ABSTRACTS OF PAPERS Presented at the 16th International Pectinid Workshop Halifax, Nova Scotia, Canada May 11–18, 2007

G. Jay Parsons

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Conference Chair:

G. Jay Parsons

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EFFECT OF INITIAL STOCKING DENSITY ON *PECTEN MAXIMUS* L. LARVAL AND POST-LARVAL PERFORMANCE. **Sissel Andersen.** Institute of Marine Research—Austevoll, N-5392 Storebø; **Gyda Christophersen** and **Thorolf Magnesen**. Department of Biology, University of Bergen, Bergen, Norway.

Institute of Marine Research (IMR) is working to support the development of a sustainable aquaculture in Norway. Great scallop (*Pecten maximus* L.) is one of the marine species being focused on in developing the aquaculture industry. IMR has worked together with the University of Bergen and the bivalve hatchery Scalpro AS for several years to improve the results for production of great scallop spat. As part of a project to investigate several factors on larval and post-larval performance in production scale units, larvae were stocked initially at different densities.

Larval groups were transferred three days after spawning (d3) from Scalpro AS to large-scale facilities at IMR–Austevoll. The larvae were kept in 2800 litre up-welling cylindrical tanks with conical bottom. Standard rearing method was used: a flow rate of one tank volume per day, temperature 15–17°C and a diet consisting of *Isochrysis galbana* (Tahitian), *Pavlova lutheri* and *Chaetoceros mulleri* in the ratio 1:1:1. The initial larval stocking densities varied between 1 and 32 larvae mL^{-1}. Competent larvae were returned to Scalpro AS to settle in a commercial post-larval rearing system. Rearing conditions for post-larvae were the same as used for commercial production and were similar for all groups.

The initial larval concentration affected larval life span, larval survival and the ratio of competent larvae, the lowest larval concentrations giving the best results. Larval life span, i.e., duration from spawning until transfer to post-larval rearing systems, increased from 22 to 29 days with increasing stocking densities. Generally, final ratio of competent larvae decreased exponentially with increasing stocking density, ranging from 40% to 1% of the initial stocking density on d3. Survival until transfer day (d22–d29) decreased from 90% to 16% for stocking densities of 1 to 32 larvae mL^{-1}, respectively.

The ratio of attached post-larvae 37 days after transfer was 16–20% of competent larvae for the density groups 2–16 larvae mL^{-1}, and only 2 and 4% for the lowest and highest initial stocking density. Total yield of post-larvae (millions) was highest for initial stocking densities of 4–16 larvae mL^{-1} (Figure 1). However, the relative yield based on the initial stocking density was highest for 2 and 4 larvae mL^{-1} (7% of d3 larvae).

Rearing system design may affect the optimum values of a number of rearing factors. Optimum initial stocking density for larval and post-larval performance can change from flow-through systems without addition of antibiotics to batch systems with added antibiotics, and from large-scale to small scale rearing units. In addition to maximizing the production results, stabilizing them is just as important. The question of stability can only be answered by repeated investigations in the future.

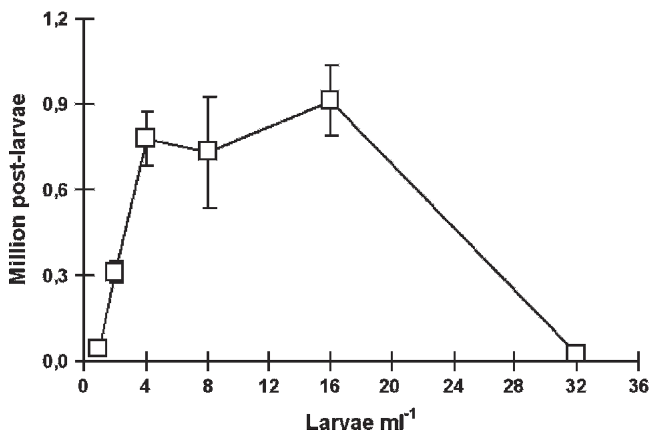

Figure 1. Final yield of post-larvae 37 days after transfer to post-larval tanks for groups initially stocked at different larval densities. Values are means (n = 5) and error bars are SE.

SCALLOP FISHERY ENHANCEMENT BY AREA ROTATION—A MANAGEMENT PERSPECTIVE. **Andrew J. Applegate**. New England Fishery Management Council, 50 Water St., Mill 2, Newburyport, MA, 01950, USA.

Although growth overfishing in the U.S. sea scallop (*Placopecten magellanicus*) fishery has occurred for decades, rotating fishing areas to improve yield has occurred only since 1999. There are presently four types of management areas: closed rotation areas, re-opened rotation areas, access areas, and open areas. Re-opened and access areas are managed by individual quotas in the form of trip allocations, which may be exchanged but not traded, and possession limits. Gear regulations control selectivity and fishing power, but there are no crew limits to control shucking capacity.

The groundfish areas were closed year around in December 1994 to enhance groundfish rebuilding, not to protect new scallop recruitment. Nonetheless, scallops from the strong 1990 year class grew to large size by 1999, when portions of the closed areas were re-opened to scallop fishing. Despite the high biomass of older scallops and infrequent fishing events, the Council set low annual F targets (F = 0.2) to minimize finfish bycatch and habitat effects. Habitat concerns also keep a significant amount of scallops off limits. Georges Bank recruitment has been poor and no new rotation closures have been implemented. Catch rates have been high, but large scallops in the Nantucket Lightship Area and Closed Area I are becoming less abundant, due to fishing and low recruitment. Meat quality of the largest scallops, particularly those from the 1990 year class, has worsened, making them less marketable.

The Hudson Canyon Rotation Area (HCA), east of NJ, closed in 1998 to protect abundant small scallops from fishing and re-opened in 2001. Daily catch of large scallops was over 900 kg/day until 2004 when the catch rate and average size began to decline. The 2005 TAC was set during by a biannual projection which

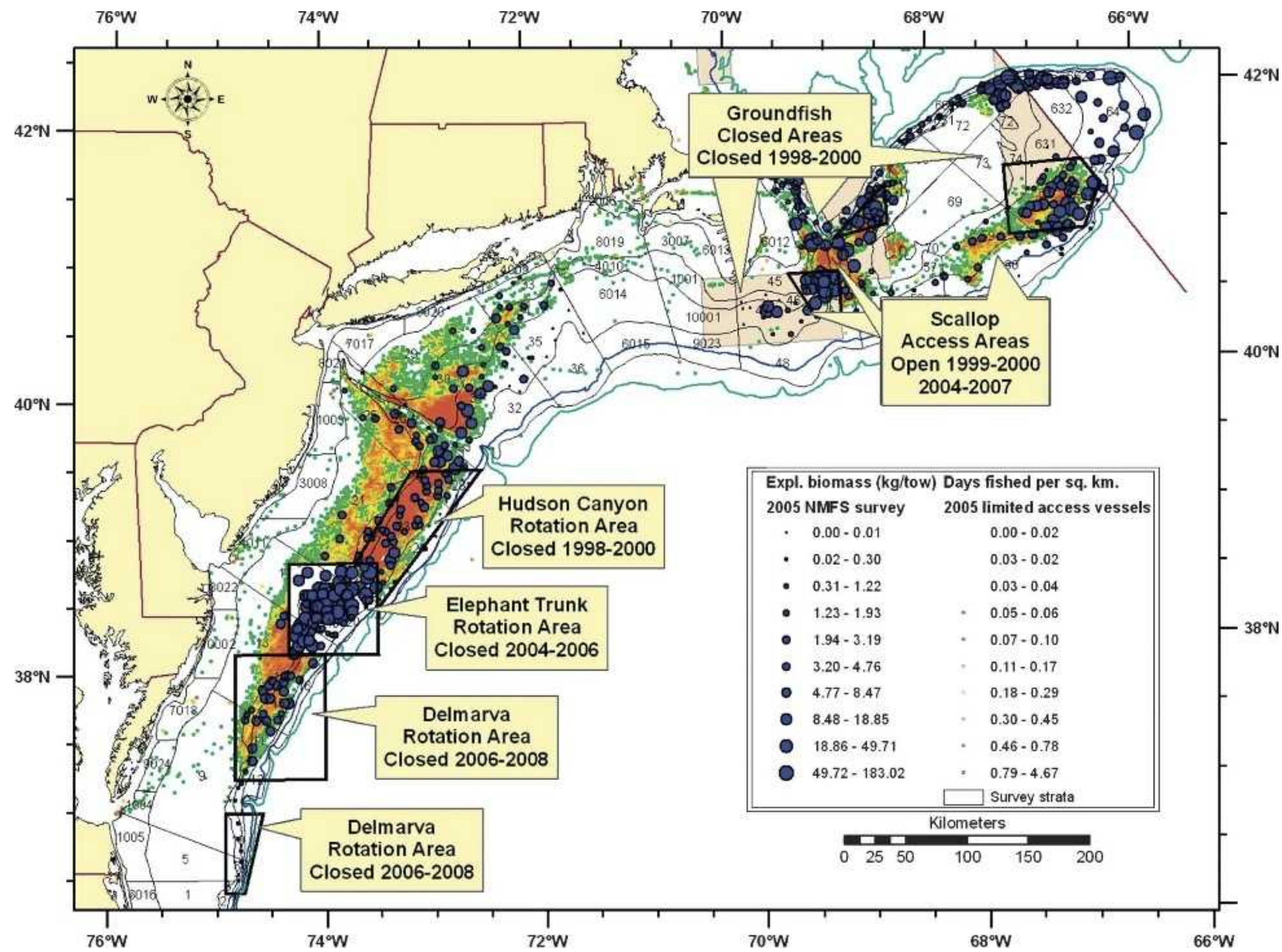

Figure 1. Rotation areas showing distribution of 2005 limited access fishing effort and exploitable biomass.

appeared to overestimate biomass. As a result of the overestimate and the high F = 0.48 rotation target, too many trips were allocated, catch rates declined, and many vessels found it difficult to catch their 8,165 kg possession limit. In response, the Council allowed vessels with uncompleted trips to postpone taking them until 2006 and 2007. This action discouraged fishing in 2005 and about one-third of the trip allocations were carried over to 2006.

The Elephant Trunk Area (ETA), east of MD and adjacent to the HCA, closed in 2004 after small scallops were observed during the 2003 survey. Using 2004 survey data, the Council estimated that the 2006 TAC should be 12,335 mt at an F = 0.16 target, which was sufficient to allocate five 8,165 kg trips per full-time vessel. Due to timing, the Council was unable to use the 2005 survey to estimate the 2007 TAC. To allow a correction, the Council established a pre-opening adjustment process that used more current NMFS and industry-based survey data collected during 2006. The updated TAC was 11,204 mt with a projected F = 0.22, but due to concerns about overfishing the resource as a whole, the Council reduced the TAC to 6,985 mt (target F = 0.13), with a three trip allocation. Total 2007 landings are still expected to be a record 27,669 mt.

Abundant recruitment was again observed in 2005, south of the ETA. Closure of the new Delmarva area was postponed until the ETA re-opened in 2007, even though some scallops would be caught by trawl gear in 2006. An earlier action would close nearly the entire Mid-Atlantic resource, particularly for vessels that carried over no 2005 HCA trips. Preliminary projections estimate a TAC of 3,054 mt with a rotation mortality target (F = 0.32) in 2010.

Since adopting area rotation as a formal policy to protect abundant concentrations of three to five year old scallops, the management plan has effectively protected abundant small scallops with two new area closures. These areas are expected to keep landings historically high, but catch in non-rotation open areas has started declining. While the ad-hoc policy is adaptable, the plan requires frequent monitoring and significant lead time to define new rotation areas and establish TACs. Closing some areas for three years or longer may be risky, particularly when growth is below average or growth asymptotes at a smaller size.

THE REPRODUCTIVE CYCLE OF THE SCALLOP *PECTEN SULCICOSTATUS* FROM FALSE BAY, SOUTH AFRICA. **Dale C. Z. Arendse**. Marine & Coastal Management, Environmental Affairs and Tourism, P.O. Box X2, Rogge Bay, Cape Town, South Africa, 8001; **Sissel Andersen**. Institute of Marine Research, Austevoll Aquaculture Research Station, Norway; **Norman J. Blake**. College of Marine Science, University of South Florida, St. Petersburg, Florida, USA; and **Grant C. Pitcher**. Marine & Coastal Management, Cape Town, South Africa.

This study reports on the reproductive cycle of *Pecten sulcicostatus* as part of an investigation into the potential commercial culture of this species in South Africa. The study formed part of the Norwegian–South African agreement funded by NORAD.

Scallops were collected from False Bay on a monthly basis, from August 2004 to October 2005, to determine seasonal variation in the gonadal-somatic index (GSI) and to assess associated histological changes within the gonads. Two size classes were collected, 39 mm-70 mm and 71 mm-110 mm shell height. The GSI displayed a clear seasonal cycle (Figure 1), the smaller size class reaching a minimum in December 2004 and the larger size class a minimum in January 2005. Thereafter, both size ranges increased before peaking in August 2005. The maximum GSI values at this time for the small and large size classes were 14.2% and 14.4%, respectively. There was a significant difference in the median value of the oocyte diameters between months ($p = <0.001$). The median oocyte diameters increased from 35 µm in November 2004 to 57 µm in August 2005 and decreased thereafter. Oocytes larger than 60 µm were present in all months except in September 2005.

From June to August most of the follicles we investigated were filled with mature oocytes and only a few immature oocytes were present. During this period the follicle membrane was very thin and in most of the follicles the nucleus of the oocytes was not visible. In September 2005 a few mature oocytes were present in our samples. From September to December the gonads were either spawned and/or the process of lysis was taking place. New and developing oocytes were present throughout these months. There was no indication of a resting period in our samples. From January to May 2005 the oocytes were developing from the early to the mid maturation and ripe stage.

Together the GSI index and histological studies indicated that the spawning season extended through winter and early spring (June-September) and peaked in August/September. This cycle follows the annual cycle of upwelling and food availability with a lag of 2–3 months.

SMALL SCALE SCALLOP FARMING ON NOVA SCOTIA'S SOUTH SHORE. **Duncan Bates**. Bay Tender Shellfish Limited, P.O. Box 35, Chester Basin, Nova Scotia, Canada B0J 1K0.

The development of scallop aquaculture in eastern Canada has been a long, arduous process that has still not resulted in significant commercial success. However, the idea is still alive as a handful of resilient operators carry the growth process forward; applying what has been learned from the various pitfalls, attempts, successes and failures of the past twenty or so years.

Here, the presenter will discuss the present state of the industry with specific reference to his own farm in Mahone Bay, Nova Scotia. Some topics up for discussion include: gear selection/handling/timing, spat collection/supply, invasive pest species, marketing and more.

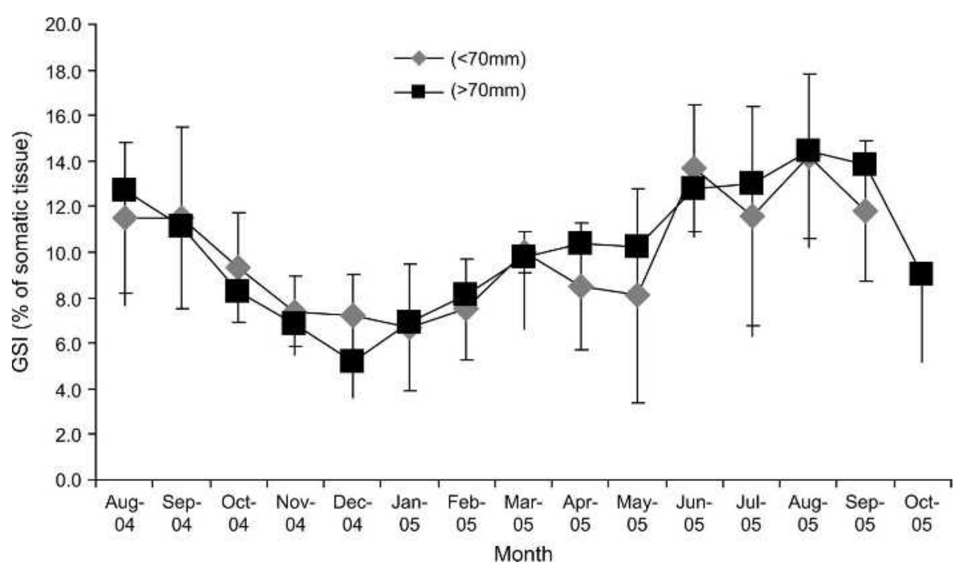

Figure 1. Monthly observations in mean values of the GSI for two size ranges of scallops. Vertical bars represent standard deviation.

EFFECT OF HARVEST SEASON ON THE EATING QUALITY OF RESTRUCTURED ADDUCTOR MUSCLES OF PACIFIC LIONS-PAW SCALLOP (*NODIPECTEN SUBNODOSUS*). **Ana I. Beltrán-Lugo** and **César A. Ruiz Verdugo**. Universidad Autónoma de Baja California Sur (UABCS), Carretera al Sur Km. 5.5, La Paz, B.C.S. 23080, Mexico; **Alfonso N. Maeda-Martínez.** Centro de Investigaciones Biológicas del Noroeste (CIBNOR), La Paz, Baja California Sur, México.

The Pacific lions-paw scallop *Nodipecten subnodosus* is one of the most economically important bivalves in Mexico. The portion of the tissues with economic value is the adductor muscle. In the scallop markets, the muscles are classified into categories, depending on the number of pieces per unit weight. The prices vary depending upon the category, being higher in those with lower counts per unit weight. The restructuring process at low temperatures (Cold-binding technology) is an alternative for obtaining uniform and commercial-size scallop meats from small or broken pieces of adductor muscles. The process consists of binding small muscles into larger pieces with characteristics similar to the raw material (Fisher 1999). Cold-binding technology seems to be a promising alternative to obtain value-added products from this species and to promote their culture. However, it is important to consider that this scallop is a very seasonal item with a great deal of variation on muscle size and quality (Beltrán-Lugo *et al.* 2006). The objective of the present study was to produce restructured scallop meats from frozen-thawed *N. subnodosus* adductor muscles and to analyze the effect of harvest season on the eating quality of restructured products.

Samples of scallops (average size 66.3 ± 6.9 mm) were harvested in winter (January), spring (April), summer (September) and fall (November) 2003 from an aquaculture farm on the Pacific coast of the Baja California Peninsula, México. Scallop meats obtained were washed, packed in plastic bags, and iced for transport to the laboratory. At the laboratory, they were frozen at –80°C until further preparation of restructured products and analysis of quality. Restructured batches of 250 g were prepared in triplicate for each season and each commercial cold-set binding system used (Activa™ or Fibrimex™). To assess the quality of the frozen-thawed adductor muscles (control) and restructured products; proximate composition (moisture, protein, lipids, ash, and carbohydrates), pH, color parameters (L^*, a^* and b^*), water-holding capacity (WHC), and texture (Warner-Bratzler shear test) were analyzed.

Results of this experiment showed that the quality of the restructured scallops were affected by season and restructuring system. Adductor muscles harvested in summer had the highest content of carbohydrate and the lowest moisture level, while that harvested in winter and autumn showed the lowest and highest content of carbohydrate and moisture respectively. An inverse pattern than that observed for carbohydrates, was shown for pH and WHC, with the lowest values recorded in summer, which may produce important losses of water during handling and processing. On the other hand the lower pH and WHC could be responsible for the softer texture perceived on summer samples than that in the other seasons. The color of adductor muscle was not affected by season. However, restructured system induced slight but significant changes in redness (a*) and yellowness (b*). A better quality of restructured products from lions-paw is obtained by using raw material collected in the winter and autumn seasons, also a better overall quality is obtained in products restructured by using Activa as cold-set binding system in comparison with those produced by Fibrimex.

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EFFECT OF DIET ON LARVAL GROWTH AND SETTLEMENT OF *CHLAMYS VARIA*. **Mohamed El Amine Bendimerad**. Université Es-Senia, Oran, Algérie; and **Guillermo Román**. Instituto Español de Oceanografía, Centro Oceanográfico de A Coruña, Muelle de Ánimas s/n, PO Box 130, A Coruña, 15080, Spain.

After settlement and before feeding starts, postmetamorphic growth and survival will rely on reserves stored from the ingested food during larval development. As the biochemical composition and the nutritional value varies in the microalgae employed for feeding the larvae, it was hypothesized that the food provided could affect not only the larval growth but the settlement rate and the post larval growth as a consequence of differences in amount and quality of stored reserves.

Larvae of *C. varia* were maintained in 12 tanks of 50 L, at a density of 1 larvae mL^{-1}. Three of the 12 tanks were fed with one of the following 4 diets, D1: *Pavlova lutheri* (100%); D2: *P. lutheri* (50%) + *Isochrysis galbana* (T-iso) (50%); D3: *P. lutheri* (25%), *I. galbana* (T-iso) (25%) and *Chaetoceros gracilis* (50%); and D4: *P. lutheri* plus *I. galbana* (T-iso) (75%) and *C. gracilis* (25%). Water was changed and food added every second day at a rate of 10 cells μL^{-1} of the described diets until larvae reached 150 μm, when food ration was increased to 30 cells μL^{-1}. The sizes of larvae were measured at each water change. Simultaneously it was recorded the number of dead larvae. When larvae reached competence, they were placed in tanks with collectors (nylon threads bearing 10 PVC tubes 3 cm length and 1.5 cm diameter). Forty-five days after spawning, all the spat settled inside the plastic tubes in one string of collectors of each tank were detached, counted and measured. One-way ANOVAs were employed for comparing the larval and spat size and the number of settled spat according to the diet.

There were recorded significant differences in larval growth according to the diet from sixth day after spawning ($D1 = D2 < D3 = D4$). The days eight and ten, $D1 < D2 < D3 = D4$, and from the day thirteen until the day 24th, D1 < D2 < D3 < D4, except the last day, when D1 = D2 (Figure 1). Competence was reached at different dates according the diet supplied. Larvae fed with diets D3 and D4 were competent 24 days after spawning, while larvae fed with diets D2 and D1 reached competence 27 and 31 days after spawning respectively. At day 13th the mortality was significantly higher in D1 (23.45%) than in the other diets (9.7%) (Figure 2). When larvae reached competence, days 24 to 31 according to the diet, there were significant differences in mortality for all diets (D1 = 86.7% > D2 = 76.0% > D3 = 53.3% > D4 = 16.0%). The number of spat settled inside the collectors showed significant differences according to the diet (D1 = 12.3 < D2 = 15.8 < D3 = 19.4 < D4 = 23.7), as did the size, in this case D1 = 391.7 μm < D2 = 483.7 μm < D4 = 499.7 μm < D3 = 519.4 μm.

Pavlova lutheri employed as a single food can cover the nutritional requirements of the larvae of *C. varia*, as they reach competence and metamorphosis. However, better results are obtained with any other combination. The employment of a mixture of a diatom and flagellates gives the better growth, survival and settlement rates. The results confirm the Robert & Gerard (1999) statement that pluriespecific diets, composed of one diatom and one or more flagellates assure a better balance in essential nutrients. A higher percentage of diatoms in the diet (D3) results in significantly higher mortality and lower larval growth and settlement rate when compared with D4, in accordance with the results of Rico-Villa *et al.* (2006), which pointed out that diatoms can exhibit teratogenic effects in certain conditions. However, postlarvae fed D3 showed the higher growth rate, suggesting changes in food preference or nutritional requirements associated to ontogeny.

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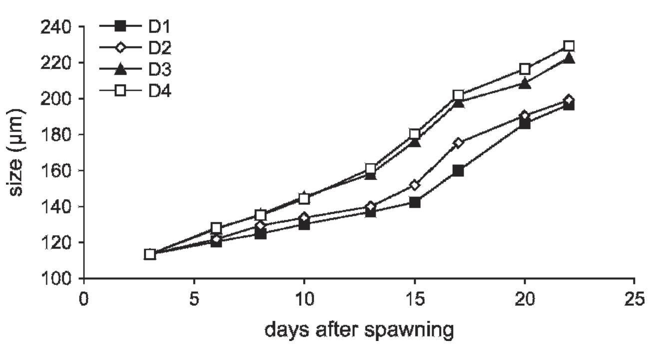


Figure 1. Growth curve of larvae of *Chlamys varia* fed different diets.

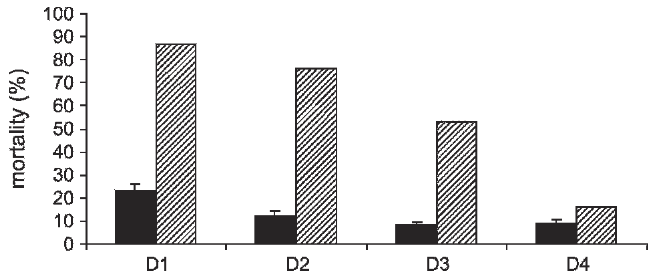


Figure 2. Percent mortality of larvae of *Chlamys varia* fed different diets 13 days after spawning (black) and at competence (hatched).

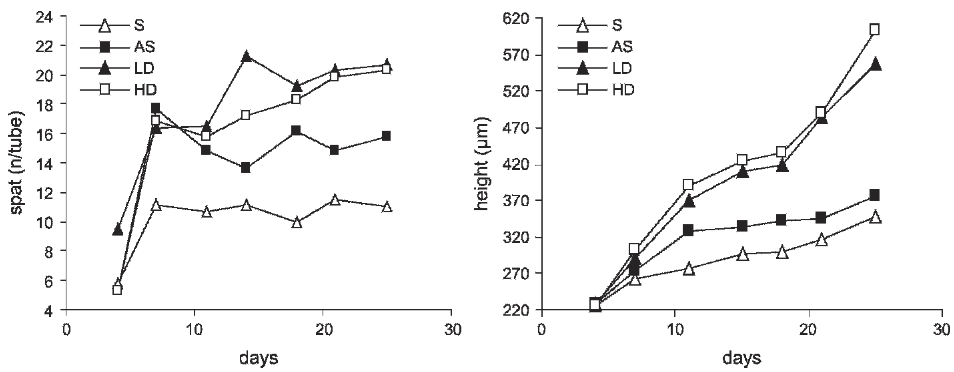
FACTORS AFFECTING SETTLEMENT AND POSTLARVAL GROWTH OF THE BLACK SCALLOP, *CHLAMYS VARIA*.

Mohamed El Amine Bendimerad. Université Es-Senia, Oran, Alger; and **Guillermo Román**. Instituto Español de Oceanografía, Centro Oceanográfico de A Coruña, Muelle de Ánimas s/n, P.O. Box 130, A Coruña, 15080, Spain.

Metamorphosis is a demanding energy process. After losing the velum, the larvae can not feed until gills are developed. Postmetamorphic growth and survival will rely on endogenous reserves stored during larval development. It is not clear when the gills are functional and suspension feeding starts. Furthermore, some bivalves pass through a transitional pedal feeding, filling the nutritional gap until suspension feeding starts. In the case of *Chlamys varia* it is not known at what size suspension feeding starts, or how the shell growth depends on endogenous reserves and the existence and extent of pedal feeding.

Larvae of *C. varia* were grown until competence, when they were sieved on 140 μm and placed in 8 × 50 L tanks. Seven lines of collectors were added to each tank (nylon threads each of them bearing 3 PVC tubes 3 cm length and 1.5 cm diameter). Four days later the larvae were sieved and the swimming larvae were discarded. Two of the 8 tanks were employed for one of four different treatments : (S) starved, (AS), starved but the collectors were aged in unfiltered seawater for 7 days to allow growth of bacteria and microalgae, (LD) feed at low diet (2.5 cells μL of a mixture of *Isochrysis galbana* (Tahitian), *Pavlova lutheri*, *Thalassiosira pseudonana* and *Chaetoceros gracilis* plus 2.5 cells μL of *Rhodomonas salina*), and (HD), feed at high diet, total 50 cells μL in the same proportion as the DB. Sampling was performed the days 4, 7, 11, 15, 18, 21 and 25. At sampling dates a line with 3 collectors was removed from each tank and all the spat detached, counted and measured. The experiments started December 23, 2005 and finished 25 days later.

Number of settled larvae: A multifactor ANOVA was employed for comparison of the number of settled larvae, factors being treatment (S, AS, LD, HD) and sampling date (days 4, 7, 11, 15, 18, 21 and 25). There are significant differences in number of settled spat according sampling date and treatment. Post-hoc comparisons employing SNK test showed that the number of settled larvae



Figures 1 and 2. Number of spat per collector tube (left) and spat growth (right) according the different treatments.

were significantly lower the first sampling day (day 4; D4) and there were not significant differences the rest of the experiment. D4 < D7 = D11 = D14 = D18 = D21 = D25. Regarding the treatment, significantly lower number of spat were recorded in starved tanks (S) than in the ones with aged collectors (AS), which in turn showed a significantly lower number than in fed tanks, disregard the diet level S < AS < LD = HD.

Growth of the postlarvae: Larval growth was recorded in all the treatments. Growth values at each sampling day were analysed employing an one-way ANOVA. There were not significant differences in size between treatments the days 4 and 7. From days 11 to 21, there were significant differences in size according treatment S < AS < LD = HD; for day 25, S < AS < LD < HD.

The significant differences in number of settled spat between day four and subsequent days could be a result of high motility of recently settled spat looking for adequate places. In fact, the fourth day all the swimming larvae were removed from the experimental tanks, remaining only the settled spat, which apparently moved from tank walls to the collectors.

According to Rupp et al, (2004), a higher settlement was expected in aged collectors (AS). In fact a significantly higher number was recorded than in (S), but lower than in tanks were food was added (LD, HD). Perhaps the added food forms a biofilm on the collectors promoting higher settlement than the produced by ageing the collectors.

Regarding the growth of the postlarvae, differences were recorded from the 11th day. The starved larvae grow employing the endogenous reserves, which are sufficient to maintain them alive and growing at least until day 25; the larvae placed in tanks with aged collectors grow faster, showing a significantly higher size from day 11 to the end of the experiment, suggesting a slight pedal feeding. However, from the day 11 the fed larvae grow significantly faster, suggesting that the capability for suspension feeding is developed when postlarvae reach 289.9 µm, which is the mean size of postlarvae on the day 7. The fed postlarvae have the same growth independently of the amount of food provided, until day 21. Only from this date the postlarvae fed at HD show a higher size.

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THE SCALLOP AQUACULTURE EXPERIENCE IN WEST ARICHAT, NOVA SCOTIA, CANADA. **Ronald Boudreau** and **Rodney Fougère**. Sea Perfect Cultivated Products Ltd., RR#1 Site 2, Comp 3, West Arichat, Nova Scotia, Canada.

Scallop aquaculture in the Arichat Nova Scotia, Canada has come a long way since the first spat collection in 1993; however, culture husbandry is still evolving. Every fall, Sea Perfect Cultivated Products Ltd deployed 2000 spat bags in Chedabucto Bay; however, last fall they deployed 10,000 collectors to answer the increased demand for giant scallop spat. Last year, St. Pierre & Miquelon purchased most of the available spat and said that next year they will need up to 15 million spat. Also, a company from Portland, Maine is planning to purchase 1 million this year. An aboriginal group from Vancouver who presently has an oyster lease said the water parameters on their lease is suitable for the giant scallop and would like to purchase 1 million spat. Right now, it may seem that Sea Perfect Cultivated Products Ltd has specialized in selling giant scallop spat; however, they also are actively trying to get setup to compete in other markets. They have been approached by a shellfish broker for whole scallops (>76 mm) and scallops on the half shelf. To do so, they must have a protocol with the Canadian Food Inspection Agency (CFIA) and have a fish processor license. The protocol is being written and many changes are required to their floating plant before it can be certified for processing. When the work will be completed they will be the only floating plant in eastern Canada.

ICELAND SCALLOP FISHERY IN MINGANIE (QUEBEC): EXAMPLE OF FISHERY MANAGEMENT BY A CONTROL OF EFFORT. **Hugo Bourdages** and **Patrice Goudreau**, Pêches et Océans Canada, Institut Maurice-Lamontagne, 850 route de la Mer, Mont-Joli, Québec, Canada G5H 3Z4; **Isabelle Morency** and **Clément Beaudoin.** Fisheries and Oceans Canada, Sept-Îles, Québec, Canada.

The Iceland scallop (*Chlamys islandica*) fishery in Quebec takes place mainly in Minganie. In this area, nine fishermen exploit the resource in three fishing areas and land annually more than 90 tons of meat, representing more than 75% of the Quebec landings. Since 1996, the fishery was managed by a control of the catch and the licence holders had individual quotas. The surveillance activities of the fishing and landing operations were then very tedious and expensive.

A new management system was put at test in 2006. In this pilot project, the fishery was managed by the control of effort, which is to say by a limited number of fishing days for the season and of fishing hours per day. Moreover, given that fishermen have access to more than one fishing area, the fishing operations at sea were monitored with a vessel monitoring system. Since some of the scallop beds are already exploited at their full potential, it was important that the change in the management system does not result in an increase in landings and does not restrain the harvesters unnecessarily.

The 2006 pilot project was a success. The objective of not increasing the intensity of the exploitation was reached and the landings stayed similar to those of 2005. The fishery managers as well as the harvesters have benefited from the new system that proved to be less compelling and expensive. Given the positive results of the pilot project, the management of the scallop fishery in Minganie will continue with a control of the fishing effort.

CULTI-MER, A BRAND NEW EXPERIENCED SCALLOP PRODUCTION COMPANY! **Mélanie Bourgeois** and **Sylvain Vigneau**. Culti-mer, 55 Route 199, Fatima, Iles-de-la-Madeleine, Quebec, Canada G4T 2H6.

Culti-mer, a new scallop (*Placopecten magellanicus*) production company created in 2006, employs 25 experienced staff and operates in Îles-de-la-Madeleine, Quebec, Canada. We produce scallops originating from natural spat collection for sale at different shell sizes for other scallop producers in Quebec and Saint-Pierre et Miquelon, fisherman and researchers. We also aim to produce 120 t of scallop by suspended culture. Culti-mer is also a shellfish production consultancy company with interests in scientific research collaboration. We will discuss the research and development needs still required to reach our objectives.

SCALLOP CULTURE IN BRITISH COLUMBIA: THE 20-YEAR SAGA. **Neil Bourne**. Department of Fisheries and Oceans, Pacific Biological Station, 3190 Hammond Bay Rd, Nanaimo, BC, Canada V9T 6N7; and **Barb Bunting**. Island Scallops Ltd., 5552 West Island Hwy, Qualicum Beach, BC, Canada V9K 2C8.

Scallop culture has been under development in British Columbia, Canada for over two decades. Twelve species of scallop are native to BC, but the Japanese scallop, *Mizuhopecten* (=*Patinopecten*) *yessoensis*, was selected for culture due to its rapid growth rate and large sized adductor muscle. Initial culture research was carried out in the 1980s at the Department of Fisheries and Oceans' Pacific Biological Station. Techniques for producing juveniles were developed, and in 1989 Island Scallops was established to commercialize scallop production in BC.

Early hatchery work at Island Scallops focused on producing large numbers of larvae and juveniles (seed), rearing juveniles in onshore nursery facilities and determining optimum size of seed to transfer to ocean farms. In the ocean, Japanese scallop seed proved to be susceptible to disease and high mortalities occurred in some locations. Breeding experiments followed, which led to selection of a disease-resistant strain and a successful cross with the native weathervane scallop (*Patinopecten caurinus*). This strain is now marketed as the "Pacific scallop". Additional challenges and developments are discussed.

Commercial operations are currently concentrated on the east coast of Vancouver Island in the Strait of Georgia. Bottom culture has been tested but at present all scallop culture in BC is suspended culture. Typically, pearl nets are used in the nursery phase and nets or earhanging employed in the grow-out stage. From hatchery to harvest requires 18–24 months.

Plans to increase hatchery production, expand farm areas and improve harvesting and processing technology are underway and are discussed in the paper. Key obstacles to further development of the scallop industry in BC are more socioeconomic and regulatory than biological and are also discussed.

A CENTURY OF ISLE OF MAN SCALLOP RESEARCH. IS THAT IT? **Andy R. Brand**. University of Liverpool, c/o Woodlea, Bradda East, Port Erin, Isle of Man, IM9 6QD, UK.

For more than 100 years University of Liverpool scientists based at the Port Erin Marine Laboratory (PEML) have studied scallops and scallop fisheries in the waters around the Isle of Man. The close proximity of a long-established, active research and teaching laboratory to abundant populations of both the great scallop, *Pecten maximus,* and the queen scallop, *Aequipecten opercularis*, together with generous core funding from the Isle of Man Government, has resulted in these fisheries becoming two of the best documented in the world.

