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GROWTH OF SCALLOP JUVENILES (*PECTEN MAXIMUS* L.) IN AN ENRICHED SHALLOW SEAWATER BASIN

by

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ABSTRACT

The aim of this work was to see if a shallow, enriched seawater basin was a suitable location for scallop culture. Growth of great scallop juveniles (Pecten maximus L.) was compared with two open sea locations, and the mean growth rate is described for 23.1-29.5 mm juveniles in three intervals from early April to late September 1989. In 1990 the mean of individual growth rate is described for 30-65 mm juveniles in April, May, June and July. Growth was measured as increase in shell height. Temperature, salinity and particulate organic material, POM, (1990) were recorded twice every week. Phytoplankton (1989) was observed weekly.

Mean growth rate per individual (mm/30 days) in 1989 was, relative to the other locations, higher in the basin in April-May, approximately equal in May-July and lower in July-September. The relative high growth rate in April-May coincided with relative higher temperature and phytoplankton biomass. The low growth rate in the basin was observed in a period of equal temperature relative to the other locations, higher phytoplankton biomass, but with large variations in salinity (25-31 ppt). In 1990 there were no significant difference in mean of individual growth rate between the locations, except for in June. The low growth rate and high mortality observed in the basin this month coincided with very high POM values (mean=17 mg/l, maximum=31 mg/l).

The conclusion so far is that the seawater basin is suitable for culturing scallop juveniles, given a certain manipulation with salinity, fertilization and water circulation.

INTRODUCTION

The culture of marine organisms in small lagoons or landlocked fjords has long tradition in Norway. Since early this century spat production of flat oyster has been carried out in lagoons (Gaarder and Spärk, 1932). During the 1980'ies the interest for these marine basins increased along with the development of an extensive concept for marine fish larviculture (Kvenseth and Øiestad, 1984).

A landlocked pond (Svartatjønn) located south of Bergen, Norway, has for several years been used in the development of a production line for cod and flatfish larvae (Øiestad et al., 1984; Berg et al. 1985). Both the primary production and the temperature are usually high in summer (Øiestad et al., 1984). The primary production in Svartatjønn has partly been controlled by adding fertilizer. In the mid-summer season, an over-production of algae has sometimes resulted in water quality problems. The results have been low oxygen levels, and sulphide production in the bottom layer. To solve this problem we wanted to introduce species which were able to filter out some of the algae production. Great scallop (*Pecten maximus* L.) was chosen because of its high market value and food quality.

The aim of this work was to see if Svartatjønn and similar basins could be used as a location for scallop juveniles. The growth rate obtained at this location was therefore compared with two locations in the sea.

MATERIAL AND METHODS

Locations.
The locations selected were:

1. - Svartatjønn (SVTJ), a 23 000 m^3 seawater basin with a maximum depth of 4 m. After treatment with rotenone in February, the basin was filled with seawater from 30 m depth. 50 kg of N,P,K complex fertilizer (21-4-10, Norsk Hydro A.S.) was added weekly when concentration of nitrate was below 2 μM. In 1989 a total of 1050 kg was added. This yields 220 kg nitrogen and 42 kg phosphorous. In 1990 a total of 950 kg fertilizer had been added until the end of July.

Water circulation was obtained with a propeller submerged to approximately 1.5 m depth, directing the water current slightly upwards.

Salinity and temperature were partly controlled by pumping in seawater from a depth of 30 m in the sea outside the basin. When salinity reached a lower limit of 27 ppt in rainy periods in 1989, deep-water pumping was started manually. In April and May 1990 deep-water supply was controlled by a salinity sensor which started the pump at 28 ppt and stopped it at 29 ppt. In June and July when rainfall was low, level of oxygen and water level decided when to pump in deep-water. The pump was then operated manually. The supply of cold deep-water to the upper layer of the water column, also enhanced the water circulation, and affected the temperature.

2. - *a fish farm (FF)*, licensed for 8000 m^3 cage volume for salmon and cod. The farm is used for research only, and stock size varies throughout the year. Generally, the loading of organic material such as excess feed pellets and faeces, is highest in summer (June-August) when temperature is high.

