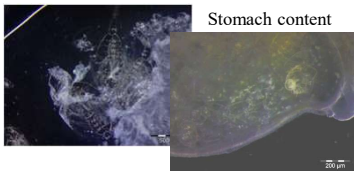
	Spring	Late summer	Fall
Yolk sac larvae released	300 000	300 000	300 000
Growth rate (% L day°C^{-1})	0.3-0.4	0.4	0.3
Growth rate (% dw day°C^{-1})	1.1-1.3	1.2-1.4	0.9-1.0
% fry discarded due to abnormalities	16	6	93
Harvest (number)	39 375	60 844	16 000

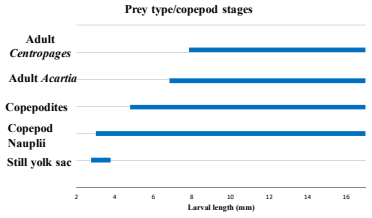
Growth rate and yield of turbot productions larvae in different seasons and batch productions in 2011. The numbers represent the sum of 3 lagoons from each season.

Prey selection



Turbot larvae choose different size of prey during growth.





Consumption of prey per day degree

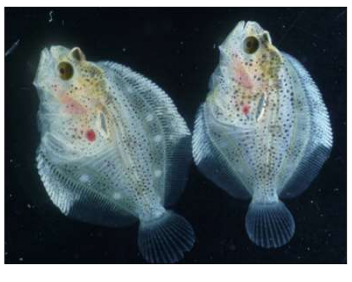
The consumption of prey can be calculated – showing that a turbot larvae needs to consume several thousand prey per day to sustain its growth, especially if only small sized prey are available. *To get the daily consumption, the numbers in the table below must be multiplied by the average temperature that day!*

Notochord L (mm)	Calculated DW (mg)	Consumed nauplii (day°C^{-1})	Consumed copepodites (day°C^{-1})	Consumed copepods (day°C^{-1})
4	0,185	17	-	-
5	0,385	35	-	-
6	0,704	63	14	-
7	1,170	105	22	9
8	1,818	164	35	14
9	2,682	241	52	21
10	3,798	342	73	29
11	5,202	468	100	40
12	6,933	624	133	53

It is assumed that (1) the larvae consume only one type of prey at a time, (2) 20% of the energy is used for growth, (3) Nauplii with a length of 100 µm has an individual dry weight of 0.64 µg, a copepodite 3 µg and an adult copepod 7.5 µg and (4) SGR (specific growth rate) is 1,152 (% day°C^{-1}), average for 2011 productions.

Conclusion

- Growth rates of turbot larvae and production yield rates were highest during the late summer productions, and lowest in the Autumn.
- The initial diatom bloom was less prominent during Autumn compared to spring and summer, and production was taken over by dinoflagellates and other flagellates of minor size.
- Egg production of *Acartia sp.* and *Centropages hamatus* was reduced during Autumn, probably due to decreasing temperatures, resulting in low densities of nauplii and copepodites and possibly also in low survival and abnormal development during "first feeding".
- It is suggested to avoid production in the fall during decreasing temparatures.



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