The first significant study of Isle of Man scallops was the well-known L.M.B.C. Memoir by Dakin (1909). While mostly on morphology and anatomy, Dakin comments that the abundant populations of scallops were not fished commercially but there was potential for them to be used as bait in the long-line fishery for cod. The commercial fishery for *Pecten maximus* for human consumption started in 1937 and within one year became the most important fishery for Isle of Man boats—a position it has held ever since. After the war the fishery developed rapidly as new grounds were discovered and more efficient dredges capable of operating effectively on a wider range of bottom types were developed. By the mid-1960s catches on all grounds had declined and the stocks were overfished. The economic decline was halted in 1969 by the discovery of a market for the very abundant local stocks of queen scallops, *Aequipecten opercularis*. The initial major diversion of effort on to queens, and increasingly strict conservation regulations on scallops, allowed the great scallop stocks to recover, and for the last 40 years the two fisheries have co-existed, with unrestricted queen fishing taking place mainly during the summer closed season for great scallops.

From the start of the commercial fishery samples were taken to determine the age and size structure of the populations (Tang 1941). However, detailed scientific study of Manx scallop stocks was only firmly established in the early 1950s by James Mason. Two of the papers he published, one on age and growth and the other on the breeding cycle (Mason 1957; Mason 1958), subsequently became models on which most other studies of scallop populations worldwide were based.

Following my appointment to PEML in 1966 research on scallops expanded greatly and, together with some 30 postgraduate students and research assistants, I have published widely on scallop biology, physiology, ecology, genetics, aquaculture, population dynamics, stock assessments, fishery management, ecological impacts of dredging, closed areas and stock enhancement over the last 40 years. Much of this work is reviewed in Brand (2006).

Two factors have contributed greatly to the overall success of this programme: the establishment of a catch and effort database since 1981, based on fishermen's logbooks reported on an unusually small spatial scale (5 × 5 nautical miles) and the closure of a small area to mobile fishing gear since 1989. The early availability of these facilities, and the long time-series of data they generated were key factors that allowed well-funded research programmes to be developed on the ecological impacts of scallop dredging and subsequently on closed area management and stock enhancement.

With the closure of PEML in September 2006 the University of Liverpool has now withdrawn from the Isle of Man. But does this mean that a major scallop research programme, spanning more than a century, must come to an end? The answer, fortunately, is probably no, though the scale and nature of the research must change. The Isle of Man Government has recently awarded a 4-year contract to the University of Bangor to provide fisheries support and I have been asked to collaborate with them on the scallop fisheries—but the scope and nature of their future work remains to be seen.

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ZYGOCHLAMYS PATAGONICA SPAT: WE FOUND THEM!

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After exploratory cruises in the Argentine Sea during 1995 (Lasta and Bremec 1998), the Patagonian scallop fishery produced total annual scallop catches ranging from 37,000 to nearly 43,000 tons/year, between 1996 and 2005. Evaluation of the different management units is developed annually to assess biomass of the stocks and composition of the invertebrate by-catch. During 2006, the study of epibiosis on species of invertebrates was faced with particular emphasis in order to register the presence of recently settled spat (*sensu* Cragg 2006) of *Zygochlamys patagonica* and to recognize their primary settlement substrate (PSS) in the exploited areas along the highly productive shelf break front (Acha *et al.* 2004). We present results about spatial distribution of microscopic spat and preferential settlement substrates between 37° and 44°S along the 100 m isobath.

Benthic fauna was collected during the evaluation cruises carried out between March and June 2006 (CC 05/06 and CC 06/06 INIDEP) in two management Sectors; 84 stations were sampled in the Northern Sector between 37°00′S–39°30′S and 83–128 m depth and 43 stations were sampled in the Southern Sector between 39°34′S–43°53′S and 87–133 m depth. Specimens of different species were observed under binocular microscope, including living scallops (nearly 10 individuals per sample), snails (*Odontocymbiola magellanica, Adelomelon ancilla, Fusitriton magellanicum*), hydrozoa, polychaetes tubes, echinoderms in general and scallop shells. Spat were measured under binocular microscope.

Patagonian scallop spats were found in the study area, ranging between 480 and 3,658 μm. Early studies on shell ontogeny of the species were developed on specimens of 5 mm minimum size (Waloszek 1984). The size structure of management units is currently assessed from 5 mm shell height individuals observed on living scallops (i.e., Campodónico and Lasta 2006; Marecos and Lasta 2006). Our results add useful information related with the recruitment of the species in exploited areas, considering morphology and measures of the spats and environmental factors (Schejter *et al.* this workshop).

We found a total of 227 spats in 25 samples distributed along the latitudinal range of the Northern Sector (Figure 1). Larger numbers, 5–86 spats, were found in 6 samples located between 38°13′S and 38°37′S (91–95 m depth), while only one spat was

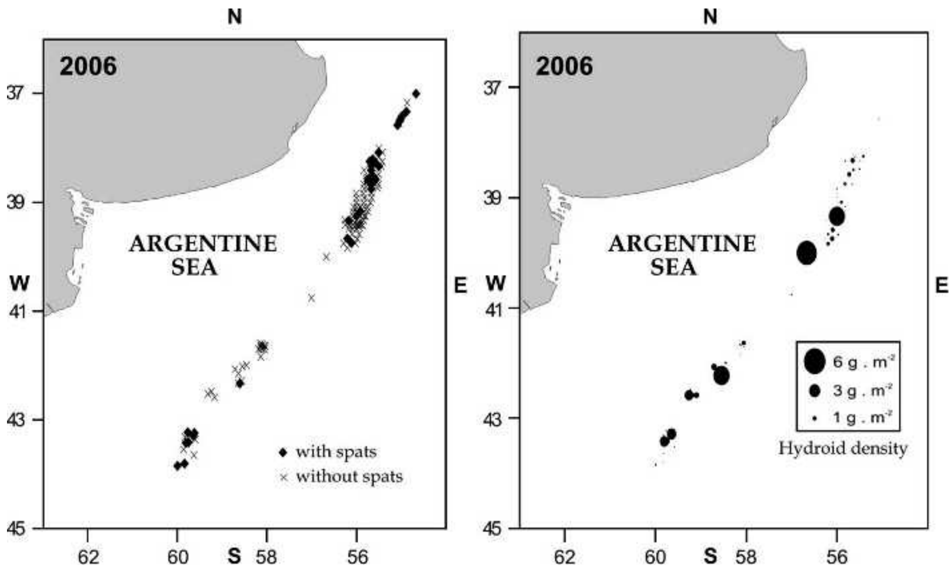

Figure 1. Spatial distribution of samples indicating presence-absence of Patagonian scallop spat and hydroids densities during 2006 in the shelf break frontal area.

found in the rest of the positive stations. 78.4% of the total number (average size 1,116.33 μm; range 480–2,304 μm) was recorded on hydrozoan colonies and correspond to the higher values referred, which mean densities between 0.04 and 1.14 spats m^2. 21.6% of spats (average size 1,136.11 μm; range 624–3,504 μm) were found on 46 living scallops (average shell height 61.6 mm) from a total of 827 observed. The maximum number of spat on scallops was 2. In the Southern Sector we found a total of 37 spat in 10 samples (Figure 1). Their presence was registered along its latitudinal range; the higher value (n = 19) at 42°19′S, 117 m depth, followed by 5–6 spat in other two sampling stations. Only 1–2 spat were found at the remaining 7 stations. 86.5% of the total number (average size 1,384.81 μm; range 816–3,654 μm) was recorded on hydrozoan colonies. 13.5% of spat (average size 1,065.6 μm; range 816–1,296 μm) were found on 5 living scallops (average shell height 62 mm) from a total of 550 observed. Only 1 spat per scallop was observed. Our data from both Sectors indicate that the presence of juveniles on adult scallops (Bremec *et al.* 2003) could be the result of both primary and secondary settlement from another substrate, hydroids in this case, which undoubtedly constituted the main PSS during 2006. The absence of juveniles on scallop non-living shells was previously mentioned from samples collected during 2001 (Bremec and Schejter 2005); we presently confirm the absence of spat on this and other potential substrates.

The hydroids that hosted Patagonian scallop spats were *Symplectoscyphus* sp. and *Grammaria magellanica*. These conform a hydroid assemblage characteristic of the scallop beds that includes 18 hydroid species, with polychaete tubes and hydroid colonies as the main biological substrata (Genzano *et al.* in prep.). Recently-settled pectinid spat have been collected from many natural substrates; filamentous fauna and flora are some of the preferred substrata for scallop settlement (see Cragg 2006 and references). Although these preliminary information shows that hydroids constitute the main primary settlement substrate of the target species, higher spat densities do not correspond with higher hydroid densities (Figure 1). The presence of substrate was related with the spatial variability of the recruitment, while variability between years is mainly the consequence of larval supply (see Pacheco and Stotz 2006). The availability of PSS in exploited areas will be consequently monitored annually.

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COMPARATIVE FUNCTIONAL MORPHOLOGY OF FEEDING ORGANS IN POSTLARVAL SCALLOPS: WHAT CAN WE LEARN ABOUT THEIR FEEDING CAPABILITIES OVER ONTOGENY? **V. Monica Bricelj, Anne Veniot** and **Melissa Anderson**. Institute for Marine Biosciences, National Research Council, 1411 Oxford Street, Halifax, Nova Scotia, Canada B3H 3Z1; and **Céline Barré**. Biology Department, Dalhousie University, Halifax, Nova Scotia, Canada.

Post-metamorphic development of feeding organs and associated mantle ciliary tracts is compared between postlarvae of bay scallops, *Argopecten irradians*, and sea scallops, *Placopecten magellanicus* from ~ 0.3 to >8 mm in shell height using scanning electron microscopy. Key anatomical transitions associated with potential changes in feeding function over ontogeny are reviewed and compared with those described in the literature for other bivalve species, including other pectinids and the oyster *Crassostrea gigas*.

Results strongly suggest that the foot is involved in particle capture and rejection in early scallop developmental stages when the labial palps and lips remain relatively undifferentiated and the gills have not attained their adult form and full suspension-feeding function. Mantle ciliary tracts, absent in adults, are suggested to play a role in particle rejection in postlarval stages before shell clapping provides an effective mechanism for evacuation of pseudofeces. This provides a transition from ciliary- to muscular-driven, hydrodynamic particle rejection in pectinids. Based on the analysis of gut contents of scallop postlarvae offered paired fluorescent microspheres of different sizes we also demonstrate ontogenetic changes in size-related particle ingestion and identify an upper size threshold for effective particle ingestion.

The much more protracted differentiation of feeding organs in *P. magellanicus* likely contributes to the greater vulnerability of this species during culture of postlarval stages compared to *A. irradians*. We propose that changes in morphological development are an important consideration in developing suitable scallop diets and contribute to our understanding of feeding physiology and food requirements in the natural environment during the scallops' life history.

EFFECTS OF THE COLONIAL ASCIDIAN *DIDEMNUM* SP. A ON CULTURED SCALLOPS WITH A COMPARISON TO OTHER BIVALVES. **Stephan G. Bullard**. University of Hartford, Hillyer College, 200 Bloomfield Ave, West Hartford, CT 06117, USA. **Sandra E. Shumway** and **Robert B. Whitlatch**. University of Connecticut, Groton, CT, USA; and **Richard W. Osman**. Smithsonian Environmental Research Center, Edgewater, MD, USA.

Many ascidians (i.e., tunicates, sea squirts) are highly invasive and can rapidly spread to new habitats. Once they become established ascidians can experience population explosions and can overgrow and cover large areas of hard substrata. The carpet tunicate (*Didemnum* sp. A) is a colonial ascidian of unknown origin with rapidly expanding populations on the east and west coasts of North America. Large colonies form nearly solid mats that may smother benthic organisms. The carpet tunicate may be of particular concern for shellfish, and thus the aquaculture industry, as colonies can overgrow individual bivalves or completely cover material used to culture them. To determine the effect of the carpet tunicate on cultured juvenile shellfish, we deployed scallops (*Argopecten irradians*), mussels (*Mytilus edulis*) and oysters (*Crassostrea virginica*) in bags at 3.5 m depth with and without fragments of *Didemnum* sp. A. We assessed the survivorship, growth and condition index of shellfish after approximately

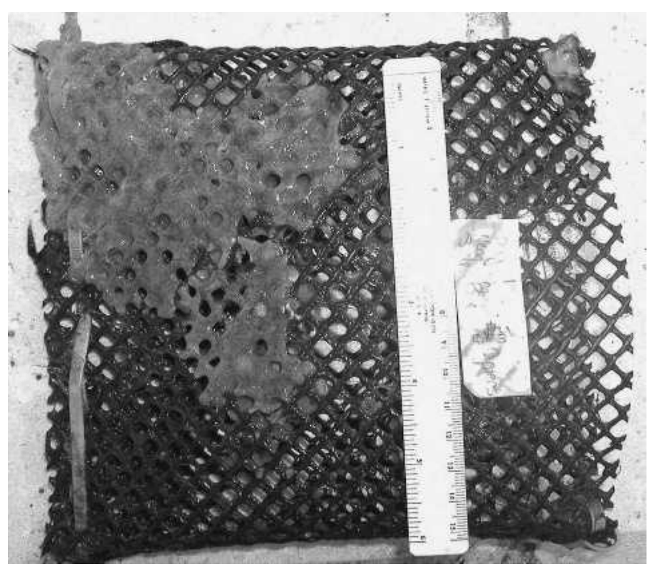

Figure 1. *Didemnum* sp. A overgrowing an aquaculture pouch.

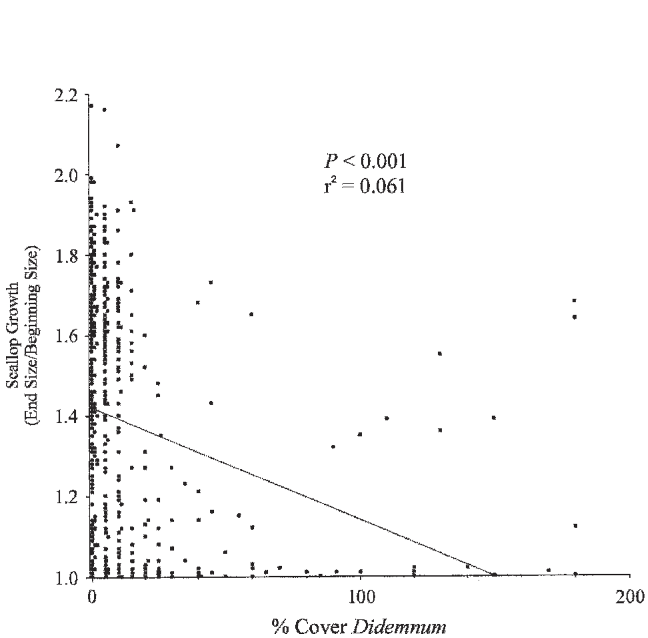

Figure 2. Correlation between the growth of juvenile scallops and the amount of *Didemnum* sp. A growing on their shells. Percent cover was assessed on both sides of scallops' shells allowing for estimates of up to 200% cover (i.e., 100% on both sides).

one and two months of deployment. By the end of the experiment, many shellfish in the treated bags had the ascidian growing on their shells; some were 100% covered. Survivorship of all bivalves was high and there was no significant difference in survivorship between shellfish with and without *Didemnum* sp. A (e.g., 77.7% and 76.7% of scallops survived in treatments with and without *Didemnum* sp. A, respectively). Fouling by the ascidian in our experiment reduced the growth of juvenile scallops, but not mussels or oysters.

Ag AND Cd PHYSIOLOGY IN SCALLOPS: GENERAL IMPLICATIONS. P. Bustamante[1], M. Metian[1,2], P. Miramand[1] and **M. Warnau.[2]** [1]International Atomic Energy Agency–Marine Environment Laboratories, Principality of Monaco 98000, Monaco; [2]Centre de Recherche sur les Ecosystèmes Littoraux Anthropisés, UMR 6217 CNRS-IFREMER-Université de La Rochelle, 17000 La Rochelle, France.

Whatever they live in tropical, temperate or polar seas, scallops have in common the capacity to accumulate various essential metals (e.g., Co, Cu and Zn) but also toxic ones (e.g., Ag and Cd) up to extremely high concentrations. Because of their bioconcentration capacities, scallops might reflect the variations of metal concentrations in the environment. However, there are still many questions to be addressed when studying the physiology of metal bioaccumulation and detoxification during the life cycle of scallops. Questions rise about the rates of metal uptake and excretion pathways, about the role of organs in the detoxification and storage of metals, and about the molecules involved in the redistribution and transfer processes within the organisms. Therefore, the goal of the present work is to give an overview of the processes that govern the bioaccumulation and detoxification mechanisms of some metals using Ag and Cd as examples. These elements have been selected for their contrasted behaviour in scallops. Results concerning both field and experimental investigations show that the digestive gland is the main storage and detoxification organ for Ag and Cd but kidneys are also important in these processes for Cd. Whatever the exposure pathway (i.e., seawater or food), Cd turn-over in scallop soft parts is very slow, with biological half-lives ranging from several months to several years according to the species considered. In the case of Ag, the metal biological half-life varies from a few days to several months according to the quality of the food source whereas almost all the Ag taken up from seawater is definitively stored in scallop tissues. Finally, the detoxification strategy differs between Ag and Cd, with Ag being stored under insoluble forms whereas Cd is mainly bound to cytosolic compounds in the digestive gland. The implications of metal physiology on the use of scallops as bioindicator species for Ag and Cd are discussed as well as their implications on the metal transfer to the scallop consumers.

MACROSCOPIC SCALE OF GONADAL STAGES AND SIZE AT FIRST MATURITY OF *ZYGOCHLAMYS PATAGONICA* (KING & BRODERIP, 1932) IN MANAGEMENT UNIT 2, SW ATLANTIC. Silvana Campodónico and **Mario Lasta.** INIDEP, Moluscos, Paseo Victoria Ocampo N° 1, Mar del Plata (B7602HSA) Argentina; **Betina Lomovasky.** Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), and Universidad Nacional de Mar del Plata, Mar del Plata, BA, Argentina; and **Gustavo Macchi.** Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata, BA, Argentina.

One of the basic goals of fisheries management is to conserve sufficient reproductive potential of a stock to allow a sustainable exploitation supported by the knowledge of reproductive variables such as size at first maturity and extension of spawning period. The Patagonian scallop *Zygochlamys patagonica* inhabit the SE Pacific extending from Chiloé Island (42°S) to Cape Horn (55°56′S), and the south-western Atlantic northwards to off the Río de la Plata estuary (35°50′S) overlapping with the Shelf-break Frontal System at the 100 m isobath. The Patagonian scallop fishery is conducted since 1996 in the SW Atlantic. Due to the commercial importance of this scallop, and in view of importance of increase the knowledge about reproductive characteristics of this species, the main objectives of this study were to: (a) describe a macroscopic scale of gonadal stages and (b) determine the size at first maturity.

A macroscopic scale of gonadal stages was determined mainly based on color, external appearance and size of testes and ovaries. Samples were collected in early March 2001. Specimens (n = 247) were shucked and gonads were examined macroscopically for determination of sexual maturity. Macroscopic appearance observed was validated using a histological scale of maturity.

Scallops were collected in a closed fishing area within Reclutas Bed (39°20′S–56°W and 39°30′S–55°52′W, 1085 km^2, SW Atlantic Ocean). Samples were obtained monthly between November 2000 and February 2001. Specimens (n = 864) were grouped in 1 mm size classes and classified histologically as mature (with oocytes or sperm present in the follicle) or immature (with scantly and small alveoli containing few sexual cells). To estimate shell height (SH) in which 50% of the specimens had already reached the ripe phase (L50), a logistic model was fitted to the proportion of mature individuals by SH class using the maximum likelihood method. Coefficients of the regression obtained for males and females were compared using a Chi^2 test.

A macroscopic gonadal scale of five stages for both sexes was defined:

I. Juvenile – Early maturation: small gonads, transparent or colorless, with an angular and flattened appearance.

II. Advanced maturation: gonads near to maximum size, testis is white or cream and the ovary is orange or bright orange.

III. Ripe: gonads larger than other body organs (is the most conspicuous organ in the scallop), it is rounded, and the surface smooth and glossy. Intense coloration: testis is white or cream; the ovary is bright orange.

IV. Spawning: gonads reduced in size and collapsed, with empty areas. Testis is white or practically colorless and the ovary is amber or dull orange.

V. Spent: gonads flaccid. Testis containing sex cells cloudy white, rest transparent. The ovary is amber or pale orange, or transparent and colorless. It is possible to discern the intestinal loop within them. In some cases, sexes are not differentiated.

The size at first maturity was 36.63 mm SH for males and 36.31 mm SH for females corresponding to 2-3 years old. No significant differences were observed between both sexes ($p > 0.05$). The smallest male and female with active gonads corresponded to 25 and 32 mm SH, respectively.

Several authors have defined macroscopic gonadal scales of scallops with five or more stages, depending on the possibilities of reaching an accurate identification of each stage of development. Regarding macroscopic differences, sometimes it is difficult to differentiate clearly between the termination of one stage and the beginning of another. Therefore, to gain accuracy in the classification, we defined a macroscopic scale of five gonadal stages clearly differentiable.

We observed that the stage II, where the gonads are clearly mature is reached around 36 mm SH (L50). Previous studies reported the size of first maturity of *Z. patagonica* from a wide latitudinal range (40°–54°S) showing a value of 45 mm SH. The differences with the present study could be attributed, however, to the different geographic scales of analysis. It is known that the reproductive cycle in marine bivalves shows high intraspecific variations, moreover, in scallops with a broad geographic distribution, many authors have mentioned the important role that latitudinal variations play in their reproductive cycles. Our work is restricted to micro or small scale (Reclutas Bed) where population processes (trophic or reproductive) correspond to the neighborhoods of individuals suggesting that the spatial scale is important to define the reproductive characteristic of the species.

RELATIONSHIP BETWEEN NATURAL SETTLEMENT OF *CHLAMYS VARIA* AND THE REPRODUCTIVE CYCLE IN A CORUÑA (GALICIA, NORTHWEST SPAIN). **Maria Jesús Campos, Laura Díaz, Juana Cano, Matías Lozano** and **Francisco López**. Instituto Español de Oceanografía, Paseo Marítimo Alcalde Francisco Váquez n° 10 A Coruña, Spain, 15001.

Chlamys varia is widely distributed species, living all along the east coast of the Atlantic Ocean, from Norway to Senegal and the Mediterranean Sea. In Spain not long ago the presence of this bivalve was only known in Galician coast, where is appreciated. But in official statistics no captures were registered due to natural stocks extinction since 1978. Seasonal settlement of *Chlamys varia* in western Mediterranean was already reported by Peña *et al.* (1996). Later, spat settlement, suitable dates for the anchorage and removal spat collectors, and culture methodology were studied in Malaga (Campos and Cano 2003; Cano and Campos 2003).

In 2004, pectinids culture research program started in four sites: two in the Mediterranean Sea (Málaga and Alicante) and two in the Atlantic Ocean (Cádiz and A Coruña). Settlement spat collectors were moored in the four study sites. In Galicia, *Pecten maximus* and *Aequipecten opercularis* were settled, and also surprisingly *Chlamys varia*, being this last one the only with enough high density rates to carry on with the studies.

The present work aimed at the analysis of natural recruitment patterns of *Chlamys varia* and the relationship with the reproductive cycle by studying the gonad condition index.

During three years, control and production collectors were moored biweekly. Settlement intensity was controlled by sampling two control collectors every two weeks. Production collectors were removed between October and December every year. Over the course of the studies, 10 specimens were sampled monthly and

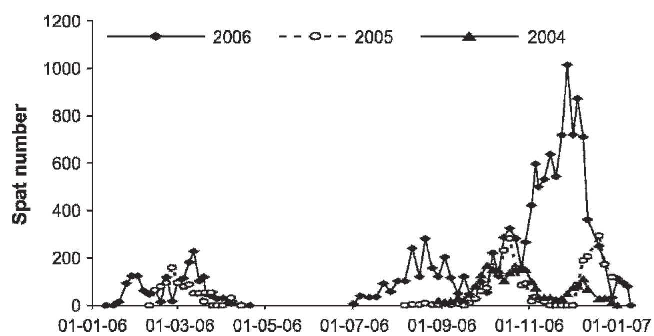

Figure 1. Spat settlement production collectors.

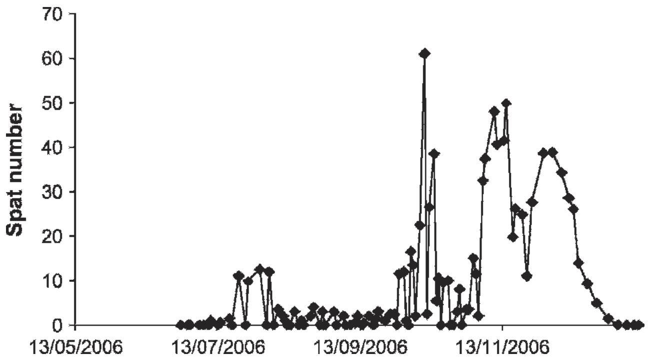

Figure 2. Spat settlement control collectors 2006.

separated by sex (males and females). Shell, adductor muscle, gonad, digestive gland and other soft tissues (gills + mantle + foot) were weighed (g) to estimate condition index, which was calculated as follows: $CI_{organ} = 100$*(organ dry weight/shell dry weight).

During 2004, 3,282 specimens of *Chlamys varia* were settled, 4,226 in 2005 and 12,307 in 2006. During the three years, the higher number of spat from production collectors was found in the ones moored in August of every year. July was the second best month to moored collectors.

Using modal progression analysis, collector spat growth was calculated to estimate the settlement date of each individual according to its size. Figure 1 shows maximum settlement values between November and December. Another relative important peak occurs in August–October and January–March periods. In 2006, control collectors had maximum settlement values in October (Fig. 2), whereas in production collectors maximum values were obtained between November and December.

Gonad condition indices show minimum values in September and January, and maximum values in April and July–August. Without any doubt the spring spawning period is not associated to an important settlement rate due to collectors being fully covered by mussels, crustaceans and drilling gastropods.

In a previous work, Parada *et al.* (1993) reported that the reproductive activity period occurred from March to July–August. Our work shows that although gonad condition index decreases point out that the main spawning activity is produced from March–April to July–August, the best periods to moor collectors would be from June to October and January to March, when 90% of spat is collected.

On the basis of these data, Galicia can be considered a good area to provide *Chlamys varia* spat, essential to support aquaculture exploitation without using a hatchery.

GROWTH AND MORTALITY OF KING SCALLOP (*PECTEN MAXIMUS*) IN FOUR SPANISH COASTAL AREAS.

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In March 2004, a research program was started to determine the relative effects of spat origin and culture site on growth and mortality of king scallop (*Pecten maximus*).

The research was carried out at four coastal areas: Conil de la Frontera (Cádiz, in southwest Spain) and Coruña (Galicia, in northwest Spain), in the Atlantic Ocean, and Santa Pola (Alicante, in east Spain) and Fuengirola (Málaga, in southeast Spain), in the Mediterranean Sea.

The scallop used spat for this research was obtained by natural settlement on moored collectors in Fuengirola in 2004 (group 1) and in 2005 (group 2). Group 1 was cultivated from November 2004 to December 2005, group 2, from November 2005 to January 2007, except in A Coruña site due to all specimens death during the transfer from the origin site. A new same age spat group was sent in March 2006.

Specimens were cultivated in 40 cm diameter oyster culture trays, suspended at a 10 meters depth over the seabed with a density of 20 scallops per tray. Its height was measured (mm) and dead specimens were counted to determine growth and mortality.

Growth coefficient was estimated using ''isometric'' von Bertalanffy growth equation:

$$L_t = L_\infty[1 - \exp(-K(t - t_o))]$$

The table shows the growth coefficients for the two groups in the different areas:

	A Coruña	Conil	Fuengirola	Santa Pola
Group 1	1.08	0.74	0.90	0.84
Group 2	0.89	0.47	0.89	0.75

Growth rates were higher throughout the first year than the second one in all sites. A Coruña presented the higher values in group 1 and Fuengirola in group 2.

In A Coruña, in group 1, from March until September, the rate of growth of scallop was higher than the previous months. During autumn, a growth rate decreasing was observed. Group 1, after 8 days from their transfer from origin site to culture site, 17% of mortality of scallop was recorded. Until July 2006 mortality rate was 35% and in January 2007 was 65%. In group 2, just a 13% of mortality rate was registered during all the trials.

A similar growth rate was recorded in Fuengirola during both years. The differences between groups were recorded in the mortality rate where group 2 presented a higher mortality rate than group 1, with 83% and 23% respectively. In both cases, higher mortality was in November.

Lowest growth values were recorded in Conil, with a decreasing rate during autumn and no growth in winter. A 50% of mortality was observed.

In Santa Pola, intermediate growth rates were recorded in comparison with the rest of sites. The difference between groups was due to the growth detention during autumn in the second group. Mortality values were the lowest ones with a 20% rate.

POST-LARVAL SETTLEMENT OF *PECTEN MAXIMUS* L. IN CULTURE AND EFFECTS OF ENVIRONMENTAL CONDITIONS. **Gyda Christophersen** and **Thorolf Magnesen**. Department of Biology, University of Bergen, P.O. Box 7800, N-5020 Bergen, Norway; and **Sissel Andersen**. Institute of Marine Research–Austevoll, Storebø, Norway.

Successful metamorphosis and settlement are keys to scallop recruitment in nature and for mass production of spat in hatcheries. The challenge in culture, therefore, is to obtain a higher and stable settlement ratio beyond today's average of about 20%.

Natural development and maximised survival between critical stages depends on matching environmental conditions. Knowledge about most favourable requirements of *Pecten maximus* during early stages in nature is fairly poor, but in hatcheries and under experimental conditions, effects of environmental factors on post-larval performance are more easily monitored. Temperature, salinity and food supply are environmental factors of high importance to optimise culture together with timing of larval transfer, settlement substrate, hydrodynamics and other husbandry procedures like handling and cleaning.

In Norway scallop spat have been hatchery produced for nearly 20 years, and for the last 10 years Scalpro AS has produced spat commercially. The hatchery has continuously performed R&D work to increase their production in collaboration with the University of Bergen and Institute of Marine Research. Major efforts have been put into solving problems related to mortality during the larval and post-larval phase. Great variations in survival have been experienced between larval batches, but the implementation of a flow-through system without prophylactic use of antibacterial agents has led to more stable production of competent larvae. Still, settlement ratio has only occasionally exceeded 20–25%.

Results from several experiments to further improve settlement of *P. maximus* in the hatchery will be presented. Competent larvae retained on 150 μm mesh were transferred to settle in traditional downwellers and to tanks for settlement on collector bags. The post-larvae mainly settled between 2 and 4 weeks, and settlement rate was affected by conditions during the larval phase. Water circulation in settlement tanks also had impact on the result, while stock origin, light conditions and collector bag colour had minor effects.

Underlying questions are: Which larvae are capable of undergoing metamorphosis and survive in the settlement system? How successful are settlement in culture compared to in nature? And, do final spat yield reflect settlement rate or ratios? Future strategies for improving post-larval success in the commercial hatchery Scalpro AS will be discussed.

VERIFICATION OF ANNUAL GROWTH INCREMENTS ON THE SHELLS OF ATLANTIC SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) USING CLOSED AREAS AND STABLE ISOTOPES. **Antonie S. Chute** and **Deborah R. Hart.** Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543 USA; and **Samuel C. Wainright**. U.S. Coast Guard Academy, New London CT 06320 USA.

Sea scallop growth can potentially be rapidly and inexpensively estimated using visible shell rings, but concerns have been raised as to whether these rings are annual. We tracked over several years the shell heights of large cohorts of sea scallops from areas closed to fishing, and compared the observed growth to the growth predicted by the rings of shells collected at the same sites where the shell heights were measured. Additionally, we aged a number of shells using stable oxygen isotope techniques, and compared these results to those from the visible growth rings. Both methods indicate that growth rings are generally annual, though the first growth ring is often visually obscure or missing. The stable isotope analysis indicates that growth rings of sea scallops on Georges Bank and in the Mid-Atlantic Bight are laid down near the temperature maximum. This result contrasts with that found in Canadian waters, such as the Bay of Fundy, where growth rings are formed near the temperature minimum. We have now analyzed the growth rings of over 7000 shells, allowing us to estimate not only mean growth rates, but also the spatial-temporal variability of growth.

EVALUATION OF DIFFERENT PARAMETERS TO OPTIMIZE COLLECTION STRATEGY OF SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) IN COMMERCIAL OPERATIONS. **Georges Cliche, Carole Cyr**. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Direction de la recherche scientifique et technique, 107-125 Chemin du Parc, Cap-aux-Meules, Québec, Canada G4T 1B3. **Denyse Hébert** and **Mélanie Bourgeois.** Culti-mer 55 route 199, Fatima, Québec, Canada.

Fine tuning of commercial collection strategy of sea scallop required evaluation of many parameters able to affect collection success and cost production of spat. In Îles-de-la-Madeleine, commercial operations of scallop spat collection have been realized since 1995. Many research projects were undertaken to specify the parameters in order to optimize the collection. Within the framework of commercial collection, this optimization should not only aim at maximizing the number of scallops per collector but the producers must also establish a strategy which will enable them to optimize the whole of the operations related to the collection:

immersion of the collectors, follow-up of the longlines, recovery and cleaning of the collectors, etc. In 2005, a research project was initiated and aimed to evaluate and compare some parameters related to the commercial collection of the company Culti-mer. This company immerses 25,000 collectors annually to ensure its supply of sea scallop spat. The company wanted to know:

1. If new substrate of collection (Netron™) was more effective than the old substrate, if the old substrate must be cleaned carefully or not after the spat has been recovered.
2. If collectors compressed to facilitate their transport to the sites of collection remained effective for the collection.
3. If a reduction of the number of collectors per longline or a reduction of the quantity of substrate in the collector could reduce the losses of scallops associated to the sinking of overloaded longlines on the sea bottom, one year after the immersion of the collectors.

Materials and Methods

All collectors used for the experiments were immersed during fall 2005 on the longlines of the company Culti-mer. The depth of water on the collection site varies between 25 and 30 meters. The longlines are deployed at 8 meters off the bottom and the collectors occupy the portion of the water column ranging from 3 to 8 meters off the bottom. The spat collectors were made of 2 mm mesh bags, each filled with 4 tubular netron sections of 40 × 80 cm. Aside from the experimental longlines supporting 800 collectors, all the other ones were longlines with 960 collectors. In an experiment comparing old and new netron, old netron substrate refers to netron used in collectors for at least one year. Compaction of collectors is done manually and allows for approximately an 80% reduction of collector volume. All the experimental collectors were recovered during fall 2006. They were cleaned and analyzed individually. Representative samples of scallops and associated species were counted and measured.

Results and Discussion

New substrate, old substrate cleaned and not cleaned

The collection rates of scallop do not differ significantly among the 3 compared treatments. These rates vary between 902 and 1053 scallops/collector. However there is a significant difference with 2 associated species: hiatella (*Hyatella arctica*) and anomia (*Anomia* sp.). The new netron collected significantly less organisms of these 2 species than old netron cleaned and not cleaned. With new netron, numbers of hiatellas and anomies per collector were 1763 and 161 respectively compared with 3687 and 631 with old netron cleaned and 3172 and 594 with old netron not cleaned. Collection rates of blue mussel (*Mytilus edulis*) and starfish (*Asterias vulgaris*) do not differ among the 3 treatments. Efficiency of collectors with old substrate cleaned or not cleaned being the same, Culti-mer may eliminate substrate cleaning without reducing efficiency of collectors and thus realize substantial economy in manpower costs.

Collectors compacted and not compacted

The rates of scallop collection do not differ significantly between collectors compacted (1040 scallops/collector) and not compacted (1132 scallops/collector). An associated species (*Anomia* sp.) differs significantly with lower collection rate in collectors not compacted 1273 compared to 3000 organisms for the ones compacted. The collection rates of hiatella, blue mussel and starfishes do not differ. The company compacted already the collectors. Results show that compaction of collectors is a good strategy. Even if anomies are more abundant on collectors compacted, it is not really problematic since these organisms are very small and easily eliminated by the mechanical sorting machine.

Longlines with 960 collectors and 800 collectors

It was not possible to conclude if the reduction in the weight of the longlines with 800 collectors was sufficient to prevent the longlines from sinking to the sea bottom. The collectors closer to the bottom have comparable collection rates on longlines with 960 and 800 collectors. Observations made while scuba diving shortly before recovering collectors showed that several collectors were lying down on the sea bottom on all experimental longlines. In November 2006, collection rates were not significantly different for collectors that had sunk to the bottom and the ones still in the water column. Probably the collectors had sunk recently and mortality in collectors had not occurred yet. In 2005, collection rates for all species on commercial collection sites were the lowest in the last 5 years. Lower weight of collectors resulting in lower numbers of organisms probably explains that collectors are dragged on the bottom for a shorter period without leading to scallop mortality in collectors.