3. - *in unloaded seawater (SEA)*, outside Svartatjønn.

Scallop.
Scallop juveniles spawned in late summer 1987, were received from the shell hatchery BioMarin A.S., Rong, Norway, in April 1989.

In 1989 the juveniles were distributed in 7 groups with 25 individuals each. The groups were composed to minimize the standard deviation of the shell height mean at the beginning of the experiment. This resulted in significant differences between the mean values of some groups, which varied between 24.0+/-1.0 mm and 26.2+/-1.5 mm. The small differences were, however, assumed not to cause any difference in growth between the groups.

One experimental group in pearl-nets were grown on the following 7 locations and depths:

SVTJ 2 m
FF 2, 5, 10 m
SEA 2, 5, 10 m

In SVTJ and FF the pearl-nets were connected to existing installations, floating on the sea surface. Both locations are however, little affected by wave motions. In SEA the pearl-nets were hung onto a floating aluminum frame in April. Because of wave motions, the pearl-nets were connected to a submerged installation in May. In July the group on 10 m in SEA were lost. In October the scallop juveniles were moved to a winter location at 20 m in the sea to ensure water temperatures above 5 °C and stable salinity.

In 1990 each individual juvenile was tagged by cementing pre-numbered "Floy-tags" onto the shell near to the hinge. The individuals were then distributed in 6 experimental groups counting 41-42 individuals each. The groups were composed to give no significant difference between their mean shell height at the beginning of the growth experiment. The mean shell height was 48.0 mm. The juveniles were grown at the same locations and depths as in 1989, but without SEA-10m. After high mortality in SVTJ in June, new groups were established in July in SVTJ, and 5 m in FF and SEA. The groups on 5 m were then reduced to 21 individuals.

To calculate growth, shell height (mm) of each individual was measured. One group at a time was gently transferred to dry units during the sampling. After maximum 30 minutes the juveniles were again submerged in seawater.

In 1989 growth of each group was calculated as the difference in mean shell height before and after a growth interval. The variance of the growth was calculated as the sum of the variances of the means. In 1990 growth of each group was calculated as the mean of individual increase in shell height. The growth rate is given as the mean growth per 30 days. Significance was tested by t-test.

The growth intervals in 1989 were:
1. 10 April to 19 May
2. 19 May to 18 July
3. 18 July to 19 September

In 1990 shell height was measured at the beginning of each month, from April to August. The intervals were:
1. 28 March to 3 May
2. 3 May to 31 May
3. 31 May to 4 July
4. 4 July to 2 August

Food particles. Phytoplankton were sampled by a Ruttner sampler and preserved in both Lugol and formaldehyde. Total cell biomass (mm3/litre) was calculated. The samples were collected on 2m, except for SVTJ in 1989 when they were collected on 1 m. The results from 1990 are unfortunately not yet ready for publication.

In 1990, water samples from all locations and depths were filtered to yield particulate organic material (POM). 200 .1800 ml were filtered through Whatman

GF/C 55 mm, precombusted at 425 °C for minimum 3 hours and preweighted. The filters were dried at 112 °C over night and the dry weight determined. After minimum 3 hours at 425 °C, the ash-dry weight (PIM) were determined. POM was calculated by subtracting the ash-dry weight from the dry weight.

Temperature and salinity. Twice a week temperature and salinity were measured with WTW Conductometer LF 191 connected to a WTW LA 1/T- sensor. Temperature and salinity was measured on all locations and depths; except for 1989 when salinity was measured in SVTJ and FF on 2 m.

RESULTS

1989.

Scallop juveniles. Mean individual growth rate was highest in May-July (table 1), except for SVTJ and SEA-2m which showed equal growth rate in April-May and July-September, respectively. In April-May the highest growth rate measured was in SVTJ. In May-July there were no significant difference between the growth in SVTJ, FF-5m and SEA-5m, which then were the three locations of highest growth rate. In July-September the growth rate in SVTJ and SEA-5m were the two lowest. Mean individual growth of the juveniles in the total period of April-September varied little between the locations and depths, but ranked them as follows: FF 2m > FF 5m > SEA 2m > SVTJ > FF 10m > SEA 5m.