Collectors with 2, 3 and 4 sections of netron

The results showed no significant difference between the collection rates of scallop and associated species in collectors with 2, 3 or 4 sections of netron. Numbers of scallops per collector were 924 ± 279, 994 ± 301 respectively and 1146 ± 312 scallops. In the past, four sections of netron were used for each collector. Last year, the company Culti-mer used 3 sections per collector. Results show that it was a good decision and possibly the company could use 2 sections per collector to reduce production costs of collectors even more.

SCALLOP AQUACULTURE IN NEWFOUNDLAND AND LABRADOR—SEARCHING FOR THE HOLY GRAIL? **Cyr Couturier**. School of Fisheries, Marine Institute, Memorial University, P.O. Box 4920, St. John's, NL, Canada A1C 5R3.

Experimental trials on farming sea scallops, *Placopecten magellanicus,* have been ongoing for nearly 40 years in Newfoundland and Labrador. The earliest trials (1960s–1980s) were aimed at seed procurement, site evaluation and adaptation of growing techniques from Japan. The 1980s saw the development of pilot scale hatchery and wild spat production as well as further site evaluation. During the 1990s several attempts at commercial seed production, both from hatchery and wild, ended in failure. During this same time the pioneer growers in the industry developed commercial scale production technologies and husbandry techniques, however the lack of seed and sudden, unexplained mass mortality events discouraged the pioneers and meant certain doom for these operations, so they opted to diversify into profit making sectors such as mussels and salmon. At present, scallop farming activities in the Province are almost non-existent with four commercial farming licences still being held and no commercial production at all. There is renewed interest in evaluating sites for commercial suspended culture in the western portion of the island, near Port-au-Port, if suitable spat collection and growout sites can be identified, so all is not lost. There is also interest in commercial scallop production in the French islands of St. Pierre and Miquelon, adjacent to Newfoundland and Labrador, sharing the same oceanic conditions, so it may be possible to collaborate on future initiatives. The major constraints to commercial scallop farming in the Province at present are: 1) lack of a reliable seed supply, 2) identification of adequate growing sites and technology, 3) lack of ''scallop-smart'' knowledgeable farm operators, and 4) financial capitalization. The first priority for R and D should be aimed at impediments 1 and 2 if there is an interest in moving forward.

REPRODUCTIVE ENDOCRINOLOGY IN BIVALVES: WE KNOW LESS THAN YOU MIGHT THINK. **Roger P. Croll**. Department of Physiology & Biophysics, Dalhousie University, Sir Charles Tupper Medical Bldg., 5850 College Street, Halifax, NS, Canada B3H 1X5.

Twenty years have passed since the initial appearance of reports describing the use of serotonin to trigger spawning in bivalves. Since that time, serotonin has provided a widely employed, although imperfect, means for inducing gamete release in both the laboratory and in aquaculture. And yet, despite advances in our understanding of certain underlying mechanisms (e.g., receptor-mediated maturation of oocytes), many questions still remain regarding the physiological actions of serotonin in the reproduction of scallops and other bivalves. For example, serotonin-containing axons are known to surround germinal acini and gonoducts in several species, including scallops, but is endogenous serotonin actually released during natural spawning? If so, is serotonin release a necessary condition for gamete release? What are the identities and locations of the nerve cells which give rise to the axons? Does stimulation of these cells alone trigger spawning or does serotonin work in concert with other substances, such as catecholamines, neuropeptides, steroids, which have also been implicated in the control of bivalve spawning? What are the metabolic pathways responsible for the synthesis and inactivation of the various substances and what are the characteristics of the receptors which mediate their actions? Does serotonin or any of these other substances also play any role in gonadal development in addition to the control of spawning?

Answers to the types of questions posed above are not simply of theoretical value but also have direct implications for the management of hatchery operations and particularly the efficiency of brood stock maintenance. For instance, applications of cocktails of different amines, peptides and steroids may more closely mimic physiological conditions underlying natural spawning and thus provide more reliable means of inducing gamete release. Monitoring of the endogenous levels of these various substances might provide a better method for determining the reproductive competence of individuals. The use of pharmacological agents will likely provide better means for manipulating long-term concentrations and/or activities of putative transmitters and hormones. Such pharmacological methods could be used not only to facilitate reproduction, but might also permit a method for temporarily blocking spawning in order to better synchronise reproductive activity within a population and or to permit faster somatic growth at different stages of the life cycle. Knowledge of underlying mechanisms is also essential for the understanding and prediction of effects of endocrine disrupting chemical pollutants which can be taken into account when positioning an aquaculture facility or when evaluating possible causes for declines in natural populations. The need for basic research to answer these types of questions will be discussed in the context of what may seem to be more pressing day-to-day issues of aquaculture and wild stock harvest.

WEEKLY SPAT COLLECTION MONITORING TO PREDICT AN OPTIMAL DEPLOYMENT PERIOD OF SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) COLLECTORS. **Carole Cyr, Georges Cliche** and **Bruno Myrand**. Centre maricole des Îles-de-la-Madeleine, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, 107-125 Chemin du Parc, Cap-aux-Meules, Québec, Canada G4T 1B3.

From year to year, undesirable organisms (*Hiatella arctica*, *Mytilus edulis*, *Anomia* spp., *Asterias vulgaris*) also settle in the scallop collectors. These organisms may slow down scallop growth (competition for food and space) and/or increase scallop mortality (predation and packing). When abundant, these undesirable organisms also add extra weight to the longlines, thus decreasing their buoyancy. In some cases, collectors end up lying down on the sea bottom where they can be damaged by chafing and thus scallops can escape or be eaten by benthic predators (crabs and seastars). Also, handling and cleaning of collectors are impeded when undesirable organisms are abundant thus leading to an increase in labour costs. All these constraints reduce the profitability of the aquaculture operations and thus, must be reduced. The present study was conducted to evaluate if the monitoring for weekly spat collection of scallops and undesirable species could contribute to predicting the best timing for collector deployment in order to reduce the presence of undesirable organisms while keeping an abundant scallop spat collection.

Materials and Methods

Study area

From 2003–2006, the experimental study was conducted in open waters off the Îles de la Madeleine in southern Gulf of St. Lawrence (Canada) near the spat collection site used by the scallop growers on the Pearl Reef (water depth: 30–32 m).

Weekly spat collection monitoring

Peak recruitment of newly settled scallops and main undesirable species was estimated using artificial collectors immersed throughout the settlement period. The spat collectors were made of 2-mm mesh bags each filled with four Netron™ sections and immersed at 2, 5 and 8 m above the bottom (to represent the settlement range on commercial line). The collectors were deployed weekly at three sites for eleven consecutive weeks in 2003 starting on August 19; for eight consecutive weeks in 2004 starting on September 9; for eleven consecutive weeks in 2005 and 2006 starting on September 6. They were retrieved a week after their deployment and cleaned individually in the laboratory using a high-pressure water jet. The recovered material retained on a 250-μm mesh sieve was then preserved in 95% ethanol until further analysis. The sea scallops (*P. magellanicus*) and four undesirable species (3 molluscs: *M. edulis*, *H. arctica*, *Anomia* sp., and 1 echinoderm: *A. vulgaris*) found in each individual collector were all counted. A random sub-sample of 30 specimens of each species inside each collector was also measured.

Cumulative spat collection monitoring

To characterize how the timing of collector immersion influences spat collection, a series of five tagged collectors was deployed weekly for 6–8 consecutive weeks starting three weeks after spawning had been initiated (i.e., on September 15, 2003; on September 22, 2004; on September 26, 2005). Each series of collectors was suspended to a longline at two meters above the bottom on the Pearl Reef. In December, collectors were retrieved, cleaned and the recovered material was handled, stored and thus, analyzed as described previously for the weekly settlement experiment. In 2006, a series of five collectors was deployed the 3rd week after spawning was initiated (i.e., on September 15) and was retrieved in December. Three other series of fifteen collectors were suspended on commercial lines at 4th, 6th and 8th weeks after the initiation of scallop spawning. These collectors will be retrieved only in fall 2007 to validate if the weekly spat collection monitoring is reliable to predict the optimal collector deployment period.

Results and Discussion

Weekly spat collection monitoring

In 2003, the scallop settlement period occurred 5 to 9 weeks after spawning began with a peak at the 7th week. In 2004, the settlement period was limited to between 7 and 9 weeks after the sea scallop spawning began and the settlement was lower than in 2003. In 2005, the settlement had greatly varied with the time and was lower than in 2003 and 2004. It is in 2006 that the settlement was the lowest. The scallop collection was significantly higher in collectors deployed for one week starting on October 13, 2003 with 465 ± 44 spat/collector; on November 1, 2004 with 338 ± 21; on October 31, 2005 with 138 ± 31; and on October 16, 2006 with 53 ± 3 spat/collector. The abundance of mussels and hiatellas found in the collectors varies from one year to the other but the first peak of *M. edulis* and *H. arctica* often occurs in September before the *P. magellanicus* peak. Weekly spat monitoring could be useful to identify when those peaks occur. As a result, growers can delay the collector deployment until after these peaks. However, later peaks of mussels and hiatellas could hardly be avoided as they occur late in fall.

Cumulative spat collection monitoring

The highest cumulative numbers of scallop observed in collectors deployed in September-October and retrieved in December (2 months later) was 5808 ± 334 scallops/collector in 2003 (6th week after the initiation of sea scallop spawning), 4680 ± 330 in 2004 (5th week), 1148 ± 41 in 2005 (3rd week) and 652 ± 37 scallops/collector in 2006 (3rd week). There seems to be a link between weekly scallop collection and cumulative scallop collection (i.e., in 2003 the scallop numbers of weekly spat collection monitoring were high, the scallop numbers of cumulative spat collection monitoring were also high, in 2006 the results were inverse). Based on results from the retrieval period of collectors in December 2003 and 2004, the best time to deploy commercial collectors would be six to eight weeks (early to mid-October) after the sea scallop began to spawn. If this recommendation is followed, the collection of scallop spat will be higher than the undesirable species (abundance of scallop/abundance of undesirable species ratio >1). In 2005, the ratio >1 was not obtained for any date probably because a partial spawning occurred two weeks before the complete spawning, contrary to 2003 and 2004.

A COMPARISON OF THE GROWTH OF WILD AND SUSPENDED SEA SCALLOPS, *PLACOPECTEN MAGELLANICUS*, IN MAHONE BAY, NOVA SCOTIA, CANADA. **Michael J. Dadswell**. Department of Biology, Acadia University, Wolfville, Nova Scotia, Canada B4P 2R6.

Sea scallops living on the bottom and suspended by ear-hanging, both within an aquaculture lease and between the depths of 5–10 m, were compared for growth characteristics. Scallops in suspension had a faster growth rate for both shell height (33%) and adductor muscle weight (400%). Three-year-old (40 months) suspended scallops achieved an average meat weight of 20.6 g, whereas 3+ yr wild scallops had a mean meat weight of only 5.2 g. The Von Bertalanffy growth coefficient (K) for meats was 0.521 for suspended scallops and 0.155 for wild scallops. Cultured scallops partitioned a greater amount of resources into meat production and less into shell production. Wild scallops grew thick, heavy shells, which were an average of 60% of total weight compared to 40% of total weight for suspended animals, and which was most likely a protective response to cope with predation encountered on bottom. Slower growth of scallops on the bottom is probably not only caused by lower and less nutritious food resources but also by the possibility of predation. How wild scallops on the sea bottom perceive the potential for predation and those in suspension do not should certainly be the focus for future research.

Growers can take advantage of enhanced growth rates and fewer predator encounters by suspending their animals and thus attain market size for meats (60–80 count/kg) or whole animals (5–10/kg) by three years of age, two years earlier than for bottom grown animals. When cleaned by pressure washing, shells from suspended scallops are aesthetically pleasing and highly appealing to buyers. There is little incentive for growers to leave suspended scallops in the water for additional years, as growth rates decline and maintenance increases.

BIANNUAL SPAWNING AND SPAT SETTLEMENT OF SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN MAHONE BAY, NOVA SCOTIA AND THE POSSIBLE LONG TERM EFFECT OF A SCALLOP FARM ON THE RECOVERY OF THE MAHONE BAY SEA SCALLOP POPULATION. **Michael J. Dadswell** and **Michael Stokesbury**. Department of Biology, Acadia University, Wolfville, Nova Scotia, Canada B4P 2R6; and **Duncan Bates**. Bay Tender Shellfish Ltd., Chester, Nova Scotia, Canada.

Mahone Bay is a deep (70 m) embayment on the south shore of Nova Scotia. Because it is separated from the open Atlantic by a sill of only 14 m depth, the Bay is stratified in summer (June-August) and water temperatures from 0–14 m range from 16–20°C. Chlorophyll-a concentrations ranged from 0.5–5.4 μg/L with two peaks in early July and late October.

Sea scallops in shallow water exhibited two peaks in their Gonadosomatic Index (GI) one in early July and a second in August–September. During the July peak the GI reached 20–25% then declined to approximately 15% by late July. Up to 20% of the population exhibited complete depletion of the gonads. Reproductive recovery, however, was rapid and by late August the GI peaked at 30%. During September and October spawning was episodic or prolonged depending on year but by late October the GI declined to 10–15% and 80–100% of scallops were totally spent.

Spat settlement in collectors set out every two weeks from June 15 to October 15, 1989–1993, occurred in two waves, one from mid-July to early August and a second from mid-September to late October. Growth rate of spat that settled during July was high (0.074 mm/day) and these spat attained 10 mm mean shell height (SH) by December. Growth rate of the fall set was slower (0.024–0.042 mm/d) and these spat did not attain a mean SH of 10 mm until July the following summer.

During the period 1989–1993 mean number of spat/collector ranged from 4.2–215.0 during the summer set and 2.0–90.9 during the fall set but the long-term average was only 42.0/collector. Shallow water (4–12 m) bottom collections of adult scallops by scuba during this period were also low ranging from 10–40/diver/hr. We established a commercial scallop farm during 1992–1994 with a population of 50,000–100,000 adults by importing spat from distant localities (Cape Breton, New Brunswick) and an annual population level of 100,000+ was maintained through 2007. By 1998, diver collections of wild scallops increased to 100+/diver/hr and during the period 1997–2000 the mean spat/collector increased to a range of 180.2-550.0 during the fall set with a mean of 292.2/collector. Mahone Bay now contains a large population of wild scallops and annual spat sets since 1998 have been sufficient to maintain our commercial farm.

SCALLOP ENHANCEMENT PROJECT IN NEW BRUNSWICK CANADA - FIRST HARVEST. **Leslie-Anne Davidson** and **Monique Niles**. Department of Fisheries and Oceans, 343 Université Ave., Moncton, New Brunswick, Canada E1C 9B6; **Bruno Frenette** and **Rachel Cassie**. Pecten UPM/MFU Inc., Shediac, New Brunswick, Canada.

In New Brunswick, Canada, a scallop enhancement project is conducted at three sites: Baie des Chaleurs, Miramichi and the Northumberland Strait (Figure 1).

Pecten UPM/MFU Inc., a non-profit company, manages the project. Even though the enhancement project was initiated in 1996, the enhancement techniques were not mastered until 2001 when two professional crews were hired to perform the work required instead of depending on volunteers. In 2001, a partnership was formed between Pecten UPM/MFU Inc. and the Department of Fisheries and Oceans (DFO) for their scientific personnel to perform surveys to assess the stock density on the seeded beds. Each site was surveyed and then closed for five years, to scallop dragging, by variation order. The DFO surveys were conducted using a black and white video camera towed from a 20 m (65 ft) research vessel. The geographic position of each video tow was recorded directly on the video tapes using a Garmin GPS Map215 with an Oakland GPS Overlay. The video recordings were analysed to determine the scallop density along with the density of other important species and to describe the bottom type.

The sites, seeded in 2001 in each region, were opened to harvesting in 2006. According the 2001 and 2005 video survey analysis, the density of scallops on the Baie des Chaleurs, Miramichi and the Northumberland Strait enhancement sites increased from 0.04 scallops/m^2 to 0.20 scallops/m^2 (5X), from 0.02 scallops /m^2 to 0.16 scallops/m^2 (8X) and from 0.009 scallops/m^2 to 0.096 scallops/m^2 (9X), respectively. Even though the observed increases are encouraging, it was not possible to attribute them to the enhancement activities alone, since the effect of the 5 year closure was not isolated.

Prior to harvesting the 2001 enhancement sites, catch rates were predicted. These predictions were based on knowledge obtained

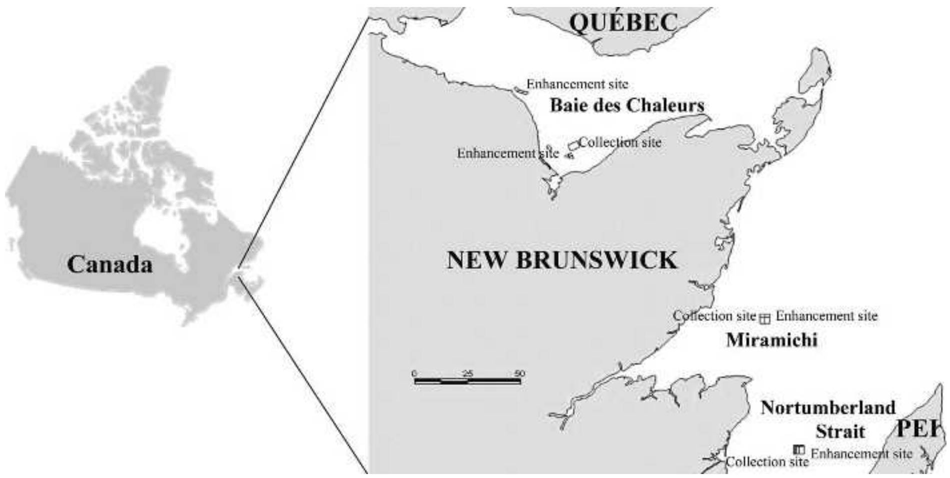

Figure 1. Scallop enhancement study sites in New Brunswick, Canada.

from video surveys conducted on commercial scallop beds in 2003 (Davidson and Niles 2005) and on the Gulf of St. Lawrence scallop sea sampling program conducted between 2001 to 2005 (Niles and Davidson 2005). The relationship between scallop density and catch rate (kg/hr) found on the commercial fishing beds was determined. The catch rate on each enhanced bed was predicted by applying the same relationship to the densities observed by videos on the enhanced beds. The catch rate predictions for Baie des Chaleurs, Miramichi and Northumberland Strait were 3.4 to 3.7, 1.7 to 2.8, 3.0 to 3.8 kg of scallop meat/hr, respectively.

To the fishermen catch rate predictions seemed low. However when the actual harvest was conducted, the predictions were accurate. Although five to ten fold increases were documented on the enhanced beds, the fishermen have expressed disappointment concerning the first harvest. The project was conducted at a relatively small scale compared to the actual size of the fishing grounds. Perhaps a larger scale enhancement project could give the fishermen the harvest they expect.

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THE TASTE OF SCALLOPS: PHYSIOLOGY, CHEMISTRY AND COOKING. **Arne Duinker**. National Institute of Nutrition and Seafood Research (NIFES), P.O. Box 2029 Nordnes, 5817 Bergen, Norway; **Stein Mortensen**. Institute of Marine Research, Bergen, Norway; and **Fredrik Hald**. Hallvard Lerøy AS, Bergen, Norway.

The presentation will explore the relationship between the osmoregulative physiology of scallops and their taste, through the need for varying the tissue osmolality with tasteful free amino acids (FAA). The sweet amino acids glycine and alanine are dominating the FAA pool in scallop adductor muscles and hence give the characteristic sweet flavour. This flavour is enhanced by high levels of arginine but also the pool of other FAA. Changes during salinity variations are seen in *Pecten maximus* in the sum of all FAA and not solely in the dominating types, and an enhanced flavour can be expected with increasing salinity. The glycogen stores, on the other hand, have only a "body" effect on the other taste components, contrary to the common assumption that these polysaccharides have a sweet flavour.

During cooking, two types of sweet flavours are targeted. The natural sweet flavour from the free amino acids is tender and various ways to enhance or mask this flavour will be discussed. The other type is not present in foods per se, but is generated during food processing by Maillard-type reactions from carbohydrates and amino acids, and it appears with the browning of the meat. This flavour is stronger and can be matched and enhanced by other combinations of sauces, garnish etc.

The gentle texture of the scallop adductor muscles should also be treated with care during cooking. Both overcooking and acids affect the consistency negatively, and suggestions will be made for optimal heating of scallop meat.

THE UPS AND DOWNS OF SCALLOP AQUACULTURE DOWN UNDER. **Peter F. Duncan,** Faculty of Science, Health and Education, University of the Sunshine Coast, Maroochydore DC, Queensland, 4558, Australia.

Scallop aquaculture has had a relatively poor record in Australia, despite several commercial species, well-developed fisheries, domestic and export seafood markets, clean water and diverse climatic conditions. Reasons for limited aquaculture development are those typically reported in many other high-cost economy countries.

Fisheries declines over the last two decades have encouraged efforts to develop aquaculture. This paper reports on current scallop aquaculture and research activity in Australia.

Victoria

In 2002 the Commonwealth Government funded research by RMIT University to investigate hatchery production of *Pecten fumatus* for potential reseeding. However, project was abandoned largely due to water-quality problems.

There is no state government-based R&D work on scallop culture in Port Phillip Bay, although in June 2006 the Victorian Government auctioned marine aquaculture leases. Leases are for 21 years, with additional 10-year option for a government-determined market-value fee. A combinatorial auction was conducted on-line over 2-3 hours, and used a weighted bidding system to maximise value for the state government. Bidders submitted expressions of interest, and an AU$5000 refundable bond.

Seventeen leases, between 2.5–27 hectares were sold, with 7 deep enough for suspended culture, 5 × 18 ha (16–18 m) and 2 × 27 ha leases (20–25 m). Average sale price was AU$3000 per hectare. Lease conditions require site development within 3 years, i.e., at least one longline per ha, otherwise the lease is cancelled. After 3 years lease can be sold, although the auction attracted no speculators. Additional leases will be available in future (14 × 27 ha, > 30 m). Leases likely to be initially for *Mytilus edulis* culture, with scallop culture later. Scallop culture in Port Phillip Bay will rely on natural settlement, although hatchery development is proposed.

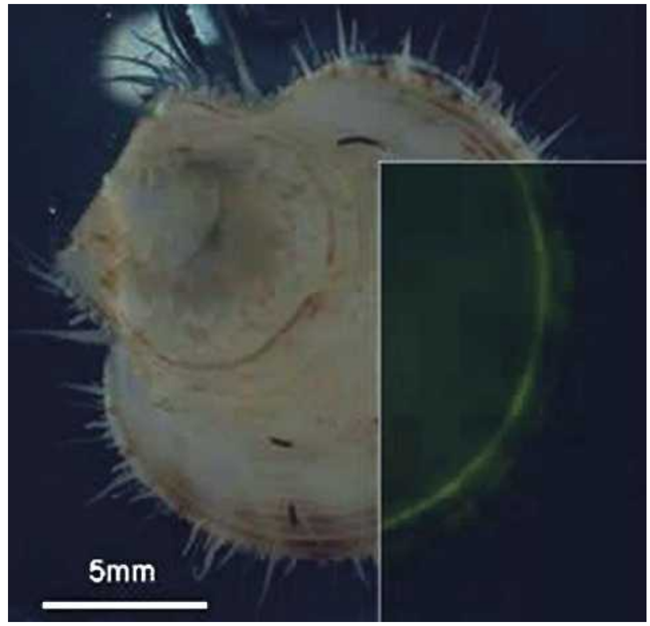
There are no seabed leases and dedicated restocking is not allowed. The issue of seabed property rights has yet to be addressed.

Queensland

Queensland Sea Scallop (QSS) Ltd, established in 2002, comprises 24 local share holders, 6 full-time and 5 casual employees. The company conduct spat (hatchery) production and seabed ranching operations with *Amusium balloti* in Hervey Bay, where they have unique seabed leases totalling 72 km^2.

An 80,000 L larval-rearing capacity hatchery was constructed in 2004/05, and has mixed-species algal production capacity of 800 L/week from batch culture and 1,500 L/week via a Bayes system. Approximately 500,000, 4 mm spat were seeded in 2004, 3,000,000 in 2005 and 5,000,000 in 2006 (total 8.5 million). Harvest of hatchery-produced scallops occurred in 2005, with intended expansion to densities of 1 scallop/m^2 on seabed sites. Future programme development includes multiple research projects; marking hatchery spat (see below), broodstock maturation, modelling hydrology, algae and larvae dispersion around seeding sites and hatchery-bacteria control.

Identification of hatchery-reared animals is important for gauging stocking success, differentiation from natural settlement, ownership issues etc, but molecular markers are expensive and require specialised facilities. Several chemical dye markers are being trialled; calcein, oxytetracycline and alazarin red, all having a shell-calcium binding mechanism. Fluorescent bands (Figure) are visible under hand-held UV light for the first two chemicals, and under normal light for alizarin red. Ongoing work is investigating tag longevity, toxicity effects and multiple applications for cohort differentiation.



Tasmania

Main Tasmanian hatchery (Shellfish Culture Ltd) is not currently producing scallop spat, since their single customer is now focussed on mussel culture. The hatchery is producing mainly oyster (*C. gigas*) spat.

Western Australia

The *Amusium balloti* hatchery and seabed culture operation in WA has finished, mainly due to variable results in hatchery production following the stocking of 12 million spat in 2003. Broodstock nutritional status may be a critical factor in variable larval quantity and quality. The hatchery has now closed and the leases are likely to lapse.

No scallop production or research activity is reported from New South Wales, South Australia or Northern Territory.

A NEW *PECTEN* FROM WESTERN AUSTRALIA. **Peter F. Duncan**. Faculty of Science, Health and Education, University of the Sunshine Coast, Maroochydore DC, Queensland, 4558, Australia; and **Gary Wilson.** Little Grove, Albany, Western Australia, Australia.

The genus *Pecten* (Muller 1776) comprises approximately 15 species, distributed throughout temperate and tropical seas (Rombouts 1991). In 2004 five intact, paired shell-valves of a

Pecten-like shell were diver collected in approximately 40 m depth from two sites in sub-tropical/tropical Western Australia. Sites were approximately 200 km apart at Exmouth Gulf (site 1) and Gnaraloo (site 2) with two specimens from site 1 and three from site 2. Sites were limestone reef with coral-sand substrate. The specimens were unlike any previously described from WA, or from Australian waters, and as such warranted further investigation.

Shell Descriptions

Shell valves are typically *Pecten* in form (Djikstra 1999). Specimens from both sites have differences in external shell characters, although they appear closely related. All specimens are adult, with a mean dorso-ventral length of 42.82 mm (SD = 3.80, n = 5), and anterio-posterior length of 47.58 mm (SD = 4.53, n = 5).

Left valves are concave (Gnaraloo) or very strongly concave (Exmouth) with 14–16 strong radial costae, more pronounced in Gnaraloo specimens. Weak secondary radial ribs occur on some Gnaraloo specimens. Commarginal lamellae are well defined in Gnaraloo specimens, but weak in Exmouth specimens. The ground colour is off-white, with predominantly light pink (Exmouth) to red-pink (Gnaraloo) blotchy pigmentation over the entire valve. Distinct white (unpigmented) chevrons, symmetrical and centred on principal costae, open ventrally and incorporate a black border on the closed, dorsal end. The umbonal region is off-white or, more typically, pigmented pale pink reflecting overall valve colour. Auricles are lamellate, equal, with colour reflecting general valve pigmentation, and showing a part-chevron pattern.

Right valves are convex or strongly convex with 16–20 strong radial costae. All specimens show strong to weak bifurcation on the costae, particularly in Gnaraloo shells. Colour is white or off-white and marked with small orange, pink or red blotches or striations, stronger in Gnaraloo specimens, weaker in Exmouth specimens. Exmouth specimens show orange-pink pigmentation marginally and on the auricles. The interior of both valves is glossy white, with marginal pink colouration in strongly pigmented specimens.

The most comparative taxa appears to be the Asian species *Pecten excavatus* (Anton 1838) = *P. sinensis* (Sowerby II, 1842) = *P. puncticulatus* (Dunker, 1877).

Methods, Results and Discussion

Genetic analysis of WA specimens is not possible due to lack of tissue samples. Instead, statistical comparison of shell characters was used to compare taxa (with *P. excavatus* from Japan). Multiple shell parameters were measured and compared using discriminate function analysis in SPSS.

Results indicated that pooled WA (n = 5) and Japanese specimens (n = 6) differed significantly in external rib counts of both shell valves (WA 15.6 ± 0.89 cf Japan 14.0 ± 0 for left valve, and WA 17.75 ± 1.71 cf Japan 17.0 ± 0 for right valve), $P < 0.002$ for left valve external ribs and $P = 0.00$ when external ribs on both valves were compared together, i.e., populations could be definitively separated using external rib counts from both valves.

Investigations indicate that the newly discovered pectinid from tropical Western Australia appears related to *P. excavatus*, which has previously only been reported from China (the type locality), Japan, Korea and Taiwan (Bernard *et al.* 1993). The WA specimens indicate at least a significant range extension, and a new addition to the Australian pectinid fauna. However, significant differences in external morphology and shell colour suggest that WA specimens are not the same as typical *P. excavatus*. Given the large geographic distance separating previously reported locality records for *P. excavatus* it seems appropriate to assign subspecific status, and possibly full species status to these specimens. Ongoing analysis may provide additional support for this conclusion.

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SCALLOP DREDGE SELECTIVITY: A REVIEW OF SEQUENTIAL RING SIZE INCREASES FROM 1994 TO 2003 IN THE U.S. SEA SCALLOP FISHERY. **William D. DuPaul** and **David B. Rudders**. College of William and Mary, Virginia Institute of Marine Science, 1208 Greate Rd., Gloucester Point, VA, 23062, USA.

In the 1990s a series of changes to sea scallop (*Placopecten magellanicus*) dredge ring size were initiated in an attempt to delay age of harvest and result in an increase in yield-per-recruit. The first change occurred in 1994, increasing the ring size (internal diameter) from 3″ (72 mm) to 3.25″ (83 mm) and then to 3.5″ (90 mm) in 1995. The most recent increase occurred in 2003 with an increase to 4.0″ (102 mm). In support of the regulatory changes in dredge ring size, comparative gear studies were conducted aboard commercial sea scallop vessels. The objective of these studies was to evaluate the relative effect of increasing ring size with respect to size selectivity and efficiency. By utilizing commercial vessels, two dredges can be simultaneously towed. This paired design allows for catch comparisons between a dredge equipped with rings conforming to current regulations and another identically rigged dredge with the exception of rings that represent the size corresponding to the proposed increase. In total, 161 comparative tows were sampled over three trips in support of studies examining the 3.25″ (83 mm) dredge; 301 comparative tows were sampled over five trips in support of studies examining the 3.5″ (90 mm) dredge, and 197 comparative tows were conducted during the 4.0″ (102 mm) rings dredge studies. Results indicate that an increase in

dredge ring size both increases the harvest efficiency of larger scallops while concurrently reducing the capture of smaller scallops. The shell height at which a relative change in harvest efficiency occurs, varies and is dictated by both the internal diameter of the ring and the dimensions of the inter-ring spaces. The reduction in the relative capture rates of smaller scallops realized by the increase of dredge ring size has positive implications for the resource and fishery. By allowing the smaller scallops to pass through the rings and inter-ring spaces, small scallops are left on the sea floor and the rates of both direct and incidental fishing mortality is reduced. The benefits to the fishery by reducing mortality on smaller scallops are realized in terms of increased yield-per-recruit and a potential increase in spawning potential.

ZYGOCHLAMYS PATAGONICA FISHERY: BY-CATCH DATA FROM THE "OBSERVERS ON BOARD PROGRAM" (INIDEP). **Mariana Escolar, Mariano Diez, Angel Marecos, Silvana Campodónico, Eduardo Vallarino, Laura Schejter** and **Claudia Bremec.** CONICET–INIDEP, Paseo Victoria Ocampo 1, Mar del Plata (B7602HSA), Argentina.

Since the beginning of the Patagonian scallop fishery in 1996 (Res. ex-SAGPyA N°150/96), an Observers On Board Program (INIDEP) was established. Observers are technically qualified to collect information about fishing practices. This information is a useful tool to evaluate the relationships between the non-target organisms and the resource, regarding to fishery fluctuations, together with the information from annual monitoring and evaluation cruises developed by the INIDEP (Schejter and Bremec 2007). Considering that bottom otter trawls scrape the seabed affecting the substrate as well as densities of the benthic species (Bergman *et al*. 1992; Orensanz *et al*. 1991; Lasta and Bremec 1998), the goals of this study were to build a database with information on catches, by-catches and fishing efforts (trawls shots number by area and year) provided by the observers and to determine the invertebrates by-catch composition between 1997 and 2002 in commercial fishing grounds of Patagonian scallops in the Argentine Sea.

Data of 640 samples were selected from ~1000 data registered from fishery trawls shots carried out by the commercial fleet at the Patagonian scallop grounds (discarded data correspond to incomplete information). The material collected was gained with non-selective bottom otter trawl by the F/V "Erin Bruce", "Mister Big", "Atlantic Surf I", "Atlantic Surf II" and "Atlantic Surf III", between 1997 and 2002. In all trips, daily samples (Vol.: 10 lt.) were taken from the total catch. Abundance (when possible) and wet weight of commercial (≥55 mm total shell height) and non-commercial Patagonian scallops, by-catch species, invertebrate remains and scallop shells were measured by observers onboard. The database was made considering fishery vessel, trip, date, initial and final trawl position, depth, trawling time and speed, trawl distance, swept area and species biomass. By-catch species were grouped into major taxa (Echinodermata, Brachiopoda, Porifera, Gastropoda, Ascidiacea, Anthozoa, Decapoda, Polychaeta) and biomass (wet weight (g)/100 m^2) was estimated for the analysis.

Although these are preliminary results, they revealed that the scallop biomass was always higher than the by-catch and the scallop shells. During the study period the scallop biomass varied between 98.7 and 3161.7 g/100 m^{-2} (values corresponding to San Blas bed (39°48′S, 56°10′W) 1999 and SWTango B bed (43°30′S, 59°36′W) 1999, respectively) and the by-catch biomass between 31.9 and 503.1 g/100 m^{-2} (values corresponding to San Blas 1999 and 2002, respectively). The shells biomass ranged between 0.017 and 325.3 g/100 m^{-2} (values corresponding to Valdes bed (42°24′S, 58°24′W) 2002 and SWTango B bed 1999, respectively). Regarding by-catch groups, Echinodermata dominated in almost all fishing grounds, reaching approximately 86% of the total biomass. On the other hand, in Tres Puntas bed (46°47′S, 65°24′W), Brachiopoda was the most abundant group, reaching approximately 94% of the total biomass during 2002. The relative % biomass of other taxonomic groups varied in the different grounds.

Summarizing, the composition of each analyzed catch by the observers onboard, was always dominated by the resource, the Patagonian scallop. The development of a historical database of the fishery will permit future analysis of long-term ecological effects and the relationship between the fishery disturbance and the benthic community structure, taking into account areas with different levels of commercial fishing effort. These data are useful, in coincidence with detailed sampling developed annually at laboratory, and the Observers Program should be enforced.

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THE ROLE OF TELOMERES IN THE SHORT LIFE-SPAN OF THE BAY SCALLOP, _ARGOPECTEN IRRADIANS IRRADIANS_ (LAMARCK, 1819) AND SOME POSSIBLE BENEFITS OF TELOMERE EXTENSION. **Stephen L. Estabrooks**. Nantucket Marine Laboratory, 6 Williams Street, Nantucket, MA, 02554, USA.

The life spans of eukaryotes can be determinate or indeterminate. Examples of the latter are found from sponges to lobsters to rainbow trout that reproduce and grow until disease, predation, or environmental circumstances end their lives. Their tissues continually express the enzyme telomerase, theoretically keeping sufficient telomeres on the end of their chromosomes to avoid individual cell senescence and death. Bay scallops, on the other hand, have a well-defined life span, generally between 18–22 months in the Northeast, and reproduce usually once.

Argopecten irradians irradians (L.) has been found to possess fewer telomeres than a close relative, *Argopecten purpuratus* (L.), a cold water species found along the coasts of Peru and Chile that can live to 7 years or more. *Argopecten purpuratus* contains significantly more telomeres than *A. irradians* in their respective tissues. It is proposed that the short lifespan of *A. irradians* may not be a selective advantage, but rather due to an evolutionary loss of telomeres through Robertsonian fusion and extensive chromosome arm loss.

It is proposed that the bay scallop, by doubling its weight post-spawning and storing nutrients in the form of carbohydrates, lipids, and protein for the upcoming winter, is preparing for subsequent reproductive events, but rarely survives to completion. This life history suggests that *A. irradians* is not a semelparous species (one-time reproduction) but rather an example of interrupted iteroparity (repeated reproduction) caused by losses in its genome. Adding telomeres to the ends of chromosomes of *A. irradians* may "restore" this species to a normal life span with several reproductive seasons ahead. In years when larval recruitment failure occurs without concomitant loss of adult spawners, local populations could recover in as little as a single season.

ABSORPTION OF PARALYZING TOXINS FROM THE DINOFLAGELLATE *GYMNODINIUM CATENATUM* IN GIANT LIONS-PAW SCALLOP *NODIPECTEN SUBNODOSUS*. **Norma A. Estrada[1], Felipe Ascencio[2], Rubén G. Contreras[1], Marcelino Cereijido[1], Liora Shoshani[1], Rafael Torres[3]** and **Nestor Lagos[3]**. [1]Departamento de Fisiología Biofísica y Neurociencias, Centro de Investigación y Estudios Avanzados del IPN, Av. Instituto Politécnico Nacional, 2508, Col. San Pedro, Zacatenco, C.P. 07360, México D.F., Mexico; [2]Departmento de Patología Marina, Centro de Investigaciones Biológicas del Noroeste (CIBNOR), La Paz, B.C.S., Mexico; [3]Departamento de Fisiología y Biofísica, Universidad de Chile, Santiago, Chile.

Microscopic algae, including some dinoflagellates and diatoms, produce some of the most potent toxins, such as paralyzing toxins in the dinoflagellate *Gymnodinium catenatum*. These are involved in a reversible and highly specific block of ion transport by the sodium channel and affect the action potential in excitable membranes. Mollusks acquire these microalgae by filtration consumption and accumulate the toxins in several tissues. Researchers understand the molecular workings in vertebrates of many of these powerful toxins once they are ingested; however, they know far less why bivalves and other invertebrates have the capacity to accumulate large amounts of toxins and how they are transported to different tissues without apparent harm to the invertebrate. We are attempting to bridge this gap in knowledge by studying transport mechanisms involved in entry and accumulation of toxins in cells, with emphasis on the mechanisms governing the cellular and molecular physiology of transepithelial transport in scallops. Juvenile giant lions-paw scallop *Nodipecten subnodosus* were exposed to paralyzing toxins by feeding on the dinoflagellate *G. catenatum* and by injection with an extract of paralyzing toxins. In this report, we discuss experiments related to accumulation and transport of paralyzing toxins in juvenile *N. subnodosus*.

SOME RECENT TRENDS IN MAGDALENA BAY PACIFIC CALICO SCALLOP POPULATIONS. **Esteban Fernando Félix-Pico, Marcial Arellano-Martínez, Mauricio Ramírez-Rodríguez** and **Jorge López-Rocha**. Centro Interdisciplinario de Ciencias Marinas-Instituto Politécnico Nacional, Apdo. Postal 592, Ave. IPN S/N, Col. Playa Palo de Sta. Rita, La Paz, B.C.S., C.P. 23096, México.

Scallops have been an important fishery and under intensive exploitation in México. Commercial fishing activity began in Magdalena Bay in 1970, and at the 1989 and 1990 annual landings averaged about 25,000 ton. The scallop fishery is notoriously variable, so by 1991 to 1995 landings had declined to about 270 ton; and again low production in 1999 and 2000 with only 100 ton. The most recent trends related to catch increased from 2004 to 2005 to 12,000 ton. This decline has served as an impetus for fishery enhancement through aquaculture. The State of Baja California Sur has keeping the production leader with more than 95% of the Mexican production (Anónimo 2003, Félix-Pico 2006).

Material and Methods

At the beginning, in the 1970s, scallops were collected by divers operating from boats using hookah gear, the same equipment now still used. Dredges were never used. At each fishing ground, 50 to more than 800 boats worked. Unified effort data for scallops are scarce in México. The ideal measurement of effort would involve some measure of diving gear or number of divers per compressor and the time of diving, e.g., catch /No. divers h^{-1}. The catch is then reported as whole shellfish, meat, and muscle in kilograms. But usually effort data consists at best of catch boat day^{-1}. Catch per unit effort (CPUE) has analyzed data collected in 2005.

Results

According to the statistical fishery data from the SAGARPA (Anónimo 2003), the catch can be all year, however there are dates of beginning and end of season for each fishing ground. In Magdalena Bay, historical data showed the season was from June to December. Recently, the maximum monthly catch was from May to July for 16 station catches.

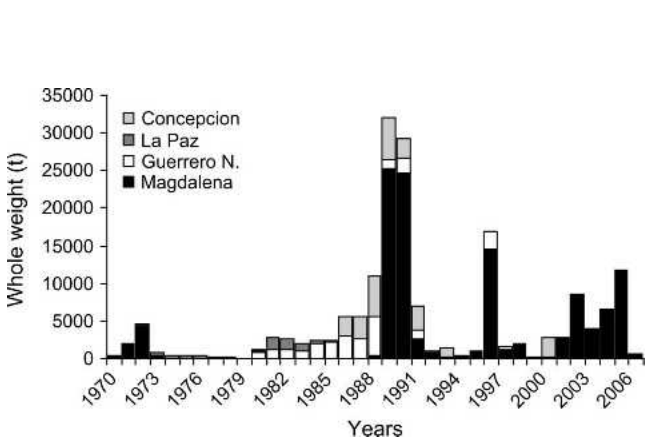

Figure 1. Total annual catch in t of scallops in B.C.S, Mexico.

The fishery of Magdalena Bay collapsed suddenly after 4 years of intensive harvest. The fishery peaked in 1989, when about 25,290 ton was landing. The landings of scallop from 1970–2006 averaged 3,950 ton year^{-1} in Magdalena Bay (Fig. 1). These beds were the first exploited on a commercial scale and the fishery expanded rapidly. In 1970, a fishery started at Magdalena Bay, but they have never reached the size of the Gulf of California fisheries (Concepción Bay, Los Angeles Bay and La Paz Bay). From 1975 to 1987 there was a radical change in the fishery, with the catch falling in only 20 t. As the fishery expanded the number of boats increased. The number of fishing boats had risen to more than 92 for each fishing season. In 2005, scallop landings reached 11,700 ton (value $3.9 million US dollars). In 1990, scallop landings reached more than 20,000 t, with fishing boats increased to 871 and now it is restricted to 324 boats.

For the *Argopecten ventricosus* fishery, Felix-Pico (2006) reported that at the Ensenada de La Paz grounds, catch averaged 29–35 kg muscle/boat day^{-1} during the 1975 season. Masso-Rojas (Massó Rojas 1996) on the same grounds reported the average catch (CPUE) was 25 kg muscle/boat day^{-1} during the 1977–78 season. The number of boats working was 35 for 20 days. Recently, for Magdalena Bay the average catch (CPUE) was 18.7 kg muscle/boat day^{-1} during the 2005 season. The number of boats working was 324 for 20 days.

The best prices are usually obtained in August to January in the U.S.A. market and shows recent market prices for frozen muscle, an almost doubling in price. The Mexican scallops are small and cheap. There were plenty calico Chinese bay scallops at prices averaging between $1.80 and $2.50 US dollars lb^{-1}, depending on size, through the winter of 1995. For 2005 the catarina scallop price was lowest $1.48 US dollars lb^{-1}.

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INNOVATIVE TECHNIQUES THAT ENABLED PECTEN UPM/MFU INC. TO TRANSFER JAPANESE SCALLOP CULTURE OPERATIONS TO NEW BRUNSWICK, CANADA. **Bruno Frenette**. Pecten UPM/MFU Inc., Shédiac, New Brunswick, Canada E4P 2G1.

Japanese are the scallop aquaculture pioneers and their culture techniques have been adopted by many growers in various countries. On the coast of New Brunswick, Canada, the company Pecten UPM/MFU Inc. is no exception. However, the Japanese techniques had to be modified for the Canadian east coast. The dynamics of the open water setting have necessitated changes in the long line structure, especially the anchoring system. Also, the traditional Japanese gears (lanterns, pearl nets) had to be adapted. Pecten UPM/MFU Inc. introduced many improvements since 1997 and produced innovative techniques that contributed to an effective scallop aquaculture operation.

OPEN WATER AQUACULTURE OF THE GIANT SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) IN NEW BRUNSWICK, CANADA. **Bruno Frenette**. Pecten UPM/MFU Inc., 408 Main St., Shédiac, New Brunswick, Canada E4P 2G1; **André Mallet.** Mallet Research Services, Dartmouth, Nova Scotia, Canada.

In collaboration with local fishermen corporations on the eastern and northeastern coast of New Brunswick, Canada, the non-profit organization Pecten UPM/MFU Inc. initiated a feasibility study on the open water aquaculture of giant sea scallops (*Placopecten magellanicus*) in October 2004. Three stocks of 1-y-old scallops (shell height <20 mm) were deployed at two locations in the Baie des Chaleurs and one location in the Northumberland Strait all with water depths >18 m. The scallops were deployed in two types of culture cages attached to submerged longlines positioned approximately 7 m off bottom.

In October 2006, there was a small but significant difference in mean shell height among sites (range: 56 to 59 mm). The "Stock × Site" interaction term was not significant, which indicated that all three stocks grew consistently across sites. Also, no significant difference in growth performance was detected between the two cage types. Survival rates of 2-y-old scallops (<35 mm) exceeded 90% at all sites in 2005, but in 2006, survival was markedly different among sites. In the Bay of Chaleurs, 3-y-old scallops exhibited 50% survival at one site and 65% at the other. In contrast, at the Northumberland Strait site, a survival rate of 98% was recorded.

Although the mean monthly temperature and the monthly degree days were comparable among sites, the two Bay of Chaleurs sites showed substantial temperature fluctuations (August-September) that were not observed at the Northumberland Strait site. It appears that this unstable temperature regime may account for the relatively poor survival of the 3-y-old scallops deployed at the Baie des Chaleurs sites.

DEVELOPMENT OF IMAGING HARDWARE AND AN OPTICAL IMAGE DATABASE AND PROCESSING TOOLS FOR AUTOMATED CLASSIFICATION OF BENTHIC HABITAT AND ENUMERATION OF COMMERCIALLY IMPORTANT SCALLOP STOCKS. **Scott M. Gallager, Jonathan Howland,** and **Amber York**. Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA; **Richard Taylor** and **Norman Vine**. Advanced Habitat Imaging Consortium; **Lakshman Prasad, Sriram Swaminarayan** and **Rajan Gupta**. Los Alamos National Laboratory, Los Alamos, NM 87545; **Paul Rago** and **Dvora Hart**. National Marine Fisheries Service, Woods Hole, MA 02543; and **Gregg Rosenkranz**. Alaska Department of Fish and Game, Kodiak, AK 99615 USA.

Understanding and characterizing benthic habitat is essential for multi-species management and for detecting how organisms respond to both short and long-term sources of environmental change. Optical imaging provides multi-scale information from microns to 1000's km with the ability to visually identify substrate and epi-benthic organisms. However, the volume of data requires automated tools to realize the goal of broad-scale habitat classification. Using high resolution, digital color imaging systems we are currently surveying ocean bottom along the Northeast coast from Georges Bank to the Mid Atlantic Bight, and along the shelf of the Gulf of Alaska. More than 3,000,000 images (12 TB) have been collected this year. From these surveys we selected 20,000 images from each of four regions representing diverse substrate and faunal composition. Each image is classified both manually and automatically. Manual classification is by substrate type (e.g., mud, sand, cobble), organism taxon (e.g., scallop, starfish, flounder) and size of each target. Automated classification begins with image correction for color, light field illumination, background and foreground segmentation based on texture and color, and extraction of segmented regions of interest (ROI). A classifier (Support Vector Machine) is trained with a library of targets from the manually identified database. Associations of targets with texture categories are made through discriminate analysis. Size, shape and density of scallops and other benthic organisms are added to a georeferenced database for later display, visualization and analysis of population distributions using spatial statistics. Segmentation of foreground targets from background substrate is the most challenging problem. Our unique collaboration intends to bring advanced techniques to bear on this problem.

A YEAR IN THE LIFE OF NORTH WEST SHELL FISH LTD, IRELANDS LARGEST SCALLOP (*PECTEN MAXIMUS*) PRODUCER. **Jerry Gallagher**. North West Shell Fish, Upper Carrick, Carrigart, Letterkenny, Co. Donegal, Ireland.

North West Shell Fish Ltd is a family owned company dedicated to scallop production in Mulroy Bay, Co. Donegal situated on the northwest coast of Ireland.

The company is totally dependant on spat from wild collection in the bay which is a limiting factor to increased production as spat numbers are low in collectors annually.

In 2006 we received grant assistance from BIM, Ireland's sea fisheries board who among their other duties have responsibility for assisting new technologies within the fisheries and aquaculture industries. Part of this project involved us deploying 45,000 extra collectors bringing total spat collectors to 120,000 in 2006.

Our year begins with preparation of spat collectors in early summer. We begin plankton monitoring in early June which continues until end of July detecting scallop larvae and stages of development. We deploy collectors at various intervals during June–July when scallop larvae are due to settle.

We sort spat collectors from September until December and put spat into either trays or lantern nets for on-growing.

From December until May we wash and prepare spat collectors, carry out predator control using crab pots and seed the previous years spat which have now grown to 4–5 cm at 18 months.

We also continue harvesting which is an all year round activity.

This presentation is given in video form as poster presentation and is a voiceover.

FLOW CYTOMETRY AS A TOOL TO STUDY IMMUNOCOMPETENCY IN *PLACOPECTEN MAGELLANICUS*. **Sophie Gauthier-Clerc** and **Jocelyne Pellerin**. Institut des Sciences de la Mer, Université du Québec à Rimouski, CAMGR, 6 rue du parc, C.P. 340, Grande-Rivière, Qc, Canada G0C 1V0; **Michel Fournier.** INRS-Insitut Armand-Frappier, Montréal, QC, Canada; and **Michel Lagacé**. SEPAQ, Québec, Qc, Canada.

Haemocytes are the immune cells of bivalves. They are actively involved in immune defense in term of cellular and humoral immunity. The characterization of haemocyte subpopulations and the analysis of their specific functions are required to assess the entire immunocomptency of animals in response of environmental factors or bacterial challenge. Classic methods in cytology are time costing and unrealistic to be used in routine. Nevertheless recent publications demonstrate the relevance of flow cytometry to identify haemocyte subpopulations in bivalves as well as some of their properties and functions.

Objectives

We intended to characterize haemocytes subpopulations in *Placopecten magellanicus* with a flow cytometer. We also investigated the production of reactive oxygen species in immune cells.

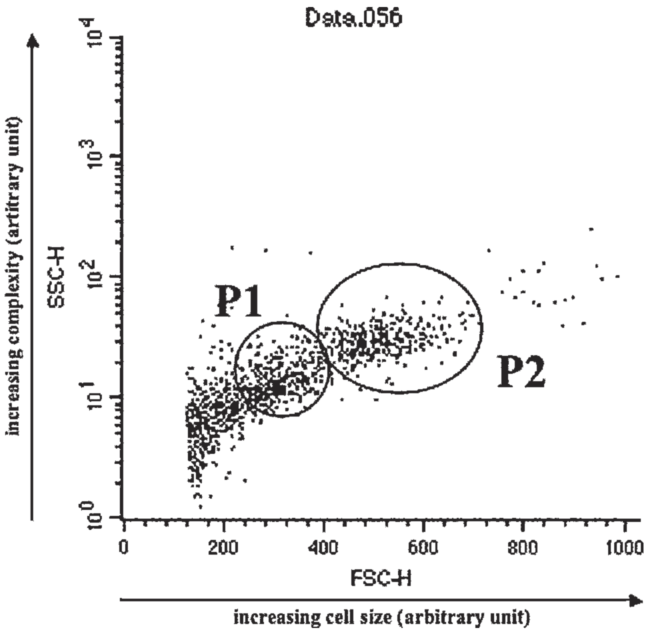

Figure 1. Discrimination of two haemocyte subpopulations (P1 and P2) in *Placopecten magellanicus* with the FACS Vantage flow cytometer.

This property also called ''oxidative burst'' is required to neutralize pathogens engulfed in cells by phagocytosis.

Material and Methods

A FACS Vantage flow cytometer (Becton Dickinson Immunocytometry Systems) was used to characterize haemocytes subpopulations of *Placopecten magellanicus* according to their size (forward scatter) and sub-surface complexity (side scatted). Fluorescent probes were used to detect NOx or H_2O_2 in cells and assess their production by the haemocytes exposed to immunostimulants (PMA, zymosan particles).

Results and Discussion

The flow-cytometric analysis clearly discriminated two haemocyte subpopulations on SCC-FSC density plot (Figure 1) in accordance with previous classifications realized with classic cytological methods (Auffret 1988). We detected higher NOx and H_2O_2 concentrations in P2 subpopulations which increased in response to cell immunostimulation with PMA. These results promote the use of fluorescent probes to assess the oxidative burst in scallop cells. Such assay would improve the diagnostic of immune cell competency.

This work represents a first step using the flow cytometry to characterize two haemocyte subpopulations in *Placopecten magellanicus* and some of their functions. Further investigations would be conducted to study immune defence mechanisms in scallop haemocytes and their efficiency in response to pathogens, environmental parameters or contaminants as already investigated in *Crassostrea virginica* (Hégaret *et al*. 2003, Goedken and De Guise 2004).

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EVALUATING THE SUCCESS OF USING PEDIVELIGERS AS A RESTORATION TOOL FOR BAY SCALLOPS. **Stephen P. Geiger** and **William S. Arnold**. Florida Fish & Wildlife Research Institute, 100 8th Ave. S.E., St. Petersburg, FL, 33701, USA; and **Jay R. Leverone**. Mote Marine Laboratory, Sarasota, FL, USA.

Release of bay scallop (*Argopecten irradians*) pediveligers is showing promise as a novel strategy for rebuilding collapsed populations of this species. The technique takes advantage of the ability to inexpensively produce a large number of larvae using well-established methods while avoiding the costly process of raising post-set individuals in the hatchery. However, measuring the success of this technique has been difficult. To date, we have completed six bay scallop restoration events in three Florida estuaries using hatchery-reared larvae and are now focusing on increasing our ability to assess post-release survival. For each event, roughly two million pediveliger larvae were released into two to four enclosures, which are designed to prevent larval dispersal. Enclosures, which encompass an area of roughly 87 m^2 each, were placed within healthy seagrass (*Thalassia testudinum*) beds to provide maximum settlement substrate and remained in place for 1–3 days to allow the larvae to complete metamorphosis and settlement. Settlement was monitored by anchoring artificial collectors (nylon scour pads) inside and outside each enclosure. In one event, seagrass was also collected from inside and outside the enclosure to look for spat. We have conducted surveys in the footprint of the enclosure for juvenile scallops at three months post-release and adults at nine months post-release.

The settlement rate on the artificial substrate has ranged from 0–2,220/m^2 inside the enclosures and 0–173/m^2 outside the enclosures. Settlement on seagrass was 3 times higher than on artificial substrate. Qualitatively, more larvae settled on artificial substrates when the enclosures were left in place for three days and fewer larvae settled on collectors when the enclosures were left in place for a single day.

Post-release surveys for juveniles and adults within the footprint of the enclosure have been generally disappointing, but long-term results in the targeted restoration populations have been very promising in at least one case, and encouraging in others. The surveys have found juvenile scallops at 0–1.6 per m^2 and adults at 0–0.3 per m^2. Both high-end values came from a single larval release experiment where there was a distinct patch of scallops within the footprint of the enclosures (more than 2 orders of magnitude above background levels). Survival between settlement and age 3 months was 0.023 and was 0.1875 between age 3 months and age 9 months.

Our recommendations for the use of this methodology include: carefully timing the release to coincide with the onset of metamorphosis, maintaining the enclosures for at least three days and increased monitoring of post-release abundance including examination of natural settlement substrates. During future restoration attempts we plan to continue to optimize both our release strategies and our assessment methods.

ABUNDANCE AND DISTRIBUTION OF CALICO SCALLOPS (*ARGOPECTEN GIBBUS*) ON TWO HISTORIC FISHING GROUNDS. **Stephen P. Geiger, Janessa Cobb, Brett Pittinger** and **William S. Arnold**. Florida Fish & Wildlife Research Institute, 100 8th Ave. S.E., St. Petersburg, Florida, 33701, USA.

Calico scallops supported a commercial fishery in the southeastern United States for over four decades. In Florida's waters, calico scallop landings declined from a peak of 42.7 million pounds of adductor muscle meats landed in 1984 to none landed in 2004 or 2005. One historic fishing ground, near Cape Canaveral, Florida, produced the majority of all calico scallops landed. It was well studied before the peak of the fishery through a series of NOAA surveys that lasted from 1954–1976, was the focus of renewed interest during the expansion of the fishery in the mid-1980′s and has been poorly studied since complete collapse of the fishery in the late 1990′s. A second fishing ground off southwest Florida has received almost no prior scientific study and is known primarily through verbal accounts of the fishing community. Removal of large quantities of scallop shell and other shell as bycatch has been hypothesized to have depleted the essential fisheries habitat for settling veligers.

The goal of this study was to describe current abundance and distribution of calico scallops, shell, and associations between spat and its preferred substrate on these two historic scallop fishing grounds. We conducted a series of eight surveys to describe current abundance and distribution in two regions. On each survey, we conducted 15, randomly placed, 5-minute scallop dredges in each of four zones for a total of 60 samples per survey, and a total of 480 overall. We recorded start and stop time and location, depth, and wire length. Catch data included total weight, number and weight of scallops, scallop shells and other shell, and number and weight of live macrofauna, identified to the lowest taxon practicable at sea. Photographs and voucher specimens were preserved for many but not all unknown specimens. We also recorded observations of any calico scallop spat and their settlement substrate if possible. Scallops were considered to be spat only if they were less than 20 mm if loose, but always as spat if bysally attached to a substrate.

On the Cape Canaveral fishing grounds, scallops were collected at 40% of the stations, spat at 23% of the stations, and both calico scallop shell and other shell at greater than 90% of the stations. Spat were most commonly found on scallop shells (70%), but were also found on other shells, loose, on rocks, live calico scallops and trash. Overall, shell from other molluscs was slightly more abundant than scallop shell. We collected from 55 to 105 separate taxa per survey. Potential predators included *Portunus gibbesii* (also common in the Gulf), *Astropecten articulatus*, and *Distorsio clathrata*.

On the southwest Florida fishing grounds scallops were collected at 20% of the stations, spat at 9% of the stations, scallop shell at 70% of the stations, and other mollusc shell at 85% of the stations. Rocks and hard bottom were common. Spat were most common on other mollusc shells (64%) but were also found loose, on rocks, and on calico scallop shells. Shell from other molluscs was 20 times as abundant as scallop shell. We collected roughly 65 separate taxa per survey.

Our findings suggest that the Cape Canaveral calico scallop bed currently has a similar spatial extent that described in historic records, and that calico scallops are seasonally abundant and are associated with shell deposits. The southwest Florida scallop bed is limited in extent and abundance. Calico scallop spat were most common in areas where adult calico scallops and calico scallop shells were abundant. However, when scallop shell was not abundant, spat appeared to be most common on the most abundant substrate.

SPATIAL SCALES AND MODELLING OF AQUACULTURE/ECOSYSTEM INTERACTIONS. **Jon Grant.** Dalhousie University, Dept. of Oceanography, 1355 Oxford Street, Halifax, Nova Scotia, Canada B3H4J1.

Coastal zone management (CZM) requires a balance between multiple resource users and preservation of marine habitats. Among coastal impacts, bivalve culture generates lots of angst, much of it unnecessary. Traditionally, CZM has been more oriented toward social science rather than natural science. Predictive ecosystem modelling has potential as a quantitative tool in CZM, but is often seen as too complex or arcane for broad-scale application. A hierarchy of models allows increases in complexity as management need arises, ranging from index models to box models to fully spatial GIS models. All of these share a strong physical-biogeochemical coupling and links to PNZ (phytoplankton-nutrients-zooplankton) ancestry. Application of these models to scallop aquaculture impacts is presented as a means of assessing carrying capacity as well as environmental impact of culture.

FORCE RECORDINGS DURING ESCAPE RESPONSES BY *PLACOPECTEN MAGELLANICUS* (GMELIN): SEASONAL CHANGES IN THE IMPACT OF HANDLING STRESS. **Helga Guderley** and **Xavier Janssoone.** Département de Biologie, Université Laval, Québec, Québec, Canada G1K 7P4; **Madeleine Nadeau**. Centre Maricole des Iles–de-la-Madeleine, Direction de l'Innovation et des Technologies, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Cap-aux-Meules, les Iles de la Madeleine; **Mélanie Bourgeois** and **Hernán Pérez Cortés**. Département de Biologie, Université Laval, Québec, Québec.

During the vigorous escape response of scallops, rapid adductions of the valves can propel scallops considerable distances. The strength of the escape response varies according to the danger a predator presents (Legault and Himmelman 1993). Scallop physiological status modifies the escape response, with reproductive investment and thermal stress changing aspects of the escape response (Brokordt *et al.* 2000a, b; 2006; Lafrance *et al.* 2003). Seasonal changes in escape performance and in the response to stress may occur given changes in muscle physiological and metabolic status (Hall *et al.* 2002). We used force recordings during escape responses to evaluate whether the impact of handling stress on force production and contraction rate of juvenile *Placopecten magellanicus* varies seasonally, examining both phasic and tonic contractions.

Results and Discussion

Handling stress coupled with air exposure reduced the contractile performance during escape responses of 2+ scallops, *Placopecten magellanicus*, modifying maximal and mean phasic force production, the number of phasic contractions and the minimal interval between phasic contractions as well as reducing maximal tonic force production and increasing the reliance upon tonic contractions. The impact of handling stress was mitigated in scallops studied in the fall (late October) relative to the summer (late June and late August), with smaller declines in performance for all parameters examined.

Seasonal changes in escape response performance by control scallops were few, with virtually no change in maximal or mean phasic force production, in the number of phasic contractions or in the minimal interval between phasic contractions. As the scallops sampled in October had lower condition indices than those sampled in summer, the reduced impact of handling stress was likely due to the lower air and water temperatures in the fall. This suggests that transfers of juvenile scallops during culture operations should be done during cooler periods. Force measurements during escape responses are a sensitive, but simple tool with which to assess the status of scallops as they clearly reveal the marked impact of handling stress as well as more subtle seasonal changes.

	June		August		October	
	Control	Stressed	Control	Stressed	Control	Stressed
Claps, 60 s	16.2 ± 6.1	1.8 ± 3.8	24.9 ± 8.3	3.9 ± 5.3	21.0 ± 6.7	7.1 ± 5.1
Claps, 120 s	21.3 ± 7.3	2.3 ± 4.6	30.2 ± 8.8	4.6 ± 5.8	26.9 ± 8.5	10.2 ± 5.9
Claps, 180 s	25.2 ± 8.7	2.5 ± 5.1	33 ± 8.9	5 ± 6.3	30.8 ± 9.2	12 ± 7.2
Mean phasic force, N/cm^2	2.42 ± 0.41	0.41 ± 0.60	2.41 ± 0.38	0.53 ± 0.47	2.31 ± 0.81	0.99 ± 0.55
Min. phasic interval, s	0.69 ± 0.41	3.5 ± 6.2	0.33 ± 0.13	2.01 ± 2.78	0.55 ± 0.27	0.82 ± 0.59
Maximal tonic force, N/cm^2	14.6 ± 2.9	11.1 ± 3.5	13.4 ± 2.3	7.9 ± 3.6	9.7 ± 3.2	6.8 ± 2.6
% Tonic, 60 s	54.7 ± 18.5	83.6 ± 26.6	59.4 ± 15.6	64.6 ± 32.9	45.5 ± 24.6	82.3 ± 14.8

Data are shown as X ± S.D, n = 50 scallops.

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THERMAL SENSITIVITY OF THE ESCAPE RESPONSE OF THE GIANT SCALLOP, *PLACOPECTEN MAGELLANICUS*. **Helga Guderley, Hernan Perez Cortes** and **Stéphanie Labbé-Giguère.** Département de Biologie, Université Laval, Cité Universitaire, Québec, Québec, Canada G1K 7P4.

Temperature affects ectotherms at virtually all levels of organisation. The rates of critical biological functions, such as locomotion, are particularly likely to be affected by temperature. The giant scallop swims or jumps to avoid predation by sea stars. The scallop uses jet propulsion consisting of series of adductions and abductions of its valves using the adductor muscle and the hinge ligament. Giant scallops occur over a wide latitudinal range, but occur at greater depths further south, perhaps to avoid higher temperatures. During culture operations, scallops are often maintained in suspension, exposing them to higher and more variable temperatures than occur in their natural habitats. Knowledge of the thermal sensitivity of the escape response would help assess whether the temperatures encountered during suspension culture are stressful. Thus, the aim of our study was to evaluate the thermal sensitivity of the escape performance of giant scallops. Given that tonic contractions should be energetically less costly than phasic contractions, the reliance upon tonic contractions should increase as the phasic contractions become limiting. This leads to the prediction that phasic and tonic contractions have opposing thermal sensitivities. We also evaluated the thermal sensitivity of two glycolytic enzymes, pyruvate kinase and octopine dehydrogenase in the adductor muscle to assess whether the metabolic support to muscle activity shows the same thermal sensitivity as does the activity itself.

Methods

The escape responses of juvenile scallops (3.5 cm in shell height) were monitored using force measurements (Fleury 2005). Scallops were first tested at 6°C and then gradually transferred to and maintained at 12°C for 5–6 days before escape response measurements. Finally the animals were gradually transferred to and maintained 5–6 days at 18°C before escape response measurements. Enzyme activities were measured at 6, 12 and 18°C. These temperatures correspond to those experienced by cultured scallops in the Magdalen Islands, Québec, Canada.

Results and Discussion

As predicted, phasic and tonic contractions showed contrasting responses to temperature. Scallops performed more phasic contractions at 6°C than at 12 or 18°C. On the other hand, phasic force production was almost independent of temperature. The utilisation of the catch muscle increased at higher temperature and tonic force production increased slightly at 18°C. The thermal sensitivity of tonic and phasic contractions indicates that swimming performance of the scallops is better at lower temperatures. On the other hand, both enzyme activities were higher at 18°C than at 6°C. These results indicate that the thermal sensitivity of the escape response is not set by these enzyme activities. Visual observations of escape response performance by juvenile scallops measured in September indicated that performance was better at 12°C than at 6 or 18°C. As the average temperature in the lagoons of the Magdalen Islands increases during the summer, the giant scallop may change its thermal sensitivity to maintain better escape response performance.

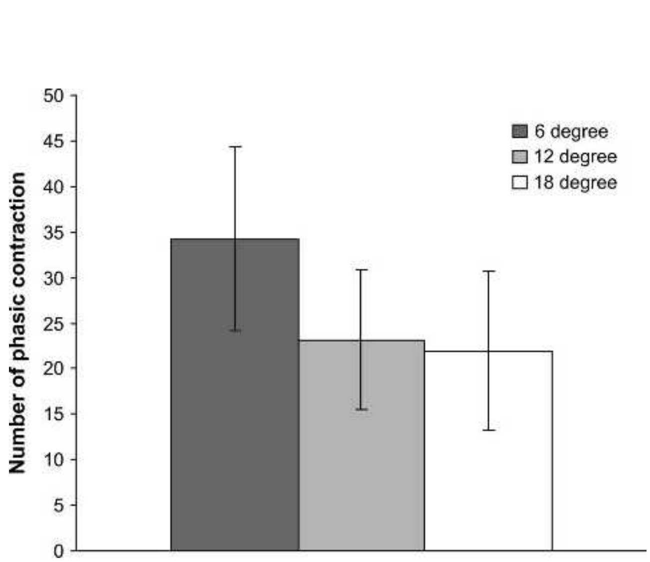

Figure 1. Number of phasic contractions performed by *Placopecten magellanicus* at 6, 12 and 18°C (mean ± SD).

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IMPACT OF INTENSIVE BUT SHORT-TERM COMMERCIAL SCALLOP DREDGING ON SOFT BOTTOM SCALLOP HABITAT OF THE TASMANIAN COMMERCIAL SCALLOP FISHERY (*PECTEN FUMATUS*), AUSTRALIA.

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In October 2005, an Industry conducted survey identified a commercial quantity of scallops, *Pecten fumatus*, in a region known as White Rock, on the east coast of Tasmania, Australia. Under Tasmania's detailed spatial management strategy, a small region (approximately 460 square km), which incorporated the known scallop bed, was opened to commercial harvesting from 26th June 2006 until 30th December 2006. During this period, the open region was sub-divided and systematically opened in a series of rolling openings, which were ultimately initiated and conducted by Industry. Approximately 3800 tonnes shell weight, or 90% of the annual Tasmanian total allowable catch, was taken from the White Rock open region during 2006.

The data collected by Industry vessels during the October 2005 survey provided detailed knowledge of scallop stock abundance and population structure for areas falling within the open region prior to the opening, which allowed the prediction of what areas within the open region would be fished. Furthermore, there was knowledge that some areas within the scallop bed would not initially be harvested. This detailed information provided a unique opportunity to conduct a detailed Before After Control Impact (BACI) study, using real commercial scallop dredging as the impact. A series of surveys were subsequently designed and conducted at various periods throughout the 2006 Tasmanian scallop fishing season. Dredged benthic community data, sediment data and water quality data were collected from randomly selected stations within four strata (three fished and one control) within the White Rock scallop bed before fishing commenced, after / during fishing with a control site, and after the control site had been fished. Vessel Monitoring System data suggested homogenous distribution of fishing effort within the four strata.

The main aim of this study was to determine any impacts of scallop dredge fishing on the dredged benthic communities found in scallop beds within the Tasmanian scallop fishery, and relate any changes to sediment structure/water quality changes (BACI designed study). Furthermore, the potential flow-on effects of sediment plumes/ water quality on protected (not fished) areas of the one scallop bed was explored. This paper provides initial results of this study.

EVALUATION OF LENGTH-BASED MODELS FOR ASSESSING THE U.S. ATLANTIC SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) FISHERY. **Deborah R. Hart, Larry D. Jacobson** and **Alan Seaver**. Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543 USA.

Length-based models are an alternative to traditional age-based methods that are especially useful for species where ageing is difficult, as is the case for many invertebrate species. For sea scallops, the first one or more annual shell growth marks are often unclear, making absolute age determination problematical. Nonetheless, the distance between marks records the annual growth increment of the shells. These increments can then be used to estimate growth transition matrices. We have developed a length-based stock assessment model, "CASA-neuvo", based on the CASA (catch at size analysis) model of Sullivan *et al*. (*Can. J. Fish. Aquat. Sci*. 47:184–198), that combines fishery-dependent and survey data with the growth transition matrices from shell increment data to estimate stock biomass, fishing mortality and fishery selectivity. We then linked this model to a spatial simulation model in order to validate the assessment model and to test its robustness to violations of assumptions. In particular, we investigate how spatial heterogeneity in scallop abundance and fishing mortality affect model results. Dynamic length-based models such as the one discussed here may be useful in assessment of many invertebrate and fish stocks.

EFFECTS OF HARMFUL ALGAE ON PHYSIOLOGY AND HEMOCYTE PARAMETERS OF THE NORTHERN BAY SCALLOP, *ARGOPECTEN IRRADIANS IRRADIANS*. **Hélène Hégaret** and **Sandra E. Shumway**. Department of Marine Sciences, University of Connecticut, 1080 Shennecossett Road, Groton, CT, 06340, USA; **Gary H. Wikfors**. NOAA-NMFS, Milford, CT, USA.

Bay scallops, *Argopecten irradians irradians*, were exposed to several harmful algal bloom (HAB) species within their range from Atlantic Canada to the mid-Atlantic U.S. coast. Recent population declines of this sub-species are often attributed to habitat loss, but at least one example of near extirpation of local populations by a HAB, *Aureococcus anophagefferens*, has been documented in the south-shore bays of Long Island, New York, during the 1980's. Possible impacts of other HABs upon bay scallops have not been studied; therefore, we conducted laboratory studies exposing bay scallops to cultured HAB species and measured several response variables.