Mortality in the experimental groups was observed on all depths in SEA, and in FF-5m (table 2). There were no mortality in SVTJ, FF-2m and FF-10m. The mortality in SEA seems somewhat higher than in FF-5m.

Temperature and salinity. The mean temperature in SVTJ in April-May was 2.6 to 2.9 °C higher than the mean temperature in any of the other locations and depths (table 3). The difference between minimum and maximum value was also higher (2.8 opposed to 1.8-1.9 °C). In May-July the differences in mean temperature between SVTJ and the other locations were less (0.9 to 2.5 °C), except for SEA 10m (3.5 °C). In July-September there are little differences between the locations and depths.

SVTJ shows almost equal mean salinity and range to FF-2m until July (table 4). In July-September the salinity range in SVTJ is nearly the double of the range observed in FF-2m.

Phytoplankton. Table 5 reflects the very high standing crop in SVTJ from April to the end of September. Total phytoplankton biomass was approximately 10 times higher in SVTJ than in SEA-2m and FF-2m. The highest values were observed in May-July. Flagellates and dinoflagellates were abundant from April to September. Diatoms counted for approximately 25% of the total biomass at the end of April.

1990.

Mean of individual growth rates, mean temperature, salinity and POM in the four months April-July is shown in fig. 1. The general trend on all locations and depths is an increase in mean of individual growth rate from April to July, along with an increase in mean temperature and also in POM in FF at all depths. SVTJ and SEA shows a lower value of POM in July than in June.

Scallop juveniles. In 1990 the mean of individual growth rates in each of the four months showed no significant difference between the different locations and depths. One exception was SVTJ in June. In June the group in SVTJ showed low individual growth and high mortality. At the time of sampling, 26 out of 42 juveniles were dead or dying. The dead individuals still had somatic tissue left inside their shell, and were assumed to have been dead for only a few days. Estimating their growth rate should therefore give correct values.

Apart from the acute mortality in SVTJ in June, only one or two individuals died in the different groups from April to the end of July. The individuals dying were the ones with shell height at the beginning of the experiment less than the mean of all individuals.

Temperature, salinity and POM. SVTJ showed the highest temperature means, starting above 8 oC in April and passing 16 °C in June. Mean salinity in SVTJ showed similar variations as 2 m on the other locations. The mean salinity increased from approximately 28 ppt to 30 ppt from April to July. Mean POM values in SVTJ exceeded the values in FF by a factor of 3 to 5. In June and July the POM values in SEA were low relative to FF (1/5 to 1/3).

DISCUSSION

The very good results for scallop growth in SVTJ in April-May 1989 relatively to the other locations, coincided with higher temperature, higher phytoplankton biomass and low variations in salinity. Several authors describe the growth of *Pecten maximus* L. or related species to be enhanced by increasing temperature (Broom and Mason 1978, Gruffydd 1981, MacDonald and Thompson 1985, Mason 1969). In July-September when growth was low in SVTJ, the salinity showed large variation. The salinity variation was a result of heavy rainfall and problems with operation of the deep-water pumping. The continuously recording of salinity in 1990 resulted in very stable salinity.

The low mean growth rate in all depths in SEA in April-May 1989, were observed in a period when the pearl-nets were attached to floating aluminum frames, and affected by wave motion. The better growth in May-July and July-September was observed after changing the set-up in order to remove the physical stress.

In 1990, higher mean temperature, more stable salinity and higher POM values relative to the other locations, did not enhance the growth rate in SVTJ. However, the low growth rate and high mortality in June coincided with a high mean POM value. The increase in mean growth rate from April to July coincided with an increase in mean temperature, and also in mean POM-values at FF (all depths). The fall in mean POM-values in SEA in July, is observed without a similar fall in growth rate.

The present work shows that small productive basins may be suitable locations for juvenile scallops, given certain manipulations with salinity, oxygen and circulation. The higher temperature seems to be most important to small sizes. Salinity variations should be kept to a minimum, but values as low as 27-28 ppt over a period of several weeks did not seem to cause problems to the juveniles in this experiment. The large primary production and high standing crop of phytoplankton may cause stress to the juveniles. By a more controlled supply of inorganic fertilizers, it should be possible to avoid the extreme peaks of POM values.