Hatchery-reared scallops were exposed to bloom concentrations of three species of harmful algae (*Alexandrium fundyense*, *Prorocentrum minimum* and *Heterosigma akashiwo*) as well as a benign control, *Rhodomonas* sp. and clearance rates were measured. Effects of HABs upon scallop clearance rates were species-specific. In separate experiments, scallops were exposed to the same three species at bloom concentrations for two days before being removed and placed individually in basins containing filtered seawater (FSW). Biodeposits were collected after 24 and 48 hours to assess the presence of intact harmful algal cells in the feces. Biodeposits were also transferred into tubes containing FSW for culture, to assess the potential for recovery of harmful algal blooms from the feces. Most HAB taxa passed intact and viable through the scallop digestive system. Accordingly, mitigation methods to limit the risk of transplant of harmful algae were assessed, leading to tentative recommendations for a "depuration" step before transplant.

An experiment was also conducted exposing bay scallops to the toxic dinoflagellate *Prorocentrum minimum* at a natural bloom concentration for 7 days. Previous experiments have shown lethal and sub-lethal, pathological effects of this alga upon scallops, such as systemic hemocyte aggregation and degradation of digestive diverticula. This experiment assessed the effect of a continuous exposure of bay scallops to *P. minimum* for 7 days on their hemocyte parameters: viability, phagocytosis of plastic microbeads, aggregation and production of reactive oxygen species, using flow cytometry. Results showed significant effects of *P. minimum* on the hemocyte parameters that were dependant upon the time of exposure of the scallops to this harmful alga.

These studies, cumulatively, demonstrate the potential of HABs to impact northern bay scallop populations in essentially all parts of the range of this sub-species.

EFFECTS OF THE PHYSICAL ENVIRONMENT ON SCALLOP GROWTH AND ABUNDANCE. **Antonio Hervas** and **Eimear O'Keeffe**. Martin Ryan Institute, National University of Ireland, Galway, Ireland; **Oliver Tully**. Bord Iascaigh Mhara (The Irish Sea Fisheries Board), Dublin, Ireland; **Alan Berry**. Marcon Computations Ltd., Ireland; and **Gerry Sutton**. Coastal Marine Resource Center, University College Cork, Ireland.

Aspects of the biology of scallop pose real difficulties for stock assessment. There is usually significant spatial variability in population densities, growth, recruitment and exploitation of the resource. As a result, the understanding of the spatial patterns of scallop biology are important if, the management of these species, is to progress.

The physical environment determines the spatial variability in population densities, growth, and recruitment. Scallop populations off the south east coast of Ireland are exposed to different temperature regimes, sediment types and current speeds depending on location. It is expected that these physical environmental factors will have an important influence on scallop growth and abundance.

In this presentation, the relationship between the physical environment and growth and abundance of scallops is investigated to develop spatially based stock assessment methods for the management of these fisheries.

Methods and Results

A number of research surveys were carried out off the south east coast of Ireland to collect biological data on growth and scallop abundance. Data on the physical environment were provided by a hydro-advection model developed for the Irish and Celtic Sea areas and by sediment maps developed with the use of MULTIBEAM acoustic methods. The acoustic information provided by this method, in combination with ground truthing, allows sediment maps of the sea floor to be developed.

Spatially referenced growth data were related to temperature, and shear stress (proportional to bottom current speed) predicted by the hydro-advection model, and depth at the seabed in order to incorporate spatial attributes of variability in growth into the estimation of growth parameters for assessment models. Highest growth rate occur in areas of high shear bed stress and highest water temperature.

Growth data and assumed rates of natural mortality, in relation to size at first capture or minimum landing size, can be used to determine the F_{max} fisheries management reference point, or the fishing mortality rate that optimises the yield per recruit. Estimates of F_{max} are higher where growth is relatively low in relation to the assumed annual rate of natural mortality (M) of 0.15. Spatial management of fishing effort, that optimises yield per recruit, should therefore delimit fishing activity along the main gradient in F_{max}. The F_{max} reference points, however, does not take into account impacts of fishing mortality on stock abundance or recruitment and should be used in combination with other reference points in the development of fisheries management strategies.

Surveys were designed in 2002–2004 to investigate the relationship between population densities and acoustic backscatter at spatial scales where variation in larval supply was unlikely to operate. Estimates of log-transformed relative scallop density increased linearly with average backscatter values. In 2005 the acoustic backscatter map was, therefore, used to establish a random stratified survey, from which stock abundance was calculated after correcting for dredge efficiency. The linear relationship between relative scallop density and backscatter values suggests that scallops discriminate, not only between sand and gravel but also between different grades of these sediments. This relationship is used to standardize survey catch data. Also regression diagnostics, of the relationship between acoustic backscatter and survey catch rate, are used to explore changes in annual trends in abundance. Finally the use of commercially derived electronic logbook data, rather than scallop survey data, in combination with the acoustic backscatter map is discussed.

IMPACT OF SCALLOP DREDGING ON BENTHIC HABITAT AND ASSOCIATED FAUNA. **Heather Hunt** and **Stéphan LeBlanc**. Department of Biology, University of New Brunswick, Saint John Campus, P.O. Box 5050, Saint John, New Brunswick, Canada E2L 4L5; and **Hugues Benoît**. Department of Fisheries and Oceans, Moncton, New Brunswick, Canada.

The impact of scallop dredging has been described in certain parts of the world, however even the southern Gulf of Saint Lawrence supports an important scallop fishery the impact it has on benthic fauna (epifauna and infauna) has never been studied. This project will analyze the impact of scallop dredging using a 2 parts study: 1) an experimental scallop dredging study and 2) a comparative study on a commercial scallop fishing ground. With the experimental scallop dredging, we plan to test the impact of low intensity (5 dredge passes over the whole area) and high intensity (15 dredge passes over the whole area) scallop dredging on benthic fauna (large epifauna and macroinfauna) species abundance in the southern Gulf of Saint Lawrence, Canada. The focus will be to determine the immediate impact and the recovery 12 months after the disturbance on 40 m $\times$ 500 m experimentally dredged plots in areas of different habitat complexity (simple, intermediate and complex habitats). The simple habitat (sand/mud) will be located in the Northumberland Strait, while the intermediate and complex habitats (gravel and rocky bottom respectively) will be located in the Baie des Chaleurs. The epifauna (>3 cm) will be described using underwater video footage and the macroinfauna (>1 mm) using replicated benthic grab samples. With the comparative study, we plan to compare epifauna species abundance between a commercially-fished scallop bed and an adjacent buffer zone in the Northumberland Strait. This will be achieved using underwater video footage. Both the commercial fishing ground and the buffer zone were sampled before the 2006 scallop fishery, that occurs between early May to early June, and again immediately after. They will be sampled again 12 months later, before the 2007 scallop fishery. The main goal of the experimental study is to determine the recovery trajectory of different habitat complexity on a time scale similar to the period between fishing seasons following low and high intensity experimental fishing. The comparative study is being applied to describe the impact of scallop dredging at the scale of the commercial fishery, i.e., in a larger scale than the experimental study on epifauna species abundance between fished compared to non-fished following a commercial fishing activity and the recovery again on a 12 month period.

MICROSATELLITE POLYMORPHISM IN *AEQUIPECTEN OPERCULARIS*. **Ana Insua, Alberto Arias, Ruth Freire** and **Josefina Méndez.** Dpto. de Biología Celular y Molecular, Universidade da Coruña, A Zapateira s/n, 15071 A Coruña, Spain.

The queen scallop *Aequipecten opercularis* (L.) is found from Iceland to Norway in the north, and to the Azores and Cape Verde in the southwest, including the Mediterranean (Wagner 1991). It is a highly valued product in the market and one of the species accounting for most of the scallop catches in Europe. Despite the importance of this scallop, molecular markers useful for genetic studies are scarce and based exclusively on protein variation. In this study we report the identification of three microsatellite loci. This type of markers usually displays high levels of polymorphism due to a variable number of short tandem repeats and it is used to investigate the population genetics of a growing number of organisms. Based on the three loci, we examined the polymorphism and genetic differentiation in *A. opercularis* from two geographically distant localities.

Material and Methods

Samples were collected from Ría de Arousa (NW Spain) and Antrim (Northern Ireland). Genomic DNA was extracted following Winnepenninckx et al. (1993). The microsatellite loci were identified from a TTC/GAA microsatellite enriched library constructed according to Billote et al. (1999). Detection of microsatellite alleles was carried out in 30-48 individuals on an automated sequencer. Observed and expected heterozygosities were computed with the program Genetix (Belkhir et al. 2005). Test for departures from Hardy-Weinberg equilibrium, F_{IS} values, genotypic disequilibrium and tests for population differentiation, using allele and genotype frequencies, were computed by Genepop (Raymond & Rousset 1995). The probabilities from these tests were adjusted for an experiment-wise probability of 0.05 using the sequential Bonferroni correction (Rice 1989). Micro-Checker program (Van Oosterhout et al. 2004) was applied to estimate the frequency of null alleles. Genetic differentiation was also assessed using F_{ST} (Weir & Cockerham 1984) and R_{ST} by Genetix and Rst Calc (Goodman 1997), respectively.

Results and Discussion

Partial analysis of the constructed library allowed the design of three primer sets amplifying TTC repeat regions (Gaop14, Gaop45 and Gaop107 loci). The cloned repeats contained 6 (Gaop14), 9 (Gaop45) and 11 (Gaop107) perfect units. The size of the PCR product yielded in the individuals examined covered 123–141 bp (Gaop14), 184–211 bp (Gaop45) and 129–165 bp (Gaop107), defining 13, 7 and 16 alleles, respectively. Loci Gaop45 and Gaop107 showed alleles differing by single-unit sizes but several alleles of the locus Gaop14 did not, suggesting the existence of indels between the priming sites. The observed heterozygosity was high for Gaop107 (0.839 and 0.895 in Ría de Arousa and Antrim, respectively) and moderate-low for the other two microsatellites (0.188 and 0.375 for Gaop14 and 0.200 and 0.070 for Gaop45). The genotypic proportions of the loci Gaop107 and Gaop45 were in accordance with Hardy-Weinberg expectations in the two localities but those of the locus Gaop14 deviated significantly from the expected values. For this locus, the number of homozygotes was higher than expected, which is probably due to the presence of null alleles (frequencies of 0.104 and 0.322 in Antrim and Ría de Arousa, respectively). Genotypic disequilibrium was not found, rejecting linkage of the loci identified. Significant differences in allele frequencies for the loci Gaop14 and Gaop45 were detected, that of Gaop45 remaining significant after sequential Bonferroni adjustment.

After estimate F_{ST} and R_{ST} values for each locus, those of Gaop45 (0.032 and 0.051, respectively) were significantly different from zero at the 0.05 level. According to these data, there is no strong evidence of genetic differentiation between the two localities. Further analysis increasing the sample size would potentially yield more information. On the other hand, it may be interesting to analyze samples from other localities, including those where genetic differentiation was noted by the analysis of protein loci (Beaumont 1982).

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PEC-NORD'S SCALLOP FARMING ACTIVITIES AND ITS CHALLENGES FOR THE UPCOMING YEARS. **Paul-Aimé Joncas**. Pec-Nord inc., 2800, St-Jean-Baptiste, Suite 230, Quebec, Qc, Canada G2E 6J5.

Pec-Nord inc. is a scallop aquaculture company established in 1989 on the Lower North Shore of Quebec (Canada). Pec-Nord's mission ***"To reveal the sea and its flavors"*** is achieved through the high quality seafood it offers. Since the spring 2001, the company sells live cultured sea scallops all year-round. It developed a great expertise in this field and continue to invest an important part of its resources on marketing issues and that's where challenges lie.

SPATIAL MANAGEMENT OF SCALLOP DREDGING: CONSEQUENCES FOR THE RECOVERY OF BENTHIC COMMUNITIES. **Michel J. Kaiser, Jan G. Hiddink** and **Samuel Shephard**. School of Ocean Sciences, University of Wales–Bangor, Menai Bridge, Anglesey, LL59 5AB, UK.

Scallops are harvested using towed dredges on the continental shelves of all areas of the globe. The direct physical impacts of scallop dredges on seabed fauna have been studied experimentally in a number of different habitats. We report a synthesis of outcome of these differing experimental studies using a formal meta-analysis. Compared to a range of other towed bottom-fishing gears, scallop dredging had consistent negative impacts on the abundance or biomass of benthic fauna. However subsequent recovery of the fauna varied among different habitats. This has management implications for the sustainability of scallop dredging as demonstrated by modelling the response of benthic biota to the relocation of scallop dredging effort from one habitat to another.

ENVIRONMENTAL INFLUENCES ON RECRUITMENT OF THE SAUCER SCALLOP *AMUSIUM BALLOTI* IN SHARK BAY AND ABROLHOS ISLANDS, WESTERN AUSTRALIA. **M. I. Kangas, N. Caputi, L. Joll** and **E. C. Sporer**. Department of Fisheries (Western Australia), Western Australian Fisheries and Marine Research Laboratories, P.O. Box 20, North Beach, WA 6920 Australia.

The saucer scallop (*Amusium balloti*) fisheries in Western Australia (WA) has shown large variations in annual catch reflecting variations in annual recruitment in both the Shark Bay and Abrolhos Islands scallop fisheries during the more than 20 years of fishery operation. A negative correlation between the strength of the Leeuwin Current and recruitment had been shown in the 1990s (Joll 1987) and more recent analyses indicate that temperature (a lower average temperature) during the spawning season may have a significant influence on annual recruitment success. A higher than expected recruitment event occurred in Shark Bay in 2006 that coincided with cooler water temperatures. This paper describes the variation in scallop recruitment in the Shark Bay and Abrolhos Islands and further explores the environmental influence on recruitment strength including wind strength, water temperature and Leeuwin Current strength as well as the influence of the spawning stock. This may allow for improved catch predictions and management of the available stocks including resource optimisation.

ASSESSMENT OF SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN COBSCOOK BAY, MAINE. **Kevin Kelly** and **Glenn Nutting**. Maine Department of Marine Resources, P.O. Box 8, W. Boothbay Harbor, ME, 04575, USA; and **Scott Feindel**. University of Maine, Darling Marine Center, Walpole, ME, USA.

A systematic dredge survey (101 tows) to assess the sea scallop (*Placopecten magellanicus*) resource of Cobscook Bay was conducted in November 2006, just prior to the Dec. 1 seasonal opening of the fishery. Cobscook Bay is a large macrotidal estuary in close proximity to the U.S./Canada border at the extreme eastern edge of the Maine coast. It has historically been one of the most productive areas for scallops in Maine and also supports other drag fisheries for sea urchins, sea cucumbers, and ocean quahogs. Although Maine scallop landings are currently low, the value of the inshore fishery is generally among the top ten marine resources for the state, and at times has been valued second only to lobster. Results of the '06 survey were compared to a survey done in 2003 and discussed in light of recently enacted area-specific regulations including an increased minimum size at harvest, minimum meat count, and trip limit. Scallop abundance and recruitment remains highest in Cobscook Bay compared to all other scalloping areas in Maine inshore waters but excessive fishing pressure may still be a concern despite new conservation rules. A high ratio of sublegal to legal-sized scallops occurs in much of Cobscook Bay and shell size frequency data show that most scallops are harvested soon after legal-size (currently 4″ shell height) is reached.

STOCK IDENTIFICATION OF SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) USING GENETIC AND MORPHOLOGICAL MARKERS. **Ellen Kenchington**. Department of Fisheries and Oceans, Bedford Institute of Oceanography, 1 Challenger Drive, P.O. Box 1006, Dartmouth, Nova Scotia, Canada B0J 2L0.

Significant genetic differentiation has recently been detected between pairs of populations of the sea scallop (*Placopecten magellanicus*) sampled throughout its distribution in the northwest Atlantic using six microsatellite DNA markers (Kenchington et al. 2006 Mol. Ecol.15:1781-1796). Isolation by distance explains a significant portion (~20%) of the observed genetic structure, with proximate scallop beds in the centre of distribution showing genetic homogeneity explained by oceanographic current patterns. In this central region scallop beds from the Bay of Fundy (Annapolis, Digby, Brier Island), Georges Bank (Canadian grounds) and Browns Bank were not significantly differentiated and may represent a loosely connected megapopulation (*sensu* Orensanz). However, non-significant F_{ST} does not necessarily prohibit assignment of individuals to putative source populations, an important issue for both enforcement and population dynamics.

To test the ability of these markers to assign individuals to their natal beds individuals from the 1988 year-class from Annapolis (N = 12), Digby (N = 20), Brier Island (N = 32), Georges Bank (Canadian population; N = 8)) and Browns Bank (N = 9) were self-assigned using a bayesian method with random simulation of multilocus genotypes based on allele frequencies using a leave-one out procedure. Classification success was high with 68 of 81 individuals correctly identified (83.95%). The same procedure applied to 11 populations from throughout the species range and combining year-classes was less successful with 326 of 699 individuals correctly identified (46.64%). These results show that even with non-significant F_{ST} values from the central portion of the species range, scallop beds are sufficiently distinct to allow correct assignment of individuals using microsatellite multilocus genotypes provided that year-class is accounted for.

Shell morphometrics can also be used in stock identification. A control (known origin) data set was established containing shell samples from locations on German Bank, Browns Bank and from the largest beds in Scallop Production Area 3, Lurcher Shoal and off Brier Island, all in Canadian waters. These known-area samples were compared with samples seized from a vessel suspected of illegal fishing. Ten measurements capturing aspects of the size and three-dimensional shape of the shell were recorded. In total 58 scallops from Brier Island (SPA 3), 58 scallops from Lurcher Shoal (SPA 3), 153 scallops from German Bank, 284 scallops from Browns Bank, and 100 Seized Samples were processed. A stepwise discriminant function analysis was performed using the morphometric variables, with the known Brier Island (n = 58), Lurcher Shoal (n = 58), German Bank (n = 153) and Browns Bank (n = 284) samples as the training set. The function was able to classify the known samples with 93% accuracy, a considerable improvement over that achieved using genetic markers. When the Seized Samples were classified with this function, 98% were identified as coming from Browns Bank with an average probability of 97%. Sixty-two of the scallops had individual probabilities of coming from Browns Bank of greater than 99% and 91 had individual probabilities greater than 92%. For comparison, when scallops known to come from Browns Bank were tested against the database 97% of them were correctly identified as coming from Browns (when we knew 100% did). These results were able to demonstrate that the scallops in question were illegally fished on Browns Bank. This approach has proven successful at very small spatial scales (between tows in some cases) and utilizes environmentally- induced shell morphometry.

MULTI-DECADAL CHANGES IN THE MEGABENTHOS OF THE BAY OF FUNDY: THE EFFECTS OF SCALLOP DRAGGING AND THEIR IMPLICATIONS FOR RESEARCH AND MANAGEMENT. **Trevor J. Kenchington**. Gadus Associates, 8765 Highway #7, R.R.#1 Musquodoboit Harbour, Nova Scotia, Canada B0J 2L0; **Ellen L. Kenchington**. Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada.

Analysis of presence / absence records from two comparable megabenthic surveys of scallop grounds in the Bay of Fundy in 1966–67 and 1997 showed profound change over three decades. No species are known to have been lost and the average number of taxa per station remained steady. However, spatial heterogeneities in the community were reduced and species composition changed significantly. Many taxa widespread in 1966–67 declined while others expanded, frequencies of occurrence of individual taxa changing by up to 71%. Whelks, the bivalves *Astarte* spp. and *Cyclocardia borealis*, toad crabs, sea urchin and brittle stars showed particular increases. Major declines were seen in boring sponges, horse mussel, Iceland scallop, the fan worm *Pseudopotamilla reniformis* and the stalked tunicate *Boltenia ovifera*. Replacement of attached, fragile, epifaunal, filter-feeding taxa by a combination of motile scavengers, motile filter-feeders and robust, burrowing filter-feeders suggests that the primary (though not the sole) cause of the temporal change was physical impacts by fishing gear – even though groundfish trawling and scallop dragging in the area were never intense and had been in progress for two and four decades, respectively, before the 1966–67 survey.

Contrasting these results with those of other studies throws into sharper relief both the importance of temporal scale and the quantitative nature of the seabed impacts of fishing gears. Following swift but incomplete recovery, in most habitats the visible effects in the track of a dredge are soon lost amongst natural variability, yet on the Fundy scallop grounds the remaining residual effects accumulated over decades. Such changes are inadequately represented by the current two-phase (“pristine” *vs.* “trawled”) model of gear impacts. The effects of dredging must instead be seen as the dynamic responses of benthic communities and habitats to fishing pressure. Hence, further attempts to detect the effects of dredging would waste scarce research resources, which should be directed towards quantification of rates of impacts and recovery, followed by modelling of the responses of the benthos. Meanwhile, qualitative management measures, such as closures, are unlikely to be efficient reactions to quantitative effects. New concepts and management tools that manipulate the dynamic responses to optimally balance resource harvest with conservation of the benthos and its ecosystem services must be developed.

EFFECT OF REPRODUCTION ON ESCAPE RESPONSES AND MUSCLE MITOCHONDRIAL OXIDATIVE CAPACITIES IN THE SCALLOP *PLACOPECTEN MAGELLANICUS*: POSSIBLE IMPLICATION OF PHOSPHOLIPIDS AND FATTY ACID COMPOSITIONS OF MITOCHONDRIAL MEMBRANES. **E. Kraffe** and **Y. Marty**. Unité mixte CNRS 6521, Université de Bretagne Occidentale, Brest, 29238 Cedex 3, France; **R. Tremblay** and **S. Belvin.** ISMER, UQAR, Québec, Canada; **F. Pernet**. IRZC, Shippagan, Nouveau-Brunswick, Canada; and **H. Guderley**. Département de Biologie, Université Laval, Québec, Canada.

Gametogenesis represents a period of high energy demand, and when external food supplies are limited, gamete production occurs at the expense of biochemical components in somatic tissues. In scallops, muscle is one of the most affected tissue, with reserves decreasing and mobilized to support gametogenesis and reproduction activity. This mobilization decreases muscle metabolic capacities with scallops showing a weaker escape response and recuperating slower from exhausting burst exercise (Brokordt *et al.* 2000a, b). Interestingly, this response or recuperation from an exhausting escape response appeared to be related to modifications in oxidative capacities of mitochondria isolated from the adductor muscle (Brokordt *et al.* 2000a, Boadas 1997).

In the present study, we first assessed the impact of the reproductive cycle on muscle metabolic capacities and compared the escape response and capacity for recuperation from exhausting exercise in terms of number of valve claps until exhaustion, rate of clapping and recovery after recuperation in adult giant scallops, *Placopecten magellanicus*, sampled at different stages in the annual reproductive cycle (immature, mature, and after spawning). In parallel, we measured the standard metabolic rate before exhaustion (VO_{2min}) and the maximal metabolic rate after exhaustion (VO_{2max}). Further, the oxidative capacities and cytochrome *c* oxidase (CCO) activity of mitochondria isolated from the adductor muscle were compared. The changes demonstrate a marked effect of reproduction on the escape responses, VO_{2min} /VO_{2max} and functional properties of isolated muscle mitochondria in scallops.

Further, we sought to identify potential mechanisms by which mitochondrial oxidative capacities changed. Specifically, an important level at which adjustments can occur is in the phopholipid composition of membranes with marked shifts in classes and fatty acid composition accompanying seasonal cycles of gametogenesis and spawning in relation to food availability and quality. To test this hypothesis, we examined the modifications of phospholipid and fatty acid compositions, contents of adenylate nucleotide translocase, cytochromes and proteins membrane of adductor muscle mitochondria. Simultaneously, we quantified lipid and fatty acid levels in various tissues to evaluate fatty acid supply modifications of the phytoplanctonic diet during the sampling period. The structural changes in membrane phospholipids contrast with the limited modifications of the membrane protein components and support the concept of specific modifications in membrane lipid composition modulating mitochondrial protein capacities.

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ANNUAL GROWTH LINE FORMATION IN THE DEEP WATER PATAGONIAN SCALLOP *ZYGOCHLAMYS PATAGONICA*. **Betina J. Lomovasky** and **Oscar Iribarne**. Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and Universidad Nacional de Mar del Plata, Mar del Plata, BA, Argentina; **Thomas Brey** and **Andreas Mackensen**. Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany; **Ana Baldoni, Mario Lasta** and **Silvana Campodónico**. Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata, BA, Argentina.

The Patagonian scallop *Zygochlamys patagonica* occurs in beds at depths around 100 m on the SW Atlantic shelf of South America between 36°S and 55°S; and it is an important economic resource in the SW Atlantic. Up to four factory trawlers capture up to 43.000 tons of scallops per year, which correspond to about 6.000 tons of adductor muscle. Present size-at-age keys for *Z. patagonica* are quite different and thus inconclusive, most likely owing to differences in the methods used, such as growth line identification on shell surface, internal growth bands and growth line validation using monthly sampling of terminal growth stage or stable isotope analysis. The purpose of our study is to provide reliable estimates of *Z. patagonica* age and growth to facilitate the management of the Atlantic populations. We combine up-to-date techniques of ageing and age validation with oceanography data to analyze and validate individual age and growth patterns in this species from four large beds across its SW Atlantic distributional range.

Stable oxygen and carbon isotope ratio analysis in scallops from the following beds: URUGUAY, 36°17′S, RECLUTAS, 39°20′S, TANGO B, 42°30′S, and BEAGLE, 55°10′S, in combination with condition indexes and oceanography date strongly suggest that shell growth lines in this species are formed annually. Most growth lines coincide with low values of both $\delta^{13}C$ and $\delta^{18}O$ (i.e., they are formed at times of high remineralization activity and of higher water temperature). This pattern is consistent throughout the distributional range (Fig. 1). Owing to the specific Argentinean shelf oceanography, higher temperatures at this depth occur during austral autumn–beginning winter in the region of RECLUTAS and TANGO B but during summer–autumn at the northern and southern limit of the distributional range.

Besides temperature, alimentation and differential energy allocation are the major determinants of growth. Seasonal oscillation in food supply can cause seasonal oscillation in growth with very slow or even no growth at times of lowest food availability.

Differential energy allocation in somatic (including shell) and gonad production is another common source of seasonal oscillation in shell growth of bivalves. The out-of-phase annual cycles of both gonad and adductor muscle relative condition index in *Z. patagonica* at RECLUTAS point in this direction. Soma is built in summer and early autumn (November to March), whereas gonads are produced in late autumn and winter (May to September), as confirmed by monthly histological analysis, showing that shell growth line coincide with a pause in somatic growth during austral winter, when energy investment is shifted from somatic growth to gonad development.

The observed interconnections between hydrography, primary production and pectinid seasonal growth cycles as observed at RECLUTAS will apply to TANGO B, too, as this scallop bed is governed by the same hydrography. Things may be different at the northern URUGUAY site and the southern BEAGLE site which both are situated in different, albeit opposite hydrographic regimes. URUGUAY bed is represented in part by a higher sea-temperatures, strongest thermocline and different temperature seasonality by

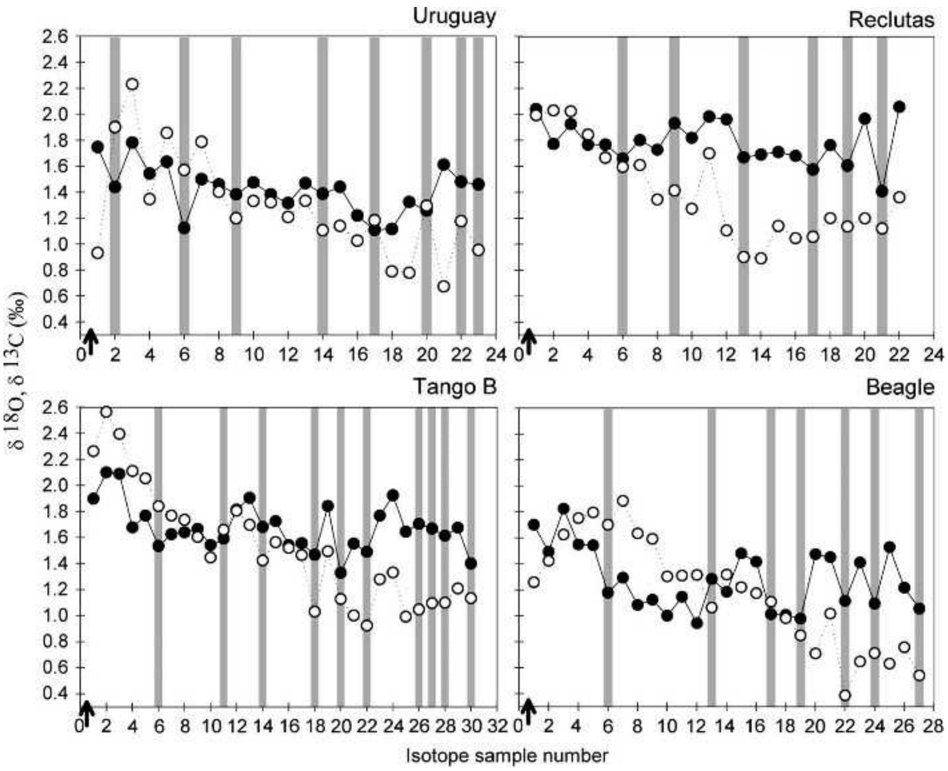


Figure 1. Stable oxygen (dots) and carbon (circles) isotope profiles along transects from the umbo (black arrow) to shell edge and corresponding growth band patterns (grey bars = internal translucent growth bands corresponding to external lines) in individual *Zygochlamys patagonica* from URUGUAY (58.67 mm height), RECLUTAS (54.72 mm height), TANGO B (66.90 mm height) and BEAGLE (63.21 mm height) beds.

the influence of the Subtropical Shelf Front and the Rio de Plata discharge. The opposite process occurs in BEAGLE bed which is characterized by a nearly homogenous water column by continuous vertically mixing and with higher sea bottom temperature amplitude (4.5°C). However, no differences were observed in the interannual variability of oxygen isotopes between beds (corresponding to 1° to 3°C), suggesting that organisms from BEAGLE bed did not deposit shell material through the full range of temperature observed; thus, not growing at higher temperatures. Thus, the mechanism that produces the annual shell growth line at these sites remains unclear so far.

The annual periodicity of external growth lines of *Z. patagonica* validated by oxygen isotopes analyses in combination with condition indexes and oceanography data give the possibility to be used as age approximation in future studies. However, the season of formation of shell growth lines across different beds could be different depending of mechanism acting in the regulation of the reproductive process which is considered as the trigger of shell growth cessation (i.e., indirect mediated by food availability).

FIRST RESULTS OF *ARGOPECTEN PURPURATUS* SPAT OBTAINED SINCE APRIL TO DECEMBER 2006 BY INTENSIVE CULTIVATION IN HATCHERY AND ON THE ARENA BEACH–CASMA, PERÚ. **Juan E. López, Alex Medina, Denny Mendoza, Julio Maidana, Nancy Vásquez** and **Hugo Chávez.** SOMEXPERU S.A.C., FONDEPES, Av. Primavera N° 2525, Dpto. 504, Limatambo, Lima, 41, Peru.

The Peruvian sea is much known in the world because has the better conditions for the growth of the marine life. In the last years the government of Peru prompted the marine-culture and the private enterprises invested in its development. It has been tested that the conditions of this sea prompt the growth of larva in reservoirs. In the initial cultivation the D-larva become a pediveliger larva from 14 to 20 days, these larvae have been fed with *Isochrysis galbana* (T-iso), *Pavlova lutheri*, *Chaetoceros calcitrans*, *Chaetoceros gracilis*, that have been mixed in different percentages. In 2006, we had achieved 9 campaigns and it has been handled 55 cubic meters in the larval phase at most, the average temperature of the culture in the reservoirs was of 19.28°C, and the average temperature of the seawater at the entrance of the hatchery originating from the suction was of 18.43°C.

First day	Campaigns	D Larvae (millions)	Pediveliger Larvae (millions)	Harvest (millions)
19 April 2006	1	559	132	8.83 achieved
23 May 2006	2	660	162	16.44 achieved
11 June 2006	3	735	42	3.46 achieved
25 June 2006	4	655	66	12.23 achieved
26 July 2006	5	1353	267	10.50 achieved
26 September 2006	6	564	114	8.00 projected
26 October 2006	7	818	35	4.50 projected
15 November 2006	8	630	28	3.50 projected
28 November 2006	9	550	26	3.40 projected

Total of achieved spat: 51.46 millions.
Total of projected spat: 19.40 millions.

The above table shows the results obtained of scallop spat with a size average of 1 cm and the projections of the campaigns not harvested.

INFLUENCE OF SPAT ORIGIN AND CULTIVATION AREA IN *CHLAMYS VARIA* GROWTH. **Matías Lozano**, **Juana Cano, Francisco López, M^a Jesús Campos** and **Laura Díaz.** Instituto Español de Oceanografía, Puerto pesquero s/n, P.O. Box 285, 29640, Fuengirola (Málaga), Spain; **Manuel Saavedra.** IFAPA El Toruño, Puerto de Santa María (Cádiz), Spain; **José Luís Márquez, Manuel Marhuenda** and **Carles Lleó.** Promociones Marsan S.L., Santa Pola (Alicante), Spain.

Nowadays, a great interest of developing the culture of the marine bivalves exists, specially the pectinids, as the scallop (*Pecten maximus*) and the black scallop (*Chlamys varia*). The Instituto Español de Oceanografía, together with the IFAPA and the Promociones Marsan S.L. company carries out a research project whose objective is concentrated in evaluating the viability of this kind of culture. Current work investigates *Chlamys varia* growth in suspension, taking into account the influence of the spat origin and the environmental conditions of the culture site.

The research was carried out at four coastal areas: Conil de la Frontera (Cádiz, in southwest Spain) and Coruña (Galicia, in northwest Spain), in the Atlantic ocean, and Santa Pola (Alicante, in east Spain) and Fuengirola (Málaga, in southeast Spain), in the Mediterranean sea. The study took over two years, from November 2004 to January 2007.

The used specimens for this research were obtained by natural settlement through anchored collectors in different sites over two years, from November 2004 to December 2005 (experiment 1) and from November 2005 to January 2007 (experiment 2). Each cultivation site received spat from different origins. Both experiments were started in November.

The *Chlamys varia* spats were maintained in culture in 40 cm diameter oyster culture trays, suspended in a 5 to 10 meters depth over the seabed. A stocking density of 40 individuals per tray was established and the growth was determined by measuring the height (mm) of the shell through monthly sampling of 40 specimens.

Growth coefficient was estimated using "isometric" von Bertalanffy growth equation: $L_t = L_\infty[1 - \exp(-K(t - t_o))]$

Table shows the growth coefficients:

In experiment number 1, results show that spat obtained in Fuengirola and A Coruña located collectors present the highest growth rate and Conil and Santa Pola the lowest ones. Regarding cultivation sites, Fuengirola shows as the best place for suspension culture of *Chlamys varia*. A Coruña and Conil have similar growth rate values and under Fuengirola values. The lowest growth rates were obtained in Santa Pola, though no data from Conil or Santa Pola spat used in this location were available due to the specimen loss at the beginning of the experiment.

	Spat origin							
	Experiment 1				Experiment 2			
Site	A Coruña	Conil	Fuengirola	Santa Pola	A Coruña	Conil	Fuengirola	Santa Pola
A Coruña	0.79	0.55	0.76	0.65	0.90	0.76	0.86	0.40
Conil	0.67	0.58	0.93	0.49	0.60	0.32	0.59	0.49
Fuengirola	0.74	0.72	0.81	0.72	1.19	0.70	0.96	0.78
Santa Pola	0.79		0.43			0.42	0.52	0.54

During the second experiment, results do not differ in a significant amount from those of the previous year. The spat growth in A Coruña and Fuengirola was good, obtaining the highest values in Fuengirola, both for the A Coruña spat as well as Fuengirola spat.

Results obtained from this investigation suggest that zamburiña best suspension cultivation sites are Fuengirola and A Coruña. A Coruña has the best spat quality and Fuengirola is the best culture place. Low spat quality and growth rates were found in Conil and Santa Pola. In spite of growth rate differences, at the end of each experiment all samples reached commercial standing (40 mm in height).

GEAR DEVELOPMENT PROJECT IN PEI, CANADA. **Ron MacLean.** Northumberland Strait Diversification Sea Scallop Research Group, RR # 1 Murray Harbour, PEI, Canada.

From 2000 to 2002, the Botsford Professional Fishermen's Association (BPFA) from New Brunswick experimented with Hillsburn cages which had been designed and used in Nova Scotia. The survival and growth of scallops in the cages were encouraging when the cages were properly placed on the bottom. Conversely, if the cages were not descended carefully they had a tendency to tip over which was detrimental to the scallops. In 2003, BPFA deployed three new cage designs that were constructed specifically to avoid being tipped over. Results were encouraging with each of the new design showing stability. However, additional studies are required to determine the ideal design. It was concluded that bottom culture cages should be constructed so that the last compartment is at least 15 to 20 cm (6 to 8 inches) from the bottom and compartments should be spaced 8 to 10 cm (3 to 4 inches) apart. The stable and low maintenance bottom culture cages greatly interest Prince Edward Island (PEI) scallop fishermen. Many PEI fishermen are also welders and have tools to construct their own fishing gear and could therefore construct bottom cages suitable to their area. A group of 41 fishermen from eastern PEI formed a corporation called "Northumberland Strait Diversification Sea Scallop Research Group". They applied for and have received funding to improve the scallop bottom culture cage. They are also planning to design the cages in such a way as to provide habitat to bottom dwelling animals such as lobsters. In other words the cages would act as temporary artificial reefs.

OSCILLATING TEMPERATURE ENHANCE GROWTH RATE AND SHORTENS GONAD CONDITIONING PERIOD IN MOLLUSKS. **Alfonso N. Maeda-Martínez, María T. Sicard** and **Jose A. López-Sánchez**. Centro de Investigaciones Biológicas del Noroeste, Mar Bermejo 195, Col. Playa Palo de Santa Rita, La Paz, BCS, México, 23090.

The mollusk biology and ecophysiology group at CIBNOR has been working during seven years with the effect of fluctuating temperature on the physiology and reproduction of mollusks, with emphasis in the Pacific lions-paw scallop *Nodipecten subnodosus*.

In the present work, the effect of different thermal (constant vs. oscillating) regimes on scope for growth (SFG) and gonad development of this scallop has been investigated. Results indicate that absorption rate was the component with higher significance in SFG equation, followed by respiration and excretion rates. SFG was nearly three times higher at oscillating compared to constant temperatures, which was produced by an increased filtration rate (24%). This increment resulted in 11.4 J/g/h enhancement of absorption rate and a significantly ($P < 0.05$) higher final biomass at oscillating temperatures. Similar results have been obtained by our group in other mollusks such as *Perna viridis* (unpublished results). Regarding reproductive maturation, results indicate that gonads of immature scallops conditioned at 20 ± 3 °C, reached gonad maturity (40% growth stage, 20% mature and 40% spent stages) in only 15 days. This condition was not achieved in scallops held at constant temperatures and at other fluctuating temperatures of higher amplitudes in the same period of time. These results were confirmed with condition and gonad indices and with quality and quantity of oocytes results.

Our findings applied to hatchery operations and site selection for new aquaculture farms, could have a great economic impact, since culture periods and operation costs could be substantially reduced.

SCALLOP AQUACULTURE IN NORWAY—POLITICAL VISION, OIL MONEY BUT NO COMMERCIALISATION STRATEGY! **Thorolf Magnesen**. University of Bergen, Department of Biology, P.O. Box 7800, Bergen, Norway, N-5020.

After more than 20 years effort to develop scallop (*Pecten maximus*) aquaculture in Norway the scale of operation has reached an interesting level for commercial activities. Most effort during the years has been on hatchery spat production and bottom culture (sea ranching) to increase survival and production. The production stages include intensive hatchery production of spat, intermediate hanging culture and sea ranching in licensed areas protected by enclosures (fences) to reduce predation from crabs. In 2006 the hatchery produced 4,5 million spat of 10-20 mm shell height and two major companies received 2 million spat each.

Scallop aquaculture is a high-cost operation in Norway. The major challenge in developing scallop aquaculture is raising financial support for R&D and particularly for production scale experiments with large biomass. Aquaculture development is high on the political agenda, but governmental funding and support for commercialisation is limited and often of only a few years duration. This put an extra pressure on the need for private capital to investments and running expenses. In addition there are multi-user conflicts in the coastal zone associated with availability of space and manpower.

Major R&D needs in coming years are related to juvenile production, optimising sea ranching and technology development. This includes production of large spat early in the season, nursery technology, development of recirculation systems, large scale diet feed production, broodstock selection and environmental interactions in different sea ranching locations.

A NEW METHODOLOGY FOR HATCHERY FERTILIZATION AND LARVAE ATTAINMENT OF *ARGOPECTEN PURPURATUS*. **Gloria Martinez**, **Livia Mettifogo** and **Miguel A. Perez.** Facultad de Ciencias del Mar, Universidad Catolica del Norte, Larrondo 1281, Coquimbo, Chile, 1781421.

Culture of northern scallop, *Argopecten purpuratus,* has developed extensively for more than 20 years in Chile, following the general methodology described by Disalvo *et al.* (1984). This scallop is a functional hermaphrodite and gamete release is usually, though not always, protandrous. Most of the times, sperm are released first and then, after a resting period, oocytes are released. This reproduction strategy may result in a degree of auto-fertilization, what finally may affect physiological efficiency and consequently, productive characters.

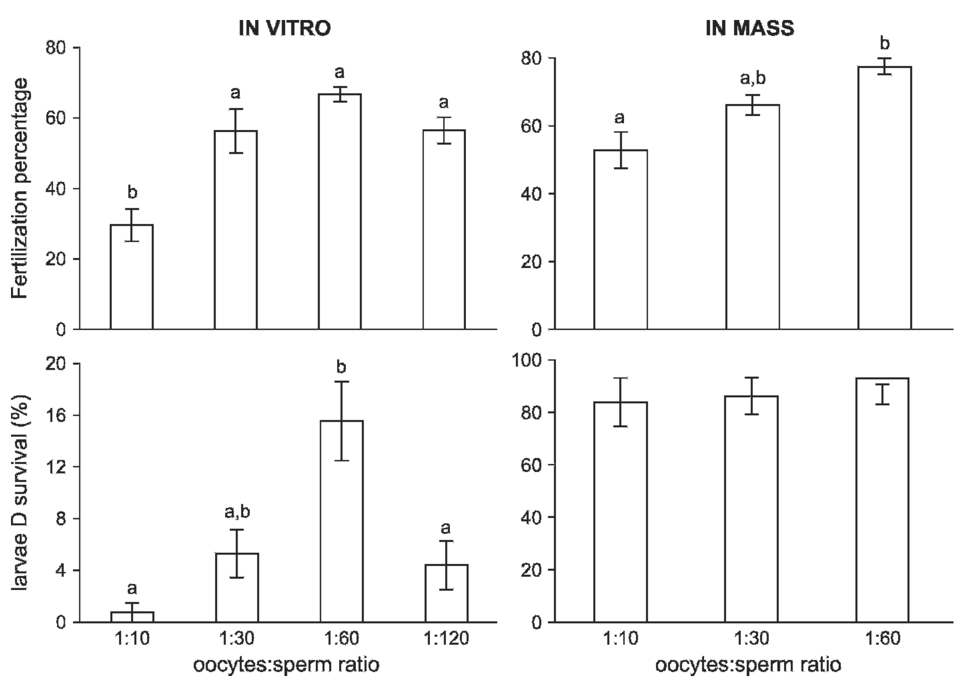
On the basis of the knowledge obtained about the role of serotonin on *A. purpuratus* spawning (Martinez et al., 2000), it was proposed the objective of developing a methodology to fertilize "in vitro" oocytes and so to diminish the inbreeding. The present work was firstly focused to define some parameters to induce oocytes, obtained directly from female gonad, to reinitiate meiosis so they can be fertilized by sperm. Then, oocytes:sperm ratio, pH, and temperature for best fertilization and larvae D survival percentages were investigated.

For resumption of meiosis experiments, gross transverse sections of female mature gonad portions were incubated in 10 or 100 μM serotonin at pH 7.5, 8 and 8.5. The highest percent of meiosis resumption was obtained when gonad tissue was incubated with 100 μM serotonin at pH 8. Then, it was decided to fertilize oocytes obtained under these conditions and this procedure is called fertilization "in vitro". The control procedure is called fertilization "in mass" meaning that oocytes are collected by natural spawning.

The next assay was to determine the best ratio oocyte:sperm for the fertilization. For this experiment oocytes obtained "in vitro" or "in mass" were suspended in a baker and added the corresponding number of oocytes as to get the different ratios in study. After two hours the fertilized gametes were counted under microscope and then left in 10 L seawater at ambient temperature for 48 hours. After this time, samples were obtained to count swimming D-larvae and survival percentages were calculated. Percentages of fertilization and D-larvae survival for fertilization "in vitro" and "in mass" are shown in the forward figure. It is clearly shown that 1:60 is the ratio oocyte:sperm to obtain the best results for these important steps in the attainment of *A. purpuratus* in hatchery. This result does not agree with what has been used for many years in Chilean hatcheries where it has been used to fertilize oocyte under a maximum oocyte:sperm ratio 1:10.

Effect of different oocytes:sperm ratios on fertilization and larvae D survival when oocytes are obtained by incubating pieces of gonad with serotonin (in vitro) or by a normal release from a stimulated scallop (in mass). Values are the mean ± SE (n = 4).

Then, we assayed the two fertilization procedures, under the best parameters already defined, at three temperatures: 15, 17 and 20°C. It was found that it did not affect the fertilization percentages



under any of the fertilization procedures, but did affect D-larvae survival. In both cases, the best D-larvae survival percentage was obtained when embryos were maintained at 17°C.

Although, larvae survival is very low in the first hours when they have been obtained under "in vitro" fertilization, the conditions defined here have been applied to obtain larvae in hatchery. These larvae have grown through metamorphosis and have yielded a much higher juvenile survival than those coming from the traditional fertilization procedure.

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CROSS-FRONTAL VARIATIONS IN RECRUITMENT AND BIOMASS OF THE PATAGONIAN SCALLOP (*ZYGOCHLAMYS PATAGONICA*) IN THE SW ATLANTIC SHELF BREAK FRONT. **Cecilia Mauna** and **Marcelo Acha**. Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Paseo V. Ocampo N° 1, Mar del Plata, Buenos Aires, B7602HSA, Argentina; **Mario Lasta** and **Ana Baldoni.** Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata, BA, Argentina; **Bárbara C. Franco.** Servicio de Hidrografía Naval, Buenos Aires, BA, Argentina; and **Oscar Iribarne.** Universidad Nacional de Mar del Plata, Mar del Plata, BA, Argentina.

Cross-frontal variations in recruitment and adult abundance of the Patagonian scallop (*Zygochlamys patagonica*) at beds located between 38°S and 39°30′S, under influence of the Shelf Break Front (SBF) in the Argentine Sea, were studied based on integrated data from commercial fleets (1996–2005) and research cruises (1998–2005). Annual and seasonal mean climatologies of sea surface temperature (SST) gradients and chlorophyll-a concentration (chl-*a*) were used to locate the SBF mean position and its variability, and estimate the concentration of primary production respectively. The SST gradients were computed using a centered difference scheme based on 13 years (1985–1997) of satellite data of the Pathfinder+Erosion monthly climatology of about 9 km × 9 km resolution. Climatological analyses of chl-*a* concentration were employed based on 7 years (1998-2004) of sea surface color images from Standard Mapped Images (SMI), supply by SeaWiFS. Data from research cruises were used to calculate variations in abundance of recruits (i.e., scallops smaller than 16 mm of total height; less than 1 year old) and abundance of adults (i.e., scallops larger than 55 mm of total height; age range between 4–14 years old). In this sense, fine scale variations in biological and fishery data were analyzed according with their positions across the SBF. To evaluate the effect of the front on scallop abundance the scallop ground was divided in 6 boxes to minimize the latitudinal influence (Fig. 1). The data were related within each box to a cross-frontal location according the initial position of tows obtained by GPS. Differences across-front on recruitment and adult abundance of scallop were tested by one-way ANOVA. The results show that the scallop beds were located mainly at central-western positions of the SBF and their extensions were associated with the seasonal variability of the zonal displacement of the front (~35 km). The annual mean position of the front has a strong effect on the spatial variability of the recruitment (in 3 boxes, $p < 0.004$), within areas where this was successful. The spatial pattern in Catch Per Unit Effort (CPUE) of recruits showed the highest values located to the center-western of the front matching with the highest concentrations of chl-*a*. A similar pattern was found in CPUE of scallop adults considering the data from research cruises (in 5 boxes, $p < 0.0002$) and commercial fleet (in 6 boxes, $p < 0.001$). The observed spatial variability in scallops abundance could be a result of: i) front variability effect on the sinking and settlement at the bottom of recruits and ii) the spatial variability in the food supply from the surface to the beds. Our results highlight the importance of phenomenon like larval retention and bentho-pelagic coupling at the SBF.

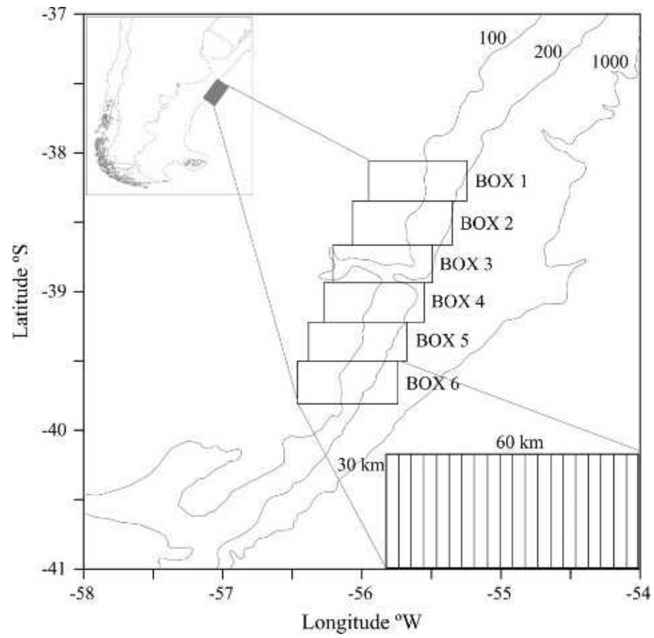

Figure 1. Study area in the South Western Atlantic. Box 1, 2 and 3 belong to "MDQ" bed, box 4 and 5 are including in "Reclutas" bed and box 6 belongs to "San Blas" bed. In the lower right corner there are the schematic box cells. Thin contours correspond to the 100, 200 and 1000 m isobath.

ONTOGENETIC CHANGES IN THE ENZYMATIC ACTIVITY OF BAY SCALLOPS, *ARGOPECTEN IRRADIANS,* AND SEA SCALLOPS, *PLACOPECTEN MAGELLANICUS.* **Lisa M. Milke**. Milford Laboratory, NOAA Fisheries Service, 212 Rogers Ave., Milford, CT, 06460, USA; **V. Monica Bricelj** and **Neil W. Ross**. National Research Council of Canada, Institute for Marine Biosciences, Halifax, Nova Scotia, Canada.

Scallops undergo profound changes in the morphology of feeding organs during larval and postlarval stages. Therefore, ontogenetic changes in the activities of various digestive enzymes might also be expected. Differences in enzymatic activity could be partly responsible for the stage- and species-specific differences in dietary requirements that have been identified among bivalves. If hatchery diets could be tailored to optimize nutrient assimilation over ontogeny, scallop growth and survival could be enhanced during these critical stages. Therefore, the main objectives of this study were 1) to determine the activity of representative digestive enzymes during early scallop development, and 2) to determine if specific activities differ between two commercially important scallop species that are adapted to different environments: the bay scallop *Argopecten irradians* and the sea scallop *Placopecten magellanicus*.

Larval scallops [initial shell height (SH) ~250 μm] were fed a mixed microalgal diet consisting of one diatom (*Chaetoceros muelleri*) in combination with one flagellate (either *Pavlova pinguis* or *Pavlova sp.*; CCMP strain 459), until they attained 4–5 mm in SH. Scallops were sampled at intervals encompassing periods of major gill development. A series of colorimetric assays were conducted to determine the specific activity of two proteases (azocasein and cathepsin B), lipase (esterase), and three carbohydrases (α-amylase, cellulase and laminarinase) in scallop tissues.

Major ontogenetic changes in enzymatic activity were detected in both bay and sea scallops, with the most pronounced differences occurring before scallops attained ~1.2 mm in shell height. While ontogenetic patterns of esterase and protease (azocasein) activity differed between species, the esterase:azocasein ratio was strikingly similar. This ratio was highest during the larval (late veliger) stage, but decreased sharply in immediately post-metamorphic scallops. This may reflect a transition from a primarily lipid- to protein-based metabolism. Bay and sea scallops also exhibited different patterns in α-amylase and cellulase activity over development, whereas ontogenetic patterns in laminarinase activity were similar between the two species. Mean specific activities of the three carbohydrases (across all postlarval SH) also varied between scallop species: higher activities of α-amylase and cellulase were observed in bay scallops, whereas laminarinase activity was twice as high in sea scallops (Figure 1). We speculate that these differences between the two scallop species might result from adaptation to different food sources and food availability in their natural environment.

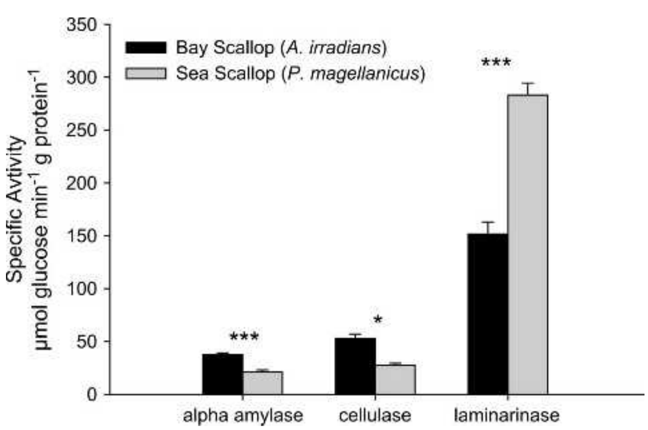

Figure 1. Between species differences in specific activity of the three carbohydrases (α-amylase, cellulase and laminarinase) from whole body homogenates of postlarvae. Values represent means of all postlarval sizes, ± S.E. differences determined by a two-way ANOVA. * = P < 0.05, *** = P < 0.001.

SPECIES-SPECIFIC GROWTH AND CONDITION IN BIVALVE LARVAE DURING THE SUMMER OF 2005 IN WAQUOIT BAY, MA. Christine Mingione and **Scott M. Gallager**. Woods Hole Oceanographic Institution, MS50, Woods Hole, MA 02543, USA; and **Rick York**. Town of Mashpee Shellfish Biologist, Mashpee, MA.

Availability of larvae competent to metamorphose is one of the major sources of variability in marine benthic population dynamics in the coastal ocean. Mortality in the plankton remains one of the more difficult variables to quantify largely because identification to species is often difficult. This is certainly true for marine bivalve larvae where, until recently, their rapid processing and identification from field samples have been hard, if not impossible. Using an automated, machine vision larval classifier that sorts microscopic images of bivalve larvae to species that have been taken under plane-polarized light, images of larvae taken from field samples can be processed rapidly. This process was used to study species-specific growth and food limitation in the plankton over a one-month period in Little River Harbor, Waquoit, MA. Plankton samples were taken periodically throughout the months of July and August 2005 and split into two fractions: One was preserved and the other brought back to the lab for culturing in the absence of predators, but in abundance of algal food. Live larvae were fed *Isochrysis galbana* at 1 × 10^4 cells/mL until they reached pediveliger stage and metamorphosed allowing more positive visual identification by conventional taxonomic approaches. Subsamples were removed from the cultures every 2–3 days for classification and measurement. Field samples were dominated by *Mya arenaria* with considerably lower concentrations of *Crassostrea virginica*, *Mercenaria mercenaria*, *Argopecten irradians*, *Placopecten magellanicus* and *Spisula solidissma*. Larvae from the field were small and contained little chlorophyll in their digestive diverticula throughout the season suggesting poor growth and food conditions. Larvae brought back to the laboratory grew rapidly, had bright green digestive diverticulae, high neutral lipid levels, and most metamorphosed within two weeks. This was particularly true for *M. mercenaria* larvae. Although total chlorophyll levels in the harbor were relatively high, size fractionated chlorophyll showed disproportionately lower levels below 10 μm. We conclude that all species of larvae were food limited, but that

M. mercenaria may be able to take advantage of high food levels more quickly than the other five species. Quantitative results of larval classification and growth will be provided.

AN OVERVIEW OF STOCK ENHANCEMENT AND AQUACULTURE POTENTIAL FOR SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) IN MAINE, USA. **Dana L. Morse**. Maine Sea Grant/UMaine Cooperative Extension, Darling Marine Center, 193 Clark's Cove Road, Walpole, Maine, 04573, USA.

Since 1999, fishermen and scientists in Maine have been working towards a productive approach for stock enhancement of sea scallops (*P. magellanicus*) in the state's coastal waters. Japanese-style spat collectors have been employed effectively for procurement of scallop seed, but subsequent bottom plantings have not proven to be demonstrably successful. Efforts continue in determining the best places and times to deploy collectors, and to create a useful nursery system, so that scallops can be released at a larger size and greater shell thickness.

In addition to the technical challenges and opportunities, the use of spat collection techniques have led to a variety of other issues and activities, such as collaboration with local conservation groups, interest in intensive culture of scallops, and the use of spat collection as an educational opportunity. In this presentation, the current state of stock enhancement, aquaculture, scallop management and opportunities for future work will be discussed.

SIMULATION OF THE SCALLOP DENSITY DISTRIBUTION IN SHARK BAY FROM SURVEY DATA: A CASE STUDY. **Ute Mueller**[1], **Mervi Kangas**[2], **John Dickson**[1] and **Errol Sporer.**[2] [1]School of Engineering and Mathematics, Edith Cowan University, Perth, Australia; [2]Western Australian Fisheries and Marine Research Laboratories, Department of Fisheries, P.O. Box 20, North Beach, WA, 6920 Australia.

The Shark Bay Scallop Fishery is Western Australia's largest scallop fishery. Its boundaries encompass the waters of the Indian Ocean and Shark Bay between 23°34′ south and 26°30′ south together with those waters of Shark Bay south of 26°30′ south latitude. Scallops are usually harvested from May to November and from 1982–2005 the annual catch varied from 600 to 22,000 t whole weight. The scallop fishing vessels include 14 Class A licenses that are allowed to fish scallops only and 27 Class B licenses that can fish both scallops and prawns.

The Research Division, Department of Fisheries WA has since 1982 carried out annual pre-season surveys in November/December to determine the abundance and distribution of recruit and residual scallops to set a season opening date and provide an overall catch estimate to ensure the sustainability of the Shark Bay scallop resource. We discuss the use of conditional sequential Gaussian simulation to model and evaluate the spatial distribution of scallops in the survey region based on the annual preseason survey. Conditional sequential Gaussian simulation is a technique that allows the modeling of reality by generating equiprobable realisations that reproduce relevant properties of a given sample. Such properties include variance, histogram and spatial correlation while ensuring that simulated values at sample locations are equal to the actual sample values.

We discuss in detail the simulation of the spatial distribution of scallops for the 2005 catch based on the 2004 pre-season survey. We produce spatial maps of the expected catch and the associated conditional variance as well as maps of the local probability distributions derived from the data. We use these to evaluate the risk with deciding to fish in a particular region. In addition we consider the question as to how well the survey results predict locations of high/low catch and if this is transferred into actual catches by fishers the following season.

SHORT-TERM DYNAMICS OF SEA SCALLOPS AND THEIR PREDATORS FOLLOWING LARGE-SCALE SEEDING. **Madeleine Nadeau**. CeMIM-MAPAQ, 107-125 Chemin du Parc, Cap-aux-Meules, Québec, Canada G4T 1B3; **Jean-Claude Brêthes**. ISMER-UQAR, Rimouski, Québec, Canada; and **Myriam A. Barbeau.** University of New Brunswick, Fredericton, New Brunswick, Canada.

Commercial-scale seeding operations of juvenile sea scallops (*Placopecten magellanicus*) are done yearly in Îles-de-la-Madeleine (Québec, Canada). Previous studies indicate that seeded scallops are subjected to high predation pressure shortly after seeding. A 3-year study initiated in 2003 was undertaken to investigate the spatial and temporal dynamics of this predation at the spatial scale of commercial seeding operations.

We monitored scallop and predator densities on a seasonal basis and during seeding periods. We used a video camera (SVS S500/21) mounted on a mobile sleigh towed by the boat. Accuracy was assessed for biases due to scallop swimming escapes, identification of scallops, and day/night changes. Predator sizes were adjusted to correct for image distortion. Predation potential was studied with scallops (25-35 mm) tethered on a metal frames (1.2 m × 1.2 m) with 12-cm long tethers. The frames were deployed on the sea bed from a boat and removed after 24-48 hours immersion. Scallop shell remains were used to evaluate predation potential by crabs (crushed shells) and sea stars (entire shell attached by the hinge). Finally, behavioural data were collected during tank trials. These data provided an estimate of the bias associated with the tethering technique, particularly due to escape limitation of the prey.

Predator densities were not affected by the seeding operations in 2003 (5.9 million scallops) and 2004 (8.5 million scallops) (Figure 1). On a seasonal basis, the density and size structure of each predator species was generally stable. Predation potential showed some temporal fluctuations on seeded and control sites. However,

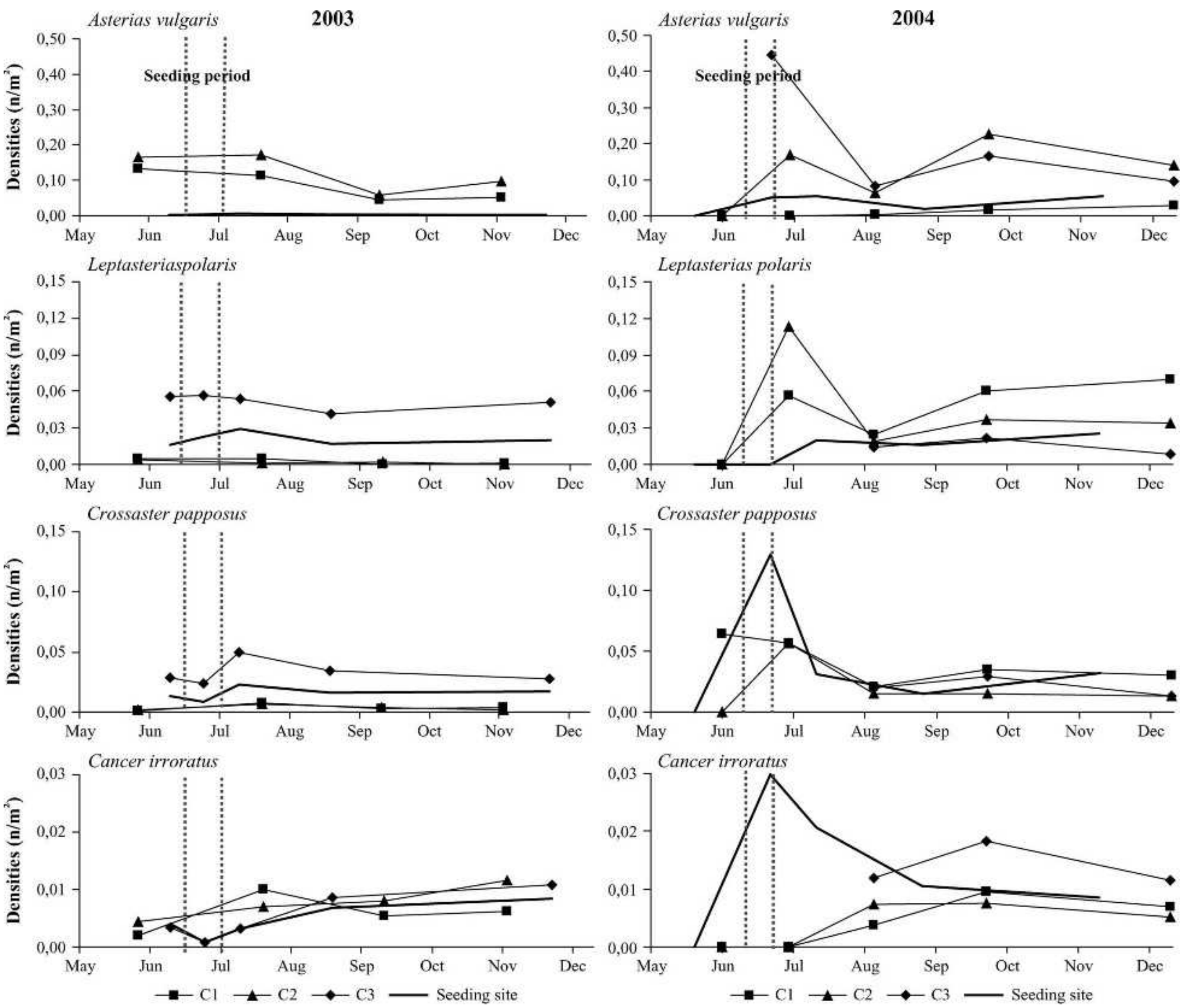

Figure 1. Predator densities on the seeding area and on control (non-seeded) sites (C1, C2 and C3).

these variations were not clearly associated to seeding. In general, losses associated with sea stars and crabs were estimated at 15% and 4%, respectively. According to past studies, predation on tethered scallops may be overestimated. As expected, our behavioural study showed that tethering had little impact on crab predation rate. Surprisingly, the bias caused on sea star predation was also limited. The larger scallop size used in our study than in previous studies may explain this result.

This project collected much information on the dynamics of predators and scallops shortly after large scale seeding operations. These data can be used to develop mathematical models and help the industry in management decisions.

UTILISATION OF GEOGRAPHIC INFORMATION SYSTEMS IN SCALLOP STOCK ASSESSMENT. **Eimear O'Keeffe** and **Antonio Hervas**. Martin Ryan Institute, National University of Ireland, Galway, Ireland; **Oliver Tully** and **John Hickey**. Bord Iascaigh Mhara (The Irish Sea Fisheries Board), Dublin, Ireland; **Gerry Sutton**. Coastal and Marine Resource Centre, University College Cork, Ireland; **Alan Berry** and **Michael Hartnett**. Marcon Computations International Ltd., Galway, Ireland; **Xavier Monteys**. Geological Survey of Ireland, Dublin, Ireland.

The spatial structure and variability in scallop distribution and biology off the south east coast of Ireland were the focus of a five-year project, from 2001–2005, aimed at improving the management of the species. The project undertook a multi-disciplinary approach to the assessment of scallops, which included a biological sampling program, a hydrodynamic model of the South Irish Sea and a seabed mapping survey. The output from these three programmes was integrated using a Geographic Information System (GIS) where various spatial analytical operations were performed.

All data stored in a GIS has positional and attribute information associated with it. This spatial data can be viewed as layers on a map. Each layer can be analysed independently or with respect to one or more different layers. A number of attributes pertaining to a location can be queried together to investigate any patterns or trends that may exist within the area of interest. The results from these queries can be viewed as a new layer on a map and can aid in the ability to understand the effects different factors have on one another in a modelled environment. In this instance, the effects the physical environment has on the biology and distribution of scallops can be visualised to good effect.

The ability to link and integrate spatial data produced from external sources into the GIS enables all factors affecting the behaviour of scallops to be studied. Data from Vessel Monitoring Systems (VMS) provide the location of all scallops boats on an hourly basis. This data can be used to estimate fishing effort. The hydrodynamic model reproduces the observed physical oceanographic features and circulation patterns that develop seasonally in the Irish and Celtic Seas. Images of temperature and stress patterns can be imported into the GIS and used as base layers over which biological survey data can be analysed.

The majority of the data from the biological survey and the seabed mapping project is tabulated and can be easily imported into the GIS. A variety of formats ranging from points on a map to imagery can be extracted from the raw data. Large datasets can be converted into colour-coded layers on a map where each shade highlights a change in the value of the attribute of interest. The ability to visualise this data highlights information that may not have been apparent in tabular format and optimises the information that can be extracted from the data.

MAPPING THE DISTRIBUTION OF DIFFERENT SEDIMENTARY FACIES IN SCALLOP FISHING GROUNDS.
Eimear O'Keeffe and **Antonio Hervas**. Martin Ryan Institute, National University of Ireland, Galway, Ireland; **Oliver Tully** and **John Hickey**. Bord Iascaigh Mhara (The Irish Sea Fisheries Board), Dublin, Ireland; **Gerry Sutton**. Coastal and Marine Resource Centre, University College Cork, Ireland; and **Xavier Monteys**. Geological Survey of Ireland, Dublin, Ireland.

Sediment type is an important factor in the settlement, distribution and abundance of scallops. Existing knowledge of scallop ecology indicates that population distributions are patchy and that high scallop abundance correlates with coarser sediments such as sands and gravels. Multibeam echosounder (MBES) sonar systems have become the tools of choice in the mapping of seabed topography, morphology and sediment characteristics. When used in conjunction with optical imagery (still and video recordings) and sediment samples the composite view that is generated facilitates very detailed spatial characterisation of seabed substrates and habitats.

In order to further study the effects of ground type on the population dynamics of scallop, an acoustic survey of the area exploited by the main scallop fishery in Ireland was commissioned in 2001. The objectives of the survey were three-fold: map the distribution of different sedimentary facies in areas that are fished for scallop to high resolution, correlate scallop catch data from fishing vessels with the backscatter values for the area dredged, and refine the extents of areas of high abundance within known scallop grounds.

Classification of the seabed according to the dominant sedimentary facies was undertaken based on detailed analyses of MBES acoustic data in combination with groundtruthing information from sediment particle size analysis and video imagery. The results of the analysis showed that gravel and coarser sediment-dominated areas were represented by higher acoustic backscatter values. In contrast, the weaker amplitude values identified areas where sandy sediments are the predominant substrate. Although not all the sediment types could be identified by amplitude value alone, the ground types that yield a high abundance of scallop could be readily distinguished from areas that are not favourable to scallops by analysing the returning backscatter signal.

The classified backscatter image acted as a base layer in a Geographic Information System (GIS) over which scallop survey data, collected over a five-year period, could be analysed. Analysis of the data using the GIS enabled the number of scallops caught at each dredged location and average amplitude value for each towed area to be obtained. The results show that there is a significant correlation between the acoustic backscatter value and the number of scallops caught. This information greatly aids the ability to pinpoint areas that maximise yield and reduce dredge hours per quantity of scallop caught. It also aids in predicting stock abundance of scallop, which will ensure the sustainable management of the scallop fishery.

INFLUENCE OF ENVIRONMENTAL CONDITION ON THE GROWTH AND GAMETOGENESIS OF THE JAPANESE SCALLOP, *PATINOPECTEN YESSOENSIS*, IN EAR-SEWING CULTURE IN OGATSU AND ONAGAWA BAY, JAPAN.
Makoto Osada and **Reiko Nakao**. Agricultural Science, Tohoku University, 15 Konorihama-mukai, Onagawa, Miyagi, Japan, 986-2242.

The Japanese scallop *Patinopecten yessoensis* is a commercially important bivalve in aquaculture of northern Japan. Recently a miniaturization of the harvested scallop in ear-sewing culture associated with the depth has been turned into an industrial issue in Ogatsu Bay. The aim of the present study was to demonstrate the environmental factors influenced on the growth and gametogenesis of the ear-sewing cultured scallop investigating environmental condition and biological characteristics of the scallop at four aquaculture sites of Ogatsu (St.1–3) and Onagawa Bay (St.4), Japan for eight months. The growth of shell and soft body of the scallop in Onagawa Bay were greater than that in Ogatsu Bay. The miniaturization of the growth of them associated with the depth was found only in Ogatsu Bay, not in Onagawa Bay where higher organic impact of the sediment was observed. There was no difference of the profiles of temperature, salinity and dissolved oxygen among every site during experimental period. Chlorophyll-a (Chl-a) concentration corresponding to the abundance of phytoplankton in Onagawa Bay was generally higher than that in Ogatsu Bay during the same period. The concentration declined with the depth in both Bays, whereas Onagawa Bay showed at least 1.0 μg/L of Chl-a at the deepest layer, which was higher than that in Ogatsu Bay. It was suggested that the lower food availability resulted in the lower growth in Ogatsu Bay and that food availability corresponding to more than 1.0 μg/L of Chl-a guaranteed a good growth of the scallop in Onagawa Bay. The underdeveloped gonad was observed only at the lower layer of St.3 of Ogatsu Bay although the Chl-a concentration was relatively higher than other sites of the same Bay. The underdeveloped gonad was resulted from small number of gonial cells and oocytes, and lower expression of vitellogenin mRNA and protein due to the small number of auxiliary cell as a vitellogenin-synthesizing cell. It was suggested that the gametogenesis might be influenced not only by food availability but also other factors.