There are still a lack of knowledge about the optimum and lethal values of environmental parameters for scallop juveniles. Such knowledge would indeed increase the possibility of successful extensive and intensive production of scallop.

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TABLES

Table 1 Mean growth rate (mm shell height/30d) in three time intervals from May to September, and total increase (TOT) in mean individual shell height (mm).

LOC	DEPTH	Apr-May	May-Jul	Jul-Sep	TOT
SVTJ	2m	3.2	3.1	0.7	**18.4**
FF	2m	1.6	2.4	1.9	**20.9**
	5m	1.8	2.7	1.6	**20.2**
	10m	2.2	2.0	1.5	**18.0**
SEA	2m	0.7	2.2	2.2	**19.4**
	5m	0.4	2.9	0.6	**14.0**
	10m	0.9	2.3	*	*

* : groups were lost after July

S.D.: was 0.3 in Apr-May, 0.2 in May-Jul and in Jul-Sep, except for FF 10m in May-Jul and Jul-Sep, and SVTJ in Jul-Sep which were 0.1

Table 2 Sum of mortality (no. of individuals) at the end of experiment.

LOC	DEPTH	MORTALITY
SVTJ	2m	0
FF	2m	0
	5m	2
	10m	0
SEA	2m	2
	5m	10
	10m	5*

* : lost after July

Table 3 Mean temperature (°C), its minimum (MIN) and maximum (MAX) values in three growth intervals.

GROWTH INTERVAL	LOC	m	TEMPERATURE	MIN-MAX
Apr-May	SVTJ	2	9.6	8.5-11.3
	FF	2	7.0	6.0- 7.9
		5	6.8	5.9- 7.8
		10	6.6	5.8- 7.8
	SEA	2	6.9	6.0- 7.7
		5	6.8	5.9- 7.7
		10	6.7	5.9- 7.7
May-Jul	SVTJ	2	15.6	12.0-18.7
	FF	2	14.7	11.6-17.0
		5	14.3	10.7-17.5
		10	13.1	9.2-16.5
	SEA	2	14.4	11.3-17.1
		5	13.5	10.6-16.4
		10	12.1	9.4-15.9
Jul-Sep	SVTJ	2	13.3	11.4-15.2
	FF	2	13.6	13.0-14.1
		5	12.9	11.1-13.6
		10	11.8	9.0-13.5
	SEA	2	13.6	13.4-13.8
		5	12.9	11.0-13.6
		10	12.0	9.0-13.5

Table 4 Mean salinity, SAL (ppt), in three growth intervals in 1989, their minimum (MIN) and maximum (MAX) values, and number of measurements (n).

GROWTH INTERVAL	LOC	m	SAL	MIN-MAX	n
April-May	SVTJ	2	29.40	28.25-30.26	11
	FF	2	30.38	29.14-30.88	7
May-July	SVTJ	2	28.85	26.60-31.60	18
	FF	2	29.02	25.23-30.64	9
July-Sept	SVTJ	2	28.80	24.92-33.39	19
	FF	2	29.17	27.00-31-90	10