EXPRESSION OF A GENE FROM *PECTEN MAXIMUS* ENCODING AN ABCA TRANSPORTER. **Antonio J. Pazos, Oscar Mauriz, Roi Martínez-Escauriaza, Crimgilt Mesías-Gansbiller** and **José L. Sánchez**. Laboratorio de Biología Molecular y del Desarrollo, Departamento de Bioquímica y Biología Molecular, Universidad de Santiago de Compostela, Instituto de Acuicultura, 15782 Santiago de Compostela, Spain.

ATP-binding cassette (ABC) transporters constitute one of the largest known superfamilies of proteins (Dean and Annilo 2005). The genes for ATP-binding cassette (ABC) transporters encode membrane proteins involved in the transport of compounds across biologic membranes. The functional protein typically contains two nucleotide-binding folds (NBFs) and two transmembrane (TM) domains. There are 48 ABC genes in the human genome divided into seven subfamilies (designated ABC A–G). Previously, we cloned an ABCA transporter from *P. maximus* (Mauriz *et al.* 2005), in the present work we examined its mRNA expression in several scallop tissues.

Material and Methods

The female gonad (FG), male gonad (MG), gills (GI), digestive gland (DG), striated adductor muscle (AM) and mantle (MT) from *P. maximus* were dissected and stored in RNA later (Ambion) at –20°C. Total RNA was purified from 100 mg of each tissue using the TriReagent kit (Sigma).

To perform semi-quantitative PCR we measured the amount of isolated total RNA by UV-spectroscopy (Nanodrop ND-1000). First strand cDNA for each sample was synthesized from 2 μg of total RNA in the presence of random primers (Invitrogen SuperScript™ III Reverse Transcriptase). For PCR amplification 1.5 μg of cDNA were used as template. The primer pairs used were ABC2 (CTCCTCCCTACAGACCATCAAGAACATCC, forward) and ABR1 (GGCACAAGCGATGGCAAGGTAGACG, reverse). The thermal program consisted of an initial denaturation (94°C 2 min), followed by X (21, 24, 27, 30) cycles of denaturation (94°C 30 s), annealing (58°C 20 s), extension (65°C 30 s) and a final extension step (65 °C 1 min). PCR products were separated on a 2% agarose gel and stained with ethidium bromide. Gels were analyzed with the Multi Gauge V3.0. software (Fujifilm).

Results and Discussion

Previous work allowed us to clone the cDNA encoding an ABC transporter (EMBL accession no AJ844280) in the scallop *P. maximus* (Mauriz *et al.* 2005). The transporter is composed by 1721 amino acid residues. The protein is most closely related to the mouse and human ABC subfamily A member 3 transporter (ABCA3).

Preliminary RT-PCR experiments were performed to ensure the specificity of the selected primers. A single band of the correct size (145 bp) was observed by ethidium bromide staining after agarose gel electrophoresis. To ensure quantification was performed at the linear phase of amplification RT-PCRs were carried out using different PCR cycle numbers (21, 24, 27 and 30). For scallops that were sampled in May 2005 highest expression levels were found in the male and female gonad. In the gill, expression was lower, but still elevated. Lowest expression occurred in digestive gland, mantle and striated adductor muscle. The relative expression levels were as follows: 100% (MG), 97% (FG), 71% (GI), 23% (DG), 17% (MT) and 19% (AM). Interestingly, expression levels of ABCA in female gonad were significantly reduced in the samples collected in January 2006. The relative expression levels in winter samples were as follows: 100% (MG), 31% (FG), 38% (GI), 21% (DG), 39% (MT) and 23% (AM).

Evidence has accumulated during the past years to suggest that ABCA subfamily transporters mediates the transport of a variety of physiologic lipid compounds (Kaminski *et al.* 2006). Human ABCA3 is required for transporting lipid molecules, mostly saturated phosphatidylcholine, to the lung surfactant membranes (Kaminski *et al.* 2006). The *ABCA3* gene is highly conserved in both mammals and fish, suggesting that its role in the production of surfactants predates the development of the lung (Dean and Annilo 2005). There is an *ABCA3*-like gene in the sea urchin genome, *suABCA* that is expressed in the sperm (Dean and Annilo 2005, Mengerink and Vacquier 2002). It has been proposed that suABCA3 is involved in the shedding of cholesterol during sea urchin sperm head maturation. *Pecten maximus* ABCA protein could be involved in lipid transport in female and male gonads, playing important roles during gamete maturation.

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VARIATIONS OF ADENYLATE ENERGY CHARGE AND PHOSPHOARGININE LEVELS IN THE ADDUCTOR MUSCLE DURING ESCAPE RESPONSES IN JUVENILE SEA SCALLOP *PLACOPECTEN MAGELLANICUS*. **H. M. Perez, X. Janssoone** and **H. Guderley**. Département de Biologie, Université Laval, Québec, Québec, Canada G1K 7P4.

Scallops avoid predators using three behaviours: swimming, jumping and valve closure (Wilkens 1981; Chantler 1991). These responses are carried out by a central adductor muscle divided into a section composed of smooth muscle fibres (catch part) and another composed of striated phasic fibres (Wilkens 1981). The catch muscle contracts slowly and is thought to be responsible for valve closure and maintenance of a given shell opening (e.g., during respiration and feeding). The striated or phasic part contracts quickly and is responsible for very rapid valve closures during swimming and jumping (Chantler 1991; Wilkens 1981). Fatigue from extensive phasic contractions seems related to decreases in the free energy of ATP hydrolysis (Bailey *et al*. 2003), indicating that phasic contractions require high levels of adenylate energy charge (AEC). Fast contracting phasic muscles maintain high levels of phosphagens, such as phosphoarginine, to regenerate ATP rapidly during muscle contraction. Our observations of force production during escape response show a typical alternation between bursts of phasic contractions and periods of tonic contraction (Fleury et al. 2005). This observation generated the hypothesis that these tonic contractions permitted the metabolic recuperation in the phasic muscle needed for further contractions. To evaluate this hypothesis, we measured the variations of energy charge and phosphoarginine levels in the phasic muscle during escape responses of juvenile sea scallop *Placopecten magellanicus*.

Methods

Scallop adductor muscles were sampled at three stages during force measurements of escape responses. A suction clamp immobilised the lower valve of the scallops in the bottom of the water bath, whereas a hook attached to the force gauge was placed under the upper valve (Quantrol by Dillon Advanced Force Gauge, AFG-50 N). In all cases, the adductor muscles were excised from the animals and were frozen within 10 s between aluminium clamps that had been pre-cooled in liquid nitrogen. Thirty scallops were sampled at rest (for a minimum of 24 h). Thirty animals were sampled after their first series of phasic contractions during force measurements (Figure 1). Thirty additional animals were sampled once their first series of phasic contractions had been followed by 1 min of tonic contraction. For analysis of metabolite levels, the samples were crushed in liquid nitrogen, extracted with 6% PCA, and neutralised with K_2CO_3. Adenylate nucleotides were measured using spectrophotometric methods whereas phosphoarginine was measured by HPLC.

Control Phasic Tonic

Adductor muscle adenylate energy charge decreased significantly ($p < 0.05$) after the first sequence of claps (14 to 20 claps) of the escape response (phasic stage). After the tonic contraction period (tonic stage), AEC recovered to initial levels (Table 1). Phosphoarginine levels decreased significantly ($p < 0.05$) after the first sequence of claps (phasic stage) and remained at this level after the tonic contraction ($p > 0.05$) (Table 2).

These changes of AEC and phosphoarginine during the escape response supported the hypothesis that tonic contractions allow

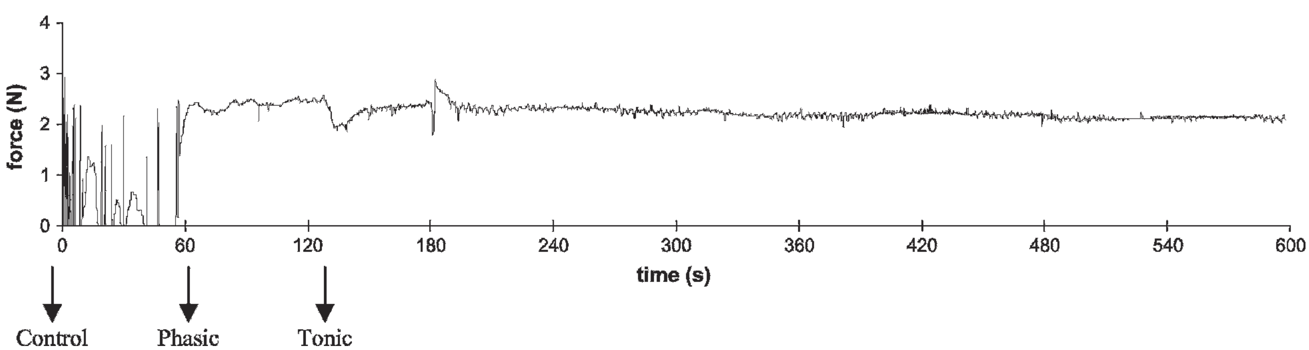

Figure 1. Force recording i*n vivo* escape responses of *Placopecten magellanicus* using advanced force gauge (Quantrol by Dillon).

TABLE 1.

Adenylate energy charge (AEC) index during escape response of juveniles scallops *Placopecten magellanicus*.

	Control	Phasic	Tonic
Average	0.923	0.895	0.925
SD	0.036	0.064	0.040

TABLE 2.

Muscle phosphoargenine levels during the escape responses of juveniles scallops *Placopecten magellanicus*.

	Control	Phasic	Tonic
Average	25.06	15.85	13.65
SD	4.53	4.19	4.65

recuperation of the phasic muscle, increasing levels of AEC and allowing further contractions.

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ISOLATION OF A PARAHOX GENE FROM THE BLACK SCALLOP, *CHLAMYS VARIA* (L.). **M. Luz Pérez-Parallé, Crimgilt Mesías-Gansbiller, Joana H. Padrao, Oscar Mauriz** and **Marcelina Abad**. Laboratorio de Biología Molecular y del Desarrollo, Departamento de Bioquímica y Biología Molecular. Instituto de Acuicultura, Universidad de Santiago de Compostela, 15782–Santiago de Compostela, Spain.

caudal (*cad*) is a ParaHox gene that encodes a homeobox-containing transcription factor. It has been cloned from many Metazoa where has a conserved role in regulating posterior development (Carroll *et al.* 2001). The ParaHox cluster is the evolutionary sister (paralog) of the Hox cluster and has three members (*Gsx, Xlox* and *Cdx*).

In *Drosophila, cad* is expressed both maternally and zygotically and is required for segment specification in the posterior region (Dearolf *et al.* 1989). In vertebrates *cdx* genes exhibit a posterior

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Gene         [accession#]                      % identity
Cvox Cad                   YSRYITIRRKAELAQTLALSERQ
Oehox Cad    [AM403121]    -----------------------  100
Pm Vox5      [AJ575213]    ----------S------------   96
Pm Vox4      [AJ575212]    ------V---S------------   91
DmHMCA Cad   [P09085]      T---------S------S-----   91
hCDX2  Cad   [Q99626]      --------------A--G-----   91
Py Cad       [Q59HW0]      ----------S------S-----   91
Hrox2        [Q25133]      --------------NQ-Q-----   87
mCDX2  Cad   [P43241]      F---------S---A--G-----   82
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Figure 1. Alignment of derived amino acid sequences of *Chlamys varia* caudal homeobox with other known metazoan sequences. Dashes indicate amino acid identity to Cvox Cad. EMBL-EBI accession numbers follow gene names. Dm, *Drosophila melanogaster*; Hr, *Haliotis rufescens*; h, human; m, mouse; Oe, *Ostrea edulis*; Pm, *Pecten maximus*; Py, *Patinopecten yessoensis*.

localization during gastrulation and neurulation with a role in the patterning of the anterior-posterior axis by regulating members of the Hox gene family (Epstein *et al.* 1997).

In a previous study we identified two *caudal* gene homologues from the scallop, *Pecten maximus* (Carpintero *et al.* 2004) and two *cdx* gene fragments from the oyster, *Ostrea edulis*. In this study we report the isolation of a *cdx* gene fragment from the black scallop, *Chlamys varia*.

Materials and Methods

We have designed a pair of degenerate oligonucleotide primers that correspond to conserved homeodomain sequences. Genomic DNA was isolated from adult black scallops. DNA was amplified using 0.5 μM of each primer and Hot Master Taq DNA Polymerase. PCR was performed at 95°C (5 min) and then at 95°C (1 min), 40°C (1 min), 72°C (30 s) for 39 cycles, and finally 10 min at 72°C. Positive PCR products were reamplified and later cloned in the pGem-T Easy Vector System II (Promega). DNA of individual clones, obtained using GenElute Plasmid Miniprep Kit (Sigma), was double strand sequenced by using ABI Prism dRhodamine Terminator Cycle Sequencing kit.

Results and Discussion

In this study we have isolated a *cdx* gene fragment from *C. varia*. The derived amino acid sequence was designated Cvox Cad, for *Chlamys varia* homeobox. The PCR amplification products yielded 69 bp of novel sequence information after the primers were excluded, corresponding to homeodomain amino acid positions 22 to 44. Comparison of the Cvox Cad homeodomain with those of several Cad proteins reveals a high level of conservation (Figure 1). Cvox Cad has invariant residues Tyr, Ala, Leu, and Leu at positions 25, 35, 38 and 40, respectively. Positions 26, 31 and 34 are also well conserved. Our research for related sequences in the public data bases was performed using the Fasta option with the EBI server. Cvox Cad shows a higher level of homology with *Ostrea* and *Pecten* (Vox 5) homeodomain, they diverge by 0% and 4%, respectively. Cvox Cad shows a higher divergence (9%) with the *Drosophila*, Human, *Pecten* (Vox 4) and *Patinopecten* caudal proteins. Cvox Cad also shows a high similarity to both *Haliotis*

Hrox 2 and mouse Cad protein. The conservation of *cdx* genes in molluscs is surprising given the evolutionary distance of (Mollusca) from other Bilaterian phyla.

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PRESENCE OF A GBX GENE HOMOLOGUE IN THE BLACK SCALLOP, *CHLAMYS VARIA* (L.).

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Gbx and *Msx* genes are both considered a non-Hox/ParaHox type of homeobox genes. *Gbx* genes are related to the *Drosophila unplugged* gene, which functions in the development of the tracheal system (Chlang *et al.* 1995).

The expression patterns of GBX class members implicate these genes in development of the nervous system. *Gbx* homeobox genes are expressed in the gastrulating embryo and later in the brain, where they play important roles in anterior-posterior patterning (Tour *et al.* 2001; Rhinn *et al.* 2004). The GBX-class of homeobox genes comprises two members in human and mice (*Gbx*-1 and *Gbx*-2).

We have recently identified a *Gbx* gene fragment in the oyster, *Ostrea edulis*. In this study we identified a *Gbx* gene homologue in the black scallop, *Chlamys varia* (L.).

Materials and Methods

We have designed a pair of degenerate oligonucleotide primers that correspond to conserved homeodomain sequences. Genomic DNA was isolated from adult black scallops. DNA was amplified using 0.5 μM of each primer and Hot Master Taq DNA Polymerase. PCR was performed at 95°C (5 min) and then at 95°C (1 min), 40°C (1 min), 72°C (30 s) for 39 cycles, and finally 10 min at 72°C. Positive PCR products were reamplified and later cloned in the pGem-T Easy Vector System II (Promega). DNA of individual clones, obtained using GenElute Plasmid Miniprep Kit (Sigma), was double strand sequenced by using ABI Prism dRhodamine Terminator Cycle Sequencing kit.

Results and Discussion

Following PCR amplification of *Chlamys varia* DNA, we were able to recover a *Gbx* gene fragment (the derived amino acid sequence was designated Cvox Gbx, from *Chlamys* varia homeobox). The PCR amplification products yielded 69 bp of novel sequence information after the primers were excluded, corresponding to homeodomain amino acid positions 22 to 44. Alignment of the Cvox Gbx sequence with other sequences in the Uniprot database reveals a high level of conservation (Figure 1). The Cvox

Gene	[accession#]		% identity
Cvox Gbx		GKKYLSLTERSHIAHNLKLSEVQ	
Oe Gbx	[AM403123]	-----------------------	100
Pm Gbx	[Q86MM9]	S----------Q-----------	95
Hrox7	[Q25138]	S----------Q-----------	95
Np Gbx2	[Q571Y8]	S----------Q-----------	95
Lo Gbx	[Q86LM6]	S----------Q-----------	95
h Gbx1	[Q14549]	C----------Q---A-------	91
h Gbx2	[P52951]	C----------Q---A-------	91
r Gbx1	[Q9JL01]	C----------Q---A-------	91
r Gbx2	[Q91XM7]	C----------Q---A-------	91
Io Hox4	[O96708]	S----------Q---S-R-----	86

Figure 1. Alignment of derived amino acid sequences of *Chlamys varia* *Gbx* homeobox with other known metazoan sequences. Dashes indicate amino acid identity to Cvox Gbx. EMBL-EBI accession numbers follow gene names. Dm, *Drosophila melanogaster*; Hr, *Haliotis rufescens*; h, human; Io, *Ilyanassa obsoleta;* Lo, *Loligo opalescens*; Np, *Nautilus pompilus*; Oe, *Ostrea edulis*; Pm, *Pecten maximus*; r, rat.

Gbx has invariant residues Tyr, Leu, Arg, Ile, Ala, Leu, and Leu at positions 25, 26, 31, 35, 38 and 40, respectively. The homeodomain sequence of the *C. varia* Gbx ortholog was identical to Oe Gbx of the bivalve *Ostrea edulis*. Cvox Gbx shows a high level of homology with *Pecten*, *Haliotis*, *Nautilus* and *Loligo* Gbx homeodomains (95%). It also exhibits significant sequence similarity with Gbx orthologs from human, rat and the gastropod *Ilyanassa obsoleta*. It would be interesting to study the evolutionary conservation of the GBX class and to examine the existence, expression patterns and role of the various class members in organisms with a primitive nervous system.

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EFFECTS OF GABA, EPINEPHRINE AND IBMX ON THE SETTLEMENT OF THE LARVAE OF *CHLAMYS VARIA* (L.).

M. Luz Pérez-Parallé, Crimgilt Mesías-Gansbiller, Antonio J. Pazos and **José L. Sánchez.** Laboratorio de Biología Molecular y del Desarrollo, Departamento de Bioquímica y Biología Molecular, Instituto de Acuicultura, Universidad de Santiago de Compostela, 15782–Santiago de Compostela, Spain; **Mohamed El Amine Bendimerad** and **Guillermo Román.** Centro Oceanográfico de A Coruña, Instituto Español de Oceanografía, A Coruña, Spain.

Difficulties in the culture of bivalve molluscs are often associated with settlement and metamorphosis. A wide variety of biotic and chemical substances such as GABA, L-DOPA, epinephrine and norepinephrine have been found to be capable of inducing settlement in larvae of different species of molluscs (Coon *et al.* 1985, Coon *et al.* 1986, Degnan and Morse 1995, Bryan and Qian 1998, Dobretsov and Qian 2003).

Chlamys varia is a small size scallop, currently in consideration for aquaculture in Spain. Hatchery culture of *C. varia* has been

% LARVAL SETTLEMENT (MEAN ± S.D.)		
INDUCERS	**24 h**	**48 h**
GABA		
10^{-4} M	20,80 ± 5,24	39,59 ± 8,25
10^{-5} M	23,86 ± 4,74	47,08 ± 6,00
10^{-6} M	26,37 ± 4,07 *	49,51 ± 8,71 *
Epinephrine		
10^{-4} M	17,66 ± 3,56	32,62 ± 4,77
10^{-5} M	30,45 ± 2,00 *	54,68 ± 7,97 *
10^{-6} M	26,47 ± 0,60 *	50,67 ± 3,94 *
IBMX		
10^{-4} M	25,80 ± 7,19	42,81 ± 6,11
10^{-5} M	20,25 ± 4,23	40,66 ± 8,79
10^{-6} M	21,40 ± 4,79	42,32 ± 8,25
Control	13,54 ± 3,94	31,19 ± 3,04

Asterisks indicate significant difference (*$p < 0.05$) from control.

previously achieved in Spain (Louro *et al*. 2003). The settlement of *C. varia* larvae can be obtained by providing large areas of substrates in conditions of low light, using collectors with a concave surface (De la Roche *et al*. 2005).

In a previous work, we identified GABA and epinephrine as settlement cues in mussels, clams and oysters (García-Lavandeira *et al*. 2005). In this study we examined the effect of GABA, epinephrine and IBMX on the settlement of the black scallop *Chlamys varia* (L.).

Materials and Methods

Larvae were cultured in the experimental hatchery in the Center of Oceanography, A Coruña after been obtained from *C. varia* reproducers (Louro *et al*. 2003). Settlement experiments were carried out in triplicate beakers in 400-mL final volume of 1 μm FSW. The larval density was 1 larvae mL^{-1}. Larvae were exposed to various concentrations of GABA, epinephrine or IBMX for 24 and 48 h. Larval settlement behaviour was monitored with a microscope Nikon SMZ-U.

Results

Table shows the percentage of larvae induced to settle by continuous exposure to various concentrations of GABA, epinephrine and IBMX after 24 and 48 h.

Epinephrine was a particularly active inducer of settlement for *C. varia*, at concentrations of 10^{-5} and 10^{-6} M. At a concentration of 10^{-6} M, GABA induced significantly higher settlement behaviour than the other concentrations tested. However when exposed to IBMX, the larvae of *C. varia* did not exhibit significantly higher settlement rates than the control larvae.

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ENERGETIC PHYSIOLOGY OF TWO GEOGRAPHICALLY SEPARATED POPULATIONS OF THE SCALLOP *NODIPECTEN SUBNODOSUS* FROM BAJA CALIFORNIA SUR, MEXICO. **Deborah N. S. Purce** and **Deborah A. Donovan**. Western Washington University, 820 4th Ave. W. Olympia WA, 98502, USA; **Alfonso N. Maeda-Martínez**. Centro de Investigaciones Biológicas del Noroeste, La Paz, BCS, México; and **Volker Koch.** Universidad Autónoma de Baja California Sur, La Paz, BCS, México.

Over-exploitation of various traditional fisheries around southern Baja California, Mexico has stimulated interest in small-scale aquaculture as a potential sustainable alternative. Due to high growth rate, large maximum size and suitability to local conditions, the Lion's Paw scallop (*Nodipecten subnodosus*) is a popular candidate for such projects. *N. subnodosus* occurs naturally on both coasts of Baja California and previous studies have sought to characterize optimal culture conditions for different populations around the peninsula. This study sought to characterize physiological differences between *N. subnodosus* from different populations of origin in relation to ecological conditions at specific culture sites around the Baja California peninsula.

In December of 2005 laboratory reared *N. subnodosus* spat from Gulf of California and Pacific coast populations were reciprocally transplanted to Gulf and Pacific coast field sites in Baja California. During summer of 2005, physiological parameters were measured for both scallop populations at both field sites. All measurements were taken in the field using a portable chamber flow-through system. Oxygen consumption rates, ammonia production rates, filtration rates and feces production were quantified and scallop energy consumption, absorption efficiency, absorbed energy, scope for growth, growth efficiency and adductor muscle body condition was calculated. The effects of time (early vs. late summer), site (Gulf vs. Pacific) and population (Gulf vs. Pacific) were compared for all variables using a three-way fixed-factor ANOVA.

We found that both energy acquisition and expenditure were significantly affected by time, site and population factors. Results suggest that scallop energy acquisition and growth efficiency are highest during the earlier, cooler part of the summer in Baja and, to some extent, are also higher at the Pacific site where food availability is highest. Significantly higher respiration rates were measured for the Pacific scallop population, leading to significantly lower SFG and K2. This indicates a significant physiological advantage for Gulf scallops during the suboptimal growth conditions that exist during summer months on both coasts of the Baja peninsula. This may have important implications for aquaculture enterprises in this region, and may also be indicative of divergence between these two geographically separated populations.

MONITORING THE REPRODUCTION OF THE GIANT SEA SCALLOP, *PLACOPECTEN MAGELLANICUS* IN PASSAMAQUODDY BAY, BAY OF FUNDY: WILL I LIVE LONG ENOUGH TO DETERMINE A LONG-TERM CYCLE?

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Scallop fisheries around the world are noted for their boom and bust cycles in recruitment. The causes of these cycles have stimulated much discussion and research around themes of overfishing, predation, disease and recruitment failure due to physical events in the ocean. Studies on recruitment issues tend to be relatively short-term (over a few years) and either respond to short-term pressures in the fishing industry or tied to graduate student theses.

While all populations undergo short-term fluctuations in recruitment, there can be longer-term biological cycles involved in the population dynamics of scallop stocks. These are virtually impossible to discern with short-term studies, but understanding these cycles will be critical to understanding larger scale issues, such as global warming. The scarcity of data on these issues are because the establishment of programs to look at these cycles require long-term commitment by researchers and their supporting agencies.

A study was initiated in the summer of 1984 to study spawning and recruitment of *Placopecten magellanicus* in the Passamaquoddy Bay region of the Bay of Fundy. Scallops were sampled by divers from a study site that was shown to be representative with other scallop beds within Passamaquoddy Bay. The annual spawning cycle was monitored using gonadosomatic indices

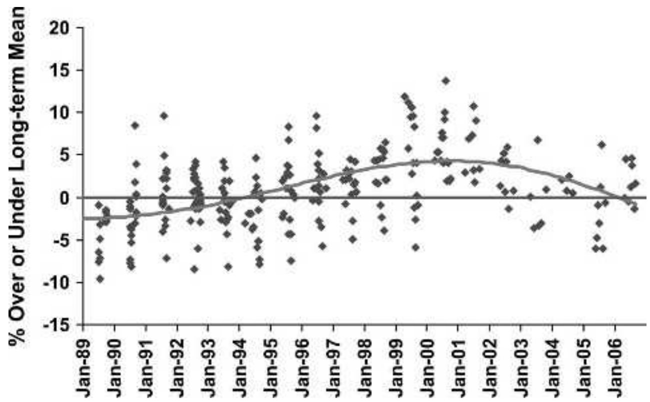

Figure 1. Residual monthly gonadosomatic indices of scallops from Passamaquoddy Bay from 1989–2006.

(GSI). Thirty scallops were sampled on seasonal-dependent time scales that ranged from weekly to 6 months in order to determine the peak in spawning and subsequent release of gametes. In 1989, a detailed hydrographic survey was initiated in the Passamaquoddy Bay area on a monthly basis to measure water temperatures, salinity and chlorophyll a (from 1996 via fluorescence) profiles. Analysis of the data from 1988 to 2006 used the residuals from the long-term mean for both the GSI and the hydrographic information.

The results of the long-term means from the GSI monitoring showed an increasing trend in the GSI's from 1989 to 2000, after which it dropped back down to long-term levels by 2006 (Fig. 1). The range in spawning around the 18 year mean was about 20%.

There was also a long-term trend in the temperature cycle from 1989 to 2006. The range in temperature around the 18-year mean was about 4 °C. Salinity did not show any such patterns and the chlorophyll signal was relative stable from year to year.

These results support the hypothesis that there may be long-term spawning cycles of scallops in the decadal range or possibly

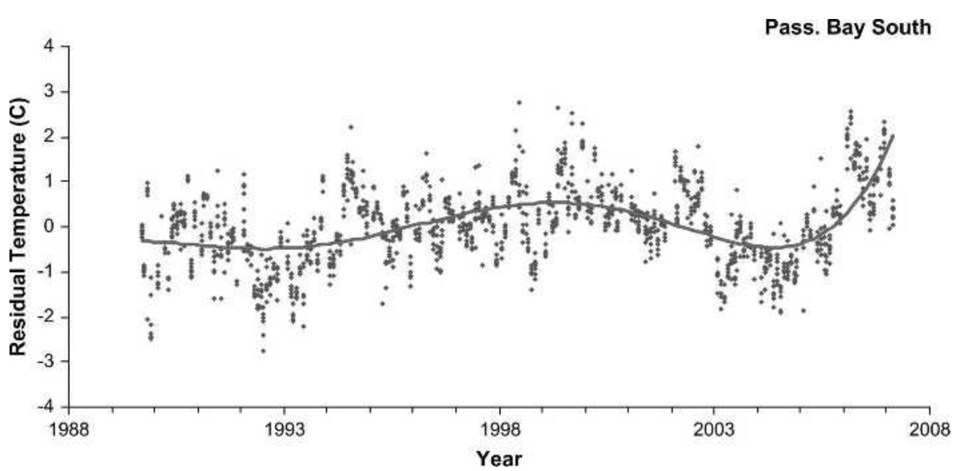

Figure 2. Residual monthly water temperatures from Passamaquoddy Bay from 1989–2006.

longer. Determining this will require a dedicated program to determine the periodicity. There also appeared to be a correlation between the residual GSI's of the scallops and the changes in residual water temperatures. If temperature is a driving variable in the reproductive rates of scallops, then increasing water temperatures associated with global warming may impact on scallop reproductive cycles and subsequent recruitment. It was interesting to note that chlorophyll did not show the same cyclical signal, suggesting that either other factors were also controlling its abundance or that the fluorescence measurements were too crude to see any differences in the primary production signal.

POTENTIAL ECOLOGICAL AND EVOLUTIONARY CONSEQUENCES OF SIZE-SELECTIVE HARVESTING ON SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*). **Sherrylynn Rowe, Stephen J. Smith** and **Mark Lundy**. Population Ecology Division, Science Branch, Fisheries and Oceans Canada, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2.

The effects of exploitation on a fished population are rarely random. Fisheries tend to target the largest, fastest-growing individuals in a population rather than the smallest, slowest-growing individuals. In the short term, such differential harvesting will reduce phenotypic, and potentially genetic, variation. In the longer term, if the characteristics that make some phenotypes more vulnerable to harvesting than others are heritable, harvesting will produce a genetic response to such differential selection. Fishing mortality, which often exceeds natural mortality by two- or three-fold, might generate high selection differentials. Given that body size is heritable, prolonged fishing can be expected to effect a genetic change that narrows the range of body sizes within affected populations. Similarly, intensive size-selective harvesting of the largest individuals in a population will result almost certainly in selection against the largest individuals of the same cohort or year class. As a consequence, faster-growing individuals will be more vulnerable to exploitation than slower-growing individuals. Using shell height-at-age data collected from sea scallops in the Bay of Fundy from 1982 to 1994, we will assess the degree to which the commercial fishery might differentially remove individuals on the basis of growth rate and discuss the potential ecological and evolutionary consequences of such harvesting patterns.

LONG-TERM MONITORING OF SEA SCALLOPS (*PLACOPECTEN MAGELLANICUS*) OFF THE NORTHEAST UNITED STATES. **Stacy Rowe, Victor Nordahl** and **Deborah Hart**. Ecosystems Survey Branch, Northeast Fisheries Science Center, National Marine Fisheries Service, NOAA, 166 Water Street, Woods Hole, MA, USA 02543.

Since 1979 the Northeast Fisheries Science Center has conducted an annual survey for the Atlantic sea scallop, *Placopecten magellanicus*. Sea scallops inhabit continental shelf waters of the Northwest Atlantic, ranging from North Carolina to Newfoundland. Our survey covers the majority of this range in the United States, with a focus on the most productive areas: the Mid-Atlantic Bight and Georges Bank. This long time series has provided information used to predict population trends and manage what was in 2005 the most valuable fishery in the United States, when the ex-vessel value of scallop landings exceeded $430 million.

Standardized dredge hauls are conducted, using a stratified random design, by towing a standard 2.44 meter wide scallop dredge at 3.8 knots for 15 minutes. Scientists sort the catch and record shell heights of sea scallops, clappers (shells of deceased scallops with the hinge intact), Iceland scallops, and finfish. Additional sampling is performed on selected scallops including: meat and gonad weight, gender, and shell preservation for later age analysis. Data are digitally captured, stored in a relational Oracle database, and analyzed to provide the current status of the stock.

Data show an overall decline in sea scallop biomass and mean size since the survey's inception until the mid-1990s. From 1994–2005 data show sea scallop biomass on the U.S. portion of Georges Bank increasing by a factor of 18, and biomass in the Mid-Atlantic Bight by a factor of eight. Mean shell height has also increased substantially. Biomass in closed areas has increased significantly, while the areas remaining open to fishing have benefited from effort reduction measures and gear restrictions. Recruitment in the Mid-Atlantic has been increasing over the time series, while Georges Bank recruitment has been trendless, with an irregular pattern of strong year classes alternating with periods of weak recruitment.

The implementation of new management measures in 1994 included closed areas, gear restrictions, crew limits, and limitations on days at sea. The results of such measures are visible in the survey data, which has provided a valuable resource for estimating the current and past sea scallop stock, as well as documented the results of effective management that led to its recovery. Technological advances are providing new opportunities to expand upon existing survey sampling methods and increase the accuracy of future surveys in order to continue to successfully manage this recovered stock.

INDUSTRY-BASED SEA SCALLOP DREDGE SURVEYS IN SUPPORT OF ROTATIONAL AREA MANAGEMENT. **David B. Rudders** and **William D. DuPaul**. College of William and Mary, Virginia Institute of Marine Science, 1208 Greate Rd., Gloucester Point, VA, 23062, USA.

As the spatial and temporal dynamics of marine ecosystems have recently become better understood, the concept of entirely closing or limiting activities in certain areas has gained support as a method to conserve and enhance marine resources. In the last decade, the United States sea scallop resource has benefited from measures that have closed specific areas to fishing effort. As a result of closures on both Georges Bank and in the mid-Atlantic region, biomass of scallops in those areas has expanded. As the time approaches for the fishery to harvest scallops from the closed areas, quality, timely and detailed stock assessment information is required for managers to make informed decisions about the re-opening. During the summer of 2006, the access areas in Georges Bank Closed Area I (GBCAI), Nantucket Lightship Closed Area (NLCA) and the entire Elephant Trunk Closed Area (ETCA) were surveyed to assess scallop distribution and estimate exploitable biomass within the closed areas. At pre-determined sampling stations within the closed areas, survey stations were sampled by simultaneously towing a dredge compliant to NMFS survey gear specifications and a standard commercial dredge. The use of two different configurations of scallop dredges conducting fine scale surveys provided a more complete view of the size distribution of the resource in the area. Results indicate that scallop abundance and biomass, especially in the ETCA are at high levels and access to these areas will benefit the fishery in the upcoming years. Additionally, a comparison of the performance of the two gears demonstrates the relative strengths and weaknesses of each and highlights the utility of using the two sampling gears simultaneously. The spatially explicit management strategy that has been implemented in the United States sea scallop fishery is intended to maximize the growth potential of the resource by protecting portions of the resource from fishing mortality. This strategy appears well suited to the sessile and rapidly growing sea scallop. However, the data needed to implement such a strategy is intensive in both time and space. The use of industry vessels in the acquisition of data to support rotational area management serves to provide information that ultimately benefits both the industry and the resource.

EFFECT OF TEMPERATURE ON GROWTH AND SURVIVAL OF SPAT OF PACIFIC LION'S PAW SCALLOP *NODIPECTEN SUBNODOSUS* (SOWERBY, 1835) AT THE LABORATORY. **César A. Ruiz-Verdugo** and **Volker Koch**. Universidad Autonoma de Baja California Sur, Ap. Postal 19-B, La Paz, B.C.S., Mexico; **Miguel Robles-Mungaray.** Acuacultura Robles, S.A. La Paz, Baja California Sur, México; **Julián Garzón**. Centro de Investigaciones Biológicas del Noroeste (CIBNOR), La Paz, Baja California Sur, México.

The Pacific Lion's Paw Scallop (*Nodipecten subnodosus)* is one of the most important commercial bivalves in México. It is found on the Pacific coast and in the Gulf of California Gulf in Mexico, which differ in temperature regime and food abundance. While the Gulf is characterized by high temperatures and low primary productivity during the summer months, the coastal Pacific is cooler and more productive. In the past decade, experimental and pilot stage aquaculture has been initiated in Baja California Sur, as spat production has become possible. However, some aspects of spat production have not yet been studied. One of these is the optimal temperature during the nursery culture in the Laboratory. In the hatchery, the cost of the nursery phase of spat production is high, due to the high of microalgae to feed spat, which translates into increased production costs.

The present study tried to assess the effect of temperature on growth and survival of Pacific Lion's Paw Scallop (*Nodipecten subnodosus)* during the nursery stage. Spat was produced at the Experimental Aquaculture Laboratory of the Universidad Autonoma de Baja California Sur using breeders from Pacific coast (Guerrero Negro). Four temperature treatments were used that represent the normal range along the distribution of the species: 15, 20, 25 and 30°C. Experimental units consisted of plastic containers (20 L) with four plastics vessels (3 inches) type upwelling with constant circulation, in which 60 spats (shell height: 3.87 ± 0.07 mm) were placed. Three replicates were used per temperature, spat was fed with a mix of *Isochrysis galbana* and *Chaetoceros gracilis* 1:1, growth, and survival were measured weekly over four weeks.