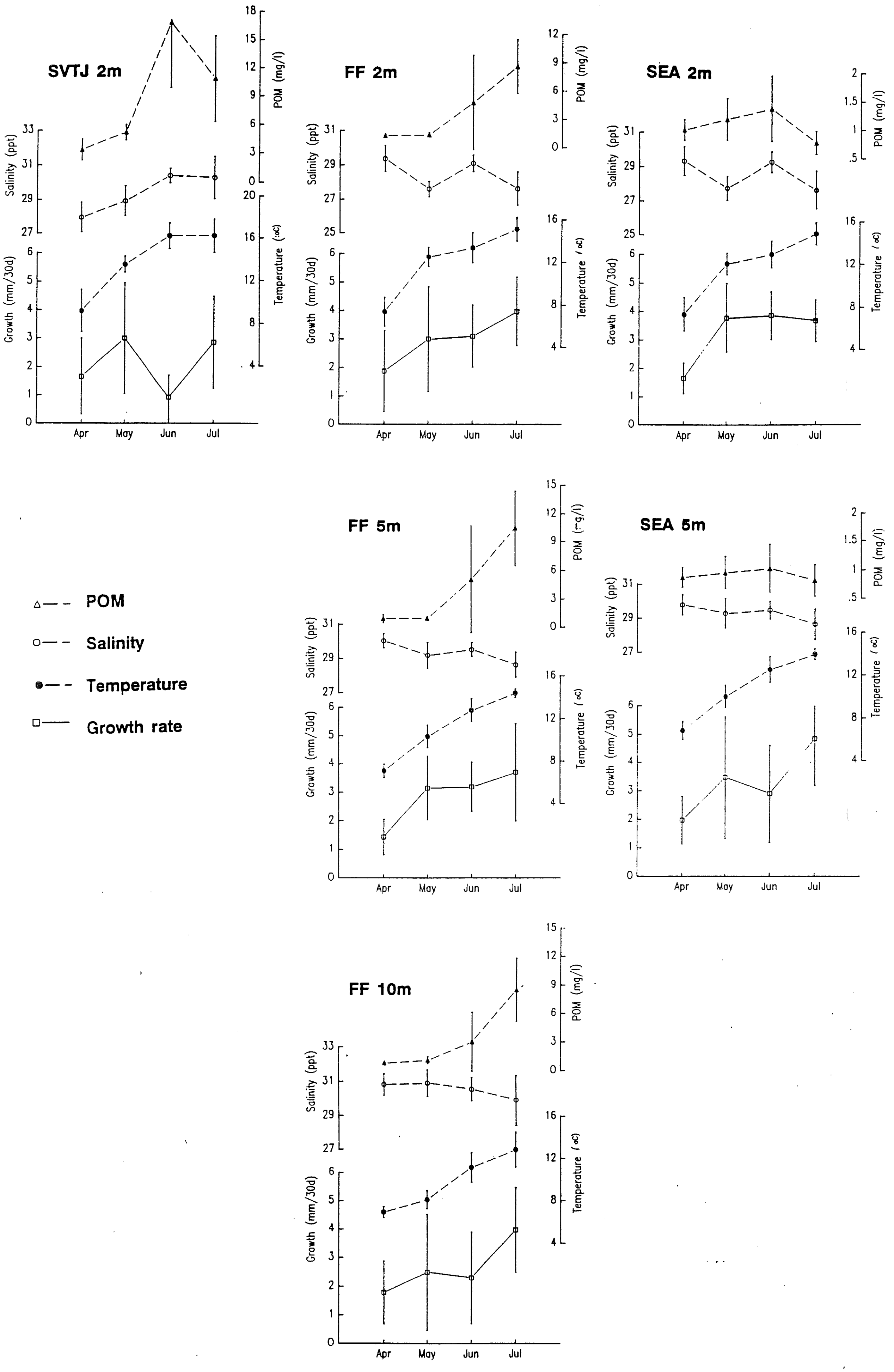
Table 5 Mean phytoplankton biomass, BM (mm^3/l), its minimum (MIN) and maximum (MAX) value.

GROWTH INTERVAL	LOC	DEPTH	BM	MIN-MAX
Apr-May	SVTJ	1m	2.8	0.5- 6.1
	FF	2m	0.3	0.2- 0.6
	SEA	2m	0.4	0.2- 0.5
May-Jul	SVTJ	1m	13.5	5.3-30.9
	FF	2m	0.8	0.3- 1.1
	SEA	2m	0.8	0.3- 1.3
Jul-Sep	SVTJ	1m	9.2	0.5-15.3
	FF	2m	1.2	0.4- 2.1
	SEA	2m	0.9	0.4- 2.3

FIGURES

Figure 1 Mean growth rate (mm/30d), mean temperature (°C), mean salinity (ppt) and mean POM values (mg/l) for each of the six locations and depths in 1990. Bars are S.D.

Figure 1


SVTJ 2m
FF 2m
SEA 2m
FF 5m
SEA 5m
FF 10m
POM (mg/l)
Salinity (ppt)
Temperature (°C)
Growth (mm/30d)
Apr
May
Jun
Jul
POM
Salinity
Temperature
Growth rate