Highest growth was observed at 25°C, and lowest growth at 15°C. No differences were observed between 20°C and 30°C; however, the highest mortality was observed at 30°C and 15°C. Regression analysis for growth data showed the maximum response of spat at thermal treatment was obtained between 23.89°C and 24.88°C, where the best growth of this species was observed.

A second study was carried out to evaluate the temperature effect depending on breeder's population. Spat were produced with breeders of different populations, Guerrero Negro (Pacific Coast) and La Paz Bay (Gulf of California). The same experimental units described above, were used. Due to the results of the first experiment three temperatures were evaluated 22, 25 and 28°C. Sixty scallop spats form each population (shell height: 9.41 ± 0.07 mm for juveniles of La Paz Bay; 9.8 ± 0.22 mm for the juveniles of Guerrero Negro) were used in each replicates. In spite of the different spat origin, nursery stage growth was not significantly different between the two populations. Highest growth rates were observed at 25°C with lower growth at 22°C and 28°C. The mortality was not significant between two spat population.

This information will permit us to maintain the organisms for the least amount of time in nursery stage, reducing the production costs, which is an essential contribution for the development of a feasible technology for commercial production. The results of this study support plans for the culture of this species with spat from both sides of the coast of Baja California Sur without significantly affecting their growth, nevertheless it is important to also consider genetic factors for commercial culture.

STATUS OF SCALLOP AQUACULTURE IN BRAZIL. **Guilherme S. Rupp**. Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina, Centro de Desenvolvimento em Aqüicultura e Pesca—CEDAP, Rod. Admar Gonzaga 1188. Itacorubí. C.P. 502, Florianópolis, SC, 88034-901, Brasil.

Commercial scallop aquaculture is currently emerging in Brazil based on the Atlantic Lion's paw scallop, *Nodipecten nodosus*. Although the first successful attempts to produce scallop spat in hatchery are dated from early 1990's, not until recently spat production has attained quantities enough as to encourage the development of small scale commercial operations. Unlike other scallops which natural spat collection is abundant, aquaculture activities of *N. nodosus* will have to rely solely on hatchery produced juveniles, therefore its abundance and sustainability of production are key elements for the development of this new activity. Furthermore, Brazilian coastline comprises tropical and subtropical areas, in which fouling aggressiveness, temperature and food availability patterns and growth rates differ from other areas where scallop aquaculture takes place in the world. Recent improvements in established hatchery facilities in the states of Santa Catarina and Rio de Janeiro are increasing seed supply, hence stimulating the development of this activity in both states. Santa Catarina, traditionally the largest producer of cultured molluscs in the country, has developed a model in which research and extension institutions working in close relationship has promoted the development of oyster and mussel aquaculture among traditional fishery communities. Such an approach is now focusing on the development of scallop aquaculture. Studies to increase seed supply and to identity the influences of depth, culture density, fouling and other environmental factors has recently been carried out and, as a result, aquaculture practices suitable for the local environment are now being transferred to mollusc growers wanting to diversify production. In 2006, a pilot production of 120,000 seeds was supplied to 50 small growers in 8 municipalities of the State, and their production is being monitored. Results are showing that after 9 month of suspended culture (starting with approx. 10 mm juveniles) scallops can attain a shell height of 7 cm (8 - 10 g adductor muscle) with high survival (near 80%) in several sites. Whole scallops are locally marketed for approximately R$ 30–32 / dozen (US$ 14–15 / dozen). However, it is not clear whether these prices are sustainable as production increases. In Rio de Janeiro state hatchery production in 2006 was estimated in 630,000 juveniles. There are currently 45 small scallop growers and recently a large scale enterprise has been established estimating a production of 140,000 scallops in 2006. Whole scallops are shipped chilled to fine restaurants in the larger cities with prices ranging from R$ 25 to 34/dozen (US$ 12–16 / dozen). It seems that seed supply is no longer the bottle neck for the establishment of scallop aquaculture in Brazil and its potential for development is beginning to come about.

INFLUENCE OF DEPTH ON GROWTH AND SURVIVAL OF THE SCALLOP *NODIPECTEN NODOSUS* IN SOUTHERN BRAZIL. **Guilherme. S. Rupp[1], L. H. L. Iwersen[2], G. C. Manzoni[3], C. C. Buglione[2], F. Herrera[4], G. G. Maes[1],** and **M. M. Bem[4]**. [1]Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina, Centro de Desenvolvimento em Aqüicultura e Pesca—CEDAP, Rod. Admar Gonzaga 1188. Itacorubí. C.P. 502, Florianópolis, SC, 88034-901, Brasil; [2]UFSC, Laboratório de Moluscos Marinhos - LMM, Florianópolis, SC, Brasil; [3]UNIVALI, CTTMar, Itajai, SC, Brasil; [4] Mar do Sul Aqüicultura Ltda., Florianópolis, SC, Brasil.

Aquaculture of the Lion's Paw scallop *Nodipecten nodosus* (Linnaeus, 1758) is currently under development in Brazil. Detailed studies about the influence of environmental factors associated with depth have not been carried out for intermediate and grow out culture stages, only for nursery culture. Influence of depth may vary according to the species, site location and season. This knowledge is important for the establishment of strategies to maximize growth and survival, in order to support the development of commercial scallop aquaculture. This study was designed to compare the influence of environmental factors associated with depth on growth and survival of *N. nodosus* in suspended culture at 3 and 10 m, at Armação do Itapocoroy, Santa Catarina State, Brazil.

Material and Methods

The study was carried out between February 2004 and March 2005. Growth was examined in terms of shell dimensions, and wet and dry masses of the adductor muscle, gonad and viscera. Environmental factors surveyed bi-weekly at both depths were chlorophyll-a, salinity, dissolved oxygen, turbidity, total seston, and organic and inorganic particulate matter. Temperature was monitored on an hourly basis and biofouling settled on the shells was estimated bi-monthly. Initially, (intermediate culture) juvenile scallops (18.5 mm) were placed in triplicate lantern nets (40-cm diameter, 6-mm-mesh) per depth. For each depth, 99 scallops were placed per layer (total 5 layers/lantern net). In May 2004, scallops were transferred to 42-cm-diameter lantern nets with 15-mm-mesh (grow out culture). In October, scallops were transferred to 53-cm-diameter lantern nets (25-mm-mesh). Lantern nets were replaced on a monthly basis, along with estimation of survival and shell biometry, and density was reduced to approximately 40% coverage of the lantern tray area. Sampling for determination of wet and dry masses of adductor muscle, gonad and viscera were carried out bi-monthly ($n = 12–15$ scallops/net). The experiment was divided in two phases, as size selection was carried out with scallops from both depths in May 2004 using a tray with 2.2-cm openings. This procedure was undertaken due to the large size variability of the scallops at both depths. After selection, larger scallops were maintained in triplicate lantern nets at their original depths. The smaller group was maintained in single nets at their original depths. Statistical analysis was carried out using Student "t" test for comparison of mean shell height and somatic tissue masses between depths.

Results and Discussion

From February to May there were no significant differences in growth and survival between depths. From May 2004 to March 2005, on the other hand, growth at 3 m was significantly higher than at 10 m, for both groups of scallops, either in shell dimensions and dry and wet masses of tissues. No difference in survival between depths was recorded. For the smaller group of scallops it ranged from 82.1% at 3 m to 85.6% at 10 m and for the larger group it ranged from 79.3% at 3 m to 78.7% at 10 m. For the larger group at 3 m, shell height attained 6.8 cm in November, and adductor muscle wet mass reached of 8.9 g, whereas at 10 m, mean

TABLE 1.

Mean values for environmental parameters 3 and 10 m at Armação do Itapocoroy, Brasil.

	Temperature (°C)	Salinity (‰)	Chlorophyll-*a* (μg/L)	Total Seston (mg/L)	PIM (%)	Turbidity (NTU)
Mean—3 m	28.9	33.9	2.70	4.35	76.1	2.46
Mean—10 m	28.4	34.4	2.76	7.84	84.4	4.98

shell height attained 6.1 cm and mean wet mass of muscle attained 5.3 g. After one year of suspended culture, mean adductor muscle mass at 3 m attained 10 g, whereas at 10 m it did not surpass an average of 6 g. The smaller group of scallops cultured at 3 m attained, at the end of experiment, a mean shell height of 5.9 cm and mean adductor muscle mass of 6.9 g, whereas at 10 m, the mean shell height was 4.8 cm and mean adductor muscle mass 3.5 g. The gonadic index showed sharp decreases between July and September (late winter), and again from November to January (early summer), indicating periods of spawning. Among the environmental parameters (Table 1), % PIM and turbidity were significantly higher at 10 m, and are those which better explain reduced growth at 10 m. Mean temperatures did not differ between depths.

In conclusion, environmental factors associated with depth significantly affected growth but not survival of *N. nodosus* cultured in suspension in southern Brazil. Commercial size scallops (minimum 6 g muscle) can be harvested after 7 months of culture at 3 m, and scallops with 10 g muscle can be harvested after 11 month of culture. At 10 m, however, an additional period of 4 months would be necessary to attain the minimum commercial size. In order to maximize growth and survival, it is recommended that *N. nodosus* is cultured at 3–4 m at Armação do Itapocoroy.

REPRODUCTION AND SPAWNING IN CALICO SCALLOPS, *ARGOPECTEN GIBBUS*, FROM BERMUDA. **Samia Sarkis**. Department of Conservation Services, Flatts FLBX, Bermuda; **Cyr Couturier**. School of Fisheries, Marine Institute, Memorial University, P.O. Box 4920, St. John's, NL, Canada A1C 5R3; **Andrew Cogswell.** Bermuda Biological Station for Research, Ferry Reach, Bermuda.

The gametogenic cycle and breeding season of the calico scallop, *Argopecten gibbus* was examined in Bermuda using both quantitative and qualitative methods. Gonadal index varied seasonally, a rapid increase occurring in the winter months from January to March, and reaching maximum values in March and April. Greatest gonad growth and spawning were associated with low seawater temperature and low food levels. Variations in muscle indices implied a partial reliance on muscle reserves during the early stages of oogenesis. The later stages of ovarian growth (vitellogenesis and oocyte maturation) seemed to show a direct dependence on food supply. Histological analysis provided further details into the gametogenic cycle whereby gamete development commenced in early fall, while oocyte ripening took place in late fall and early winter, as indicated by increased oocyte diameters and gonad indices. Individuals with gonad indices above 2 and mean oocyte diameters exceeding 50 μm were induced to spawn

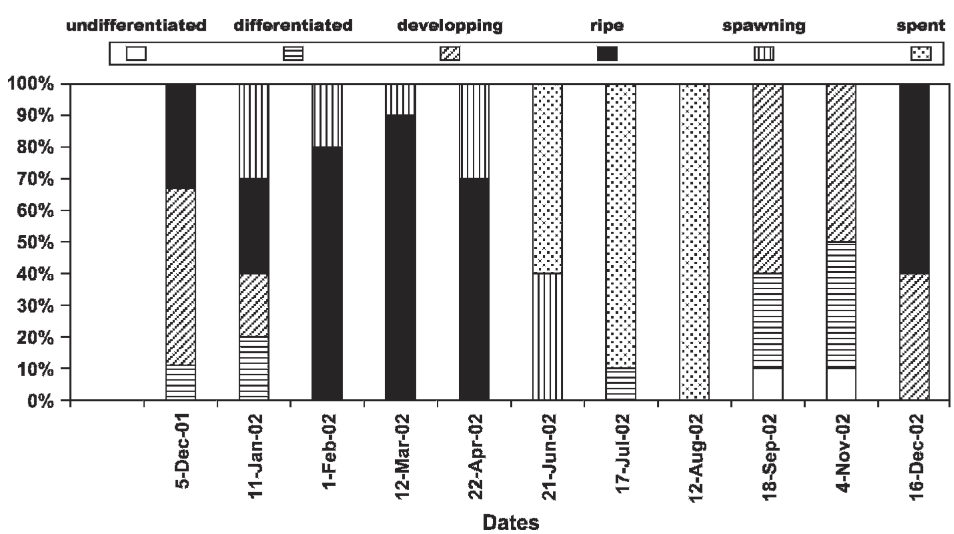

Figure 1. Qualitative assessment of reproductive patterns in the ovarian portion of the gonad of cultured *Argopecten gibbus* from Bermuda. N = 10 animals per sample date.

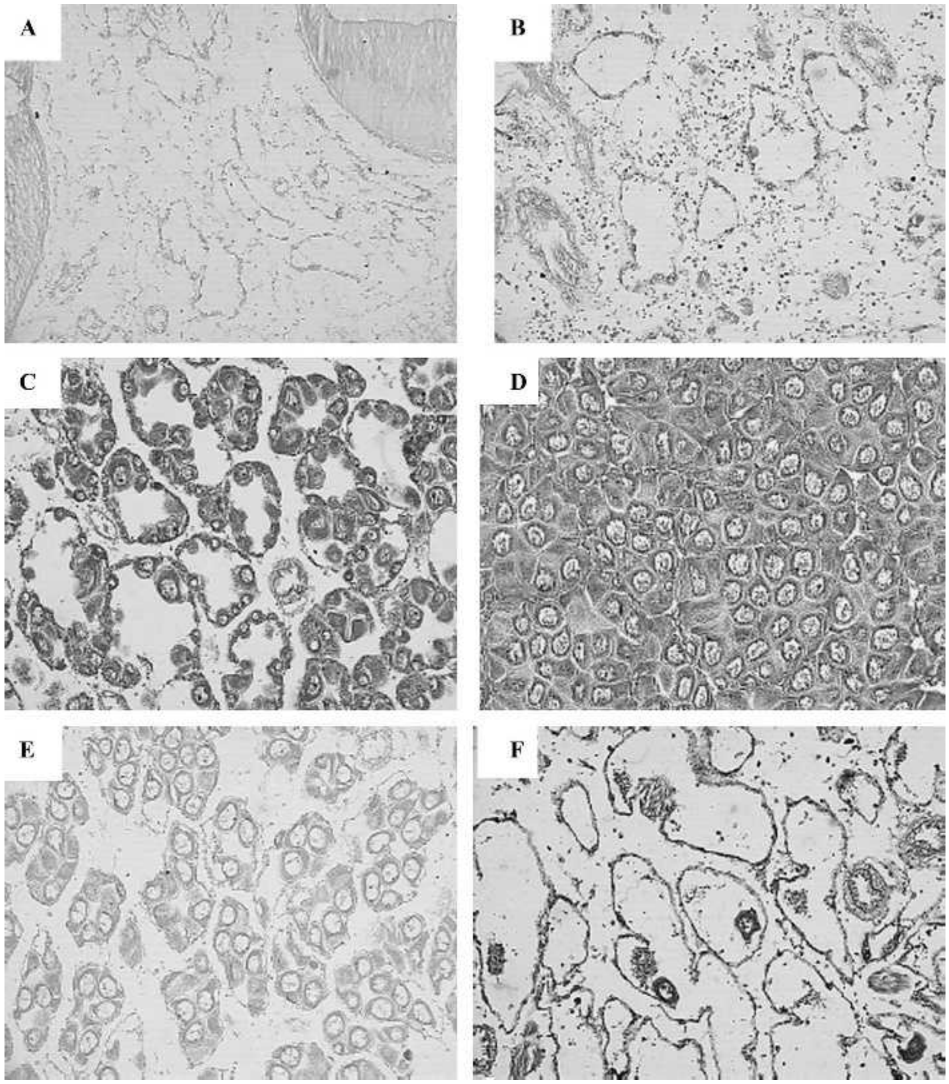

Figure 2. Stages of ovarian development in cultured *Argopecten gibbus* (magnification X 100). A, undifferentiated; B, differentiated; C, developing; D, ripe; E, spawning; F, spent.

with thermal shocks, exceeding 70% response rate in oocyte release in all trials. The present study extends our limited knowledge of the reproductive cycle in this subtropical scallop while providing a useful index to evaluate spawning readiness in cultured broodstock for routine hatchery purposes.

DID THE EPIBENTHIC BYCATCH AT THE PATAGONIAN SCALLOP ASSEMBLAGE CHANGE AFTER TEN YEARS OF FISHING? **Laura Schejter** and **Claudia Bremec**. CONICET–INIDEP, Paseo Victoria Ocampo 1, Mar del Plata (B7602HSA) Argentina.

The location of the Patagonian scallop commercial beds is related with the shelf break front, area of high productivity (Acha *et al.* 2004; Bogazzi *et al.* 2005). The epibenthos is mainly dominated by *Zygochlamys patagonica*, together with invertebrate species associated with the scallop, constituting the benthic assemblage. These beds were discovered during exploratory cruises in 1995 (Lasta and Bremec 1998), and the commercial fishery started in 1996. Total annual scallop catches ranged from 37,000 to nearly 43,000 tons/year. It is known that trawling and dredging over the marine bottom produce an important effect on the ecosystem, damaging not only the substrate, but also the invertebrates associated with the bottom. These modifications could cause destruction of the benthic habitat and long and short-term changes in the composition and structure of the associated fauna (National Research Council 2002). The aim of this study was to assess the composition and richness of benthic assemblages in the main Patagonian scallop areas subjected to fishing along the shelf break front of the Argentine sea, between the baseline condition in 1995

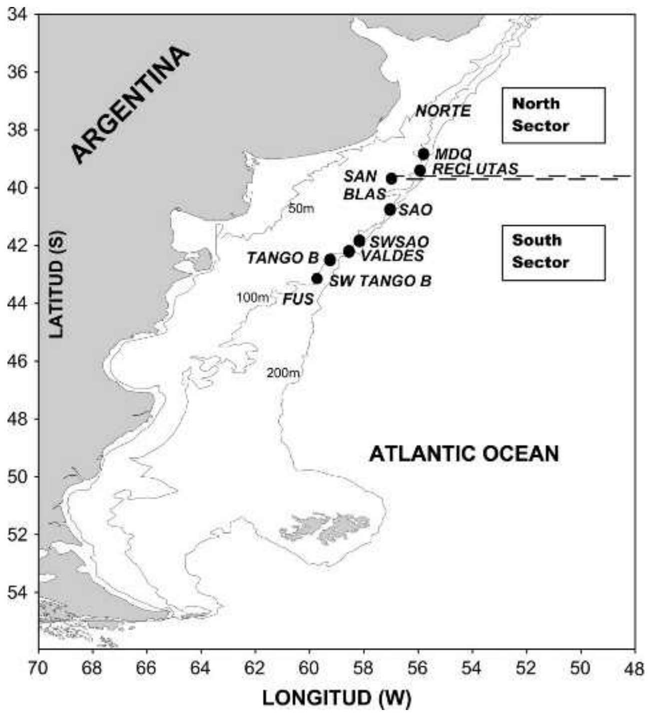

Figure 1. *Zygochlamys patagonica* beds and Sector North and South location in the Argentine Sea.

(without fishing) to 2006, considering the information of the exploration and monitoring cruises carried out by the INIDEP during 1995, 1997, 1998, 2001, 2002, 2003, 2004, 2005 and 2006. This information could be compared with data from the fleet (Escolar *et al.* 2007).

This ecological analysis is based on the study of representative samples (vol.:10 l) belonging to the exploited areas showed in Figure 1. A variable number of samples per bed (Table 1) was taken during the study period. For better assessment, the whole area was also divided into 2 major Sectors (North and South). Taxa identification and quantification of the benthic community was done on board (1995, 1997, 1998, 2001) and at the laboratory (2002, 2003, 2004, 2005, 2006) from the collected samples. Biomass of the different groups and taxa and taxa richness were estimated in every case; PRIMER statistical package was used to establish similarity between samples (SIMPER) and spatial relation between samples in the different areas considered (MDS).

In general terms, echinoderms were always dominant in by-catch groups. A total of 130 taxa was registered in the whole studied area, including strictly epibiont species, hydroids and sponges. However, Porifera (22 spp.; in part Schejter *et al.* 2006), Hydrozoa (6 spp.; G. Genzano, pers. comm.) and Bryozoa were considered for the community analysis as single taxa due to the taxonomic resolution difficulties during sampling procedures. Epibiont species (~25 spp.; in part Schejter and Bremec, submitted) were neither considered. Most of the epibenthic species (~70 spp. in total) were present in all scallop beds. Rare or occasional species were also registered, usually in more than one bed. Table 1 shows taxa richness per bed during the study period. Beds from the North area presented the highest values. Differences in richness during the study period were mainly due to differences in sampling effort (that was higher in the last two years) and to the expertise acquired in the identification of the taxa recorded. It is important to notice that taxa recorded during the baseline condition (pre-fishery) were always present during the last years of the study period. No loss of species was detected; only rare or occasional species were recorded sporadically.

Considering MDS analysis, differentiation of northern and southern management units is noticeable, in all years, and also a differentiation between more distant beds. This differentiation is due to the different proportions of taxa biomass rather than differences in species composition. During the study period, similarity (in %) of sampling sites inside a given bed was always superior to 50% (SIMPER test). A reduced number of species greatly contributed to the establishment of the assemblages that, in general terms, were persistent in time and in the different study areas.

TABLE 1.

Taxa richness in the different beds and years. Numbers in () indicate n° of analyzed samples.

	North Sector			South Sector						
Year	NORTE	MDQ	RECLUTAS	SAN BLAS	SAO	SWSAO	VALDÉS	TANGO B	SWTANGO B	FUS
1995	X	13 (3)	25 (11)	18 (5)	10 (2)	12 (3)	27 (16)	17 (3)	X	X
1997/98	X	31 (24)	31 (34)	20 (27)	X	20 (8)	22 (8)	17 (2)	X	X
2001	44 (35)	46 (56)	48 (24)	X	X	X	X	X	X	X
2002	41 (5)	50 (45)	50 (13)	43 (10)	X	43 (27)	40 (9)	38 (5)	42 (6)	36 (6)
2003	47 (8)	58 (40)	51 (13)	44 (14)	26 (2)	48 (28)	43 (11)	48 (9)	45 (10)	X
2004	54 (10)	59 (47)	52 (13)	44 (7)	X	46 (18)	31 (5)	42 (5)	44 (5)	X
2005	45 (10)	53 (47)	54 (28)	41 (8)	X	45 (15)	45 (9)	41 (7)	45 (8)	41 (7)
2006	60 (10)	61 (43)	60 (30)	42 (8)	33 (2)	47 (14)	50 (10)	40 (5)	51 (8)	44 (7)

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EMPIRICAL EVIDENCE OF PLANKTOTROPHIC LIFE IN *ZYGOCHLAMYS PATAGONICA* LARVAE.

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Almost all shallow-waters scallop species have planktotrophic development. Exceptions to this behavior are given when suspended particulate food is limited (e.g., shallow caves or abyss) or where parental environment is extremely patchy (e.g., coral reefs, mid-ocean ridges), in which lecithotrophy may improve survival chances. Prodissoconch II (PII) is much larger than prodisoconch I (PI) in planktotrophic bivalve larvae, and the ratio PI/PII is reported to be between 0.25 and 0.4 for the species that present this larvae. Contrarily, lecithotrophic larvae have a much larger PI than PII, thus PI/PII ratio is reported to be ≥0.6 (Berkmann *et al.* 1991 in Cragg 2006). In addition, a trend of decreasing species P II size with an increase in temperature is evidenced by Cragg (2006), from experimental studies, and it is in part supported by Peña *et al.* (1998) with some field evidence.

Zygochlamys patagonica is a cold-water scallop occurring on most of the Argentinian shelf and key species of a very important world scallop fishery in the SW Atlantic since 1996. The potential of this resource was already mentioned by Walossek (1991). Previous information about larvae and spat was published more than 20 years ago (Waloszek 1984), including some comments and measures of *Chlamys patriae* (synonymized to *C. patagonica* by Waloszek 1984) from Chile (Uribe Barichivith and Lopez Stefoni 1980) and description of shell morphology and sculpture of *C. patagonica* from Argentina (Waloszek 1984). During 2006 sampling procedures, recently settled spat were found attached to adult scallop and hydroids during epibiosis studies (Bremec *et al.* 2007). Spat of 482–2788 μm total shell height were detached from their hosts, and prepared for SEM. Photographs of nine specimens allowed us to make some measures in order to determine PI and P II sizes, and the PI / PII ratio. A brief description of the recently settled spat shell ornamentation is also given.

Zygochlamys patagonica fits well with the planktotrophic larvae theoretical model, having a PI/PII ratio of 0,364 ± 0,025, with an average size of the PII of 242.4 μm ± 13.879 μm and an average size of the PI of 91.75 μm ± 6.178 μm. It follows the general trend of planktotrophic larvae in "size at metamorphosis vs. temperature" Cragg's (2006) regression, considering a temperature of 6.5°C (average of the 5–8°C field range values) (Figure 1). PII size of *Z. patagonica* from Chile (Uribe Barichivith and López Stefoni 1980) was slightly minor than PII size at the present study. Nonetheless, latitudinal and habitat variations in larvae of the same species should be considered.

Microsculpture of the pre-radial stage of *Zygochlamys patagonica* left valve is composed of radial and concentric riblets forming a grid. Twenty-one primary ribs are evidenced from the biggest specimen (2,788 μm), sometimes with incipient secondary ribs between them. Primary ribs started at ~1,700 μm, which

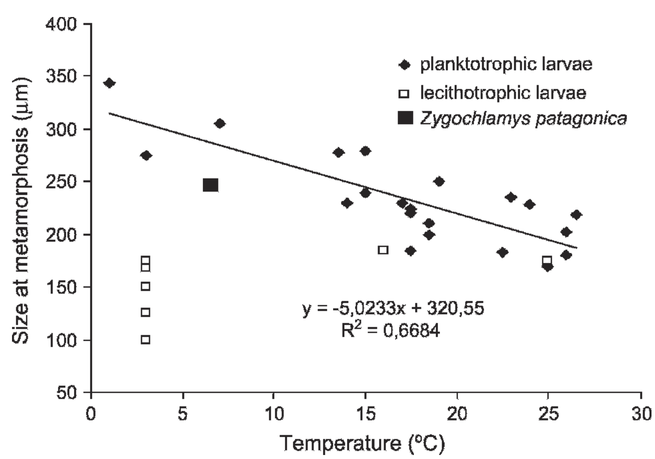

Figure 1. Relationship between water temperature and size at metamorphosis of planktotrophic and lecithotrophic larvae of pectinids. The regression line relates to the planktotrophic data. Abyssal and bathyal species have been assigned a very approximate water temperature of 3°C to permit display and comparison (Modified from Cragg 2006). *Zygochlamys patagonica* (black square) fits with the planktotrophic group of larvae.

explained the lack of this ornamentation in the other studied spats (all of them ≤1,600 μm). Auricles are almost equal in size. The right valves are completely smooth, and only presented concentric growth lines. Anterior auricles of the right valves present a radial crest with protuberances.

Future studies increasing the N of recently settled spat together with analysis of veliger larvae from plankton samples, SEM studies on hinge dentition and general body form of larvae and spats would help in identification of *Zygochlamys patagonica* larvae in plankton samples, and this fact, undoubtedly could be very useful to complement theoretical models of circulation and larval migration/transport at the shelf break front area of the Argentine Sea, where this commercial species is located in dense aggregations.

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ASSESSING THE SPATIAL DISTRIBUTION OF SCALLOP DREDGE FISHING AND THE USE OF INDUSTRY CONDUCTED SURVEYS AS THE DATA COLLECTION METHOD IN THE TASMANIAN COMMERCIAL SCALLOP, *PECTEN FUMATUS*, FISHERY, AUSTRALIA. **Jayson M. Semmens, Julian J. Harrington** and **Malcolm Haddon**. Tasmanian Aquaculture and Fisheries Institute, Marine Research Laboratories, University of Tasmania, Nubeena Cres, Taroona, Tasmania, Australia 7053.

Fisher catch return data and high resolution Vessel Monitoring System (VMS) data were used to determine the distribution of fishing effort within a region opened to commercial dredge fishing during the 2003 Tasmanian commercial scallop (*Pecten fumatus*) fishery, Australia. Fisher catch return data suggested that the vast majority (88%) of the open region was fished, however, fine-scale VMS data showed that 50% of fishing effort occurred within 0.85% of the total area available to fishing, and 95% of effort occurred within approximately 12% of the open region. The distribution of VMS inferred fishing effort was found to be patchy at all measured spatial scales (5 km × 5 km to 250 m × 250 m grid cell sizes); however, the degree of patchiness decreased with lower spatial scale cell sizes. The observed distribution of fishing effort / scallop beds within the Tasmanian commercial scallop, *Pecten fumatus*, fishery suits a closed area spatial management strategy, with the areas opened to fishing potentially being of the same scale as scallop beds (km × km).

Under the detailed spatial management system implemented within the Tasmanian scallop fishery, and given the relatively small scale of this fishery (only 4300 tonnes shell weight TAC worth an approximate $7 million AUS), how can management obtain the detailed information of scallop stock status, both within scallop beds and at the scale of the fishery, needed to manage the fishery in a cost effective manner? The use of Industry conducted surveys as the major mechanism for collecting this essential data was found to improve the affordability, spatial distribution, regularity and quantity of data collected, relative to traditional fishery-independent strategies of survey. Industry vessels were found to be very efficient in locating commercial quantities of scallops (scallop beds) throughout the fishery, and collecting the fine scale scallop density and population structure data needed to open regions of the fishery to commercial operations. Data were taken as being of a high quality and a credible data source by management and research. The increased involvement of Industry in the data collection process also initiated Industry self management initiatives during the 2006 season at White Rock. Delaying the opening of the season and conducting a series of rolling openings within the White Rock region was found to maximise the quality and quantity of scallop caught from this region. This initiative was driven, organised and monitored solely by Industry.

PHYLOGENETIC RELATIONSHIPS OF THE PECTINIDAE AND THE EVOLUTION OF SEXUAL REPRODUCTIVE MODES: HOW IMPORTANT IS DISPERSAL LIFE HISTORY? **Jeanne M. Serb** and **Louise Puslednik**. Department of Ecology, Evolution and Organismal Biology, Iowa State University, Ames, IA, 50011, USA.

The Pectinidae is a large, cosmopolitan group of marine bivalves and includes approximately 400 species. This diversity offers a rich system to examine major evolutionary questions on the origin and evolution of complex traits and life history behaviors. Within the pectinids, at least three modes of sexual reproduction are displayed: gonochorism where the sexes are separate and invariant; simultaneous hermaphroditism where both male and female gametes are produced at the same time in a single individual; and sequential hermaphroditism where male gametes are produced first, followed by the production of female gametes, or vise versa. Hermaphroditism dominates the Pectinidae; however, based on molecular data the evolution of gonochoristic reproduction has occurred independently at least three times within the family. Other aspects of life history also vary within the Pectinidae. Both the ecology and dispersal capabilities of the adult organism appear to be a dominant characteristic of species' phenotype. Hence, pectinid species can be divided into six different categories based on their dispersal life history, such as byssal attachers, cementers, nestlings, recliners, excavators or gliders. It has been hypothesized that sexual reproductive mode may be influenced by an organism's mode of dispersal. For example, organisms that are highly mobile may be more likely to be gonochoristic, while organisms that are less mobile are more likely to be hermaphrodites. To test this hypothesis, we undertook a comparative study to examine the evolutionary correlation of reproductive mode and dispersal life history in the Pectinidae using a molecular phylogenetic framework.

A molecular phylogeny was produced for approximately 75 Pectinidae species using DNA sequence from five genes: three mitochondrial (12S, 16S and COI) and two nuclear (18S and *sine oculis*). We used both maximum parsimony and Bayesian analyses to construct molecular phylogenetic hypotheses of the family. Categories of sexual reproduction and dispersal life history for each species were mapped separately onto the molecular phylogeny. We tested for correlated evolutionary change between sexual reproductive mode and dispersal life history using the phylogenetic comparative method of Felsenstein (1985) and Harvey and Pagel (1991).

We will discuss the implications of these findings for understanding the evolution and the relationship of sexual reproductive modes and dispersal life history in the Pectinidae. This work will greatly improve our knowledge of the basic biology of the Pectinidae and address questions regarding developmental biology. Finally, results from our study have potential utility for the development of new scallop species for aquaculture.

SCALLOP AQUACULTURE IN THE EASTERN UNITED STATES. **Sandra Shumway**. Department of Marine Sciences, UCONN, 1080 Shennecossett Road, Groton, CT 06340 USA; and **Norman Blake**. University of South Florida, St Petersburg, Florida, USA.

Aquaculture activities for both the sea scallop (*Placopecten magellanicus*) and the bay scallop (*Argopecten irradians*) on the east coast of the USA will be highlighted. Production remains small and efforts are primarily directed toward stock enhancement. Some culture as a secondary activity on other aquaculture sites has also been attempted. Cost of production and marketing challenges, other constraints and research and development needs will be discussed.

***PLACOPECTEN MAGELLANICUS* IN THE NORTHERN REGION OF GEORGES BANK: ITS FISHERY, SPATIAL DISTRIBUTION AND ABUNDANCE.** **M. Angelica Silva** and **Amy C. Chisholm.** Department of Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada B2Y 4A2.

The spatial distribution of the long lived dioecious scallop *Placopecten magellanicus* is restricted to the northwest Atlantic from the north shore of the Gulf of St. Lawrence (Squires 1962) to Cape Hatteras, North Carolina (Posgay 1957). Sea scallops are found preferentially over sandy and gravel substrates along its geographical distribution. Historically, the largest aggregation of scallops has been found in Georges Bank, this offshore bank has supported an over a century old fishery from both Canada and the US. Current fisheries management and assessment of the stock is done separately by each country within its own jurisdictional boundaries as it resulted from a decision by the International Court of Justice in 1984.

The management of the Canadian fishery of sea scallops within the northern region of Georges Bank has evolved since 1984 with a focus on stock rehabilitation by improving the harvesting of the resource aimed to optimize the yield, reduce the fishing effort and stabilize landings. The implementation of an enterprise allocation regime in 1986, partly to reduce fishing effort resulted in catch quotas (TAC's). In collaboration with industry several initiatives to revitalize the stock have been implemented over the years, such as decreasing the number of scallop meats to 33 per 500 g; 100% port sampling coverage, and implementing and monitoring a low tolerance level of small meats (under 10 g) in the catch. Furthermore, in 1998 the offshore industry vessels implemented satellite vessel monitoring for 100% of their fleet greatly improving its management of fishing activities.

The research survey used a stratified random design with sampling strata based on past commercial catch per unit effort. Since 1994, the survey is carried out in collaboration with industry under joint project agreements to assess the spatial distribution and abundance of the population. Overall results from the 2005 annual survey revealed high densities of pre-recruit scallops age 2, broadly distributed throughout the most northern area of the bank with some distinct areas with highest densities. Pre-recruits of age 3 were also found broadly distributed, but at lower densities throughout the same area. Recruited scallops of age 4 to 7 (fishery targeted biomass) are found distributed throughout the bank at lower densities with the older scallops age 6 and 7 found more restricted to southern areas. Research survey estimates and CPUE are used in a population model to estimate fishable biomass (age 4–7), and it presently appears to be at the long term average of 25 years (1981-2005).

MODELLING IMPACT OF SCALLOP POPULATION DENSITY ON THE SELECTIVITY OF SURVEY FISHING GEAR.

Stephen J. Smith and **Mark J. Lundy**. Department of Fisheries and Oceans, Bedford Institute of Oceanography, 1 Challenger Drive, Dartmouth, Nova Scotia, Canada B2Y 4A2.

Annual research surveys have been used to monitor changes in population numbers and biomass for the sea scallop (*Placopecten magellanicus*) beds off of Digby Nova Scotia since 1981. While models that incorporate the survey trends are currently used to model the population dynamics it has always been assumed that the survey trends on their own reflect population trends in an unbiased manner. In fact, in many other scallop beds off Nova Scotia where models have not been developed, survey trends are the main monitoring tool. Recent experience with a large year-class of scallops recruiting to the fishery in the Digby area showed that the selectivity of the survey drags changes with changes in scallop density thus potentially biasing the survey trends as indicators of population change. Selectivity is modelled here using a new Bayesian random effects version of standard selectivity models. These changes in selectivity were identified mainly because of the unique design of the survey gear. This gear consists of four Digby scallop drags, two of which are lined with shrimp mesh to capture the pre-recruit size classes. The use of lined and unlined gear together results in each survey essentially being a selectivity experiment. Our results should be of interest to researchers who use either only lined or unlined survey drags/dredges for their surveys.

ASSOCIATIONS BETWEEN SEA SCALLOP POPULATION DYNAMICS AND SEAFLOOR GEOMORPHOLOGY.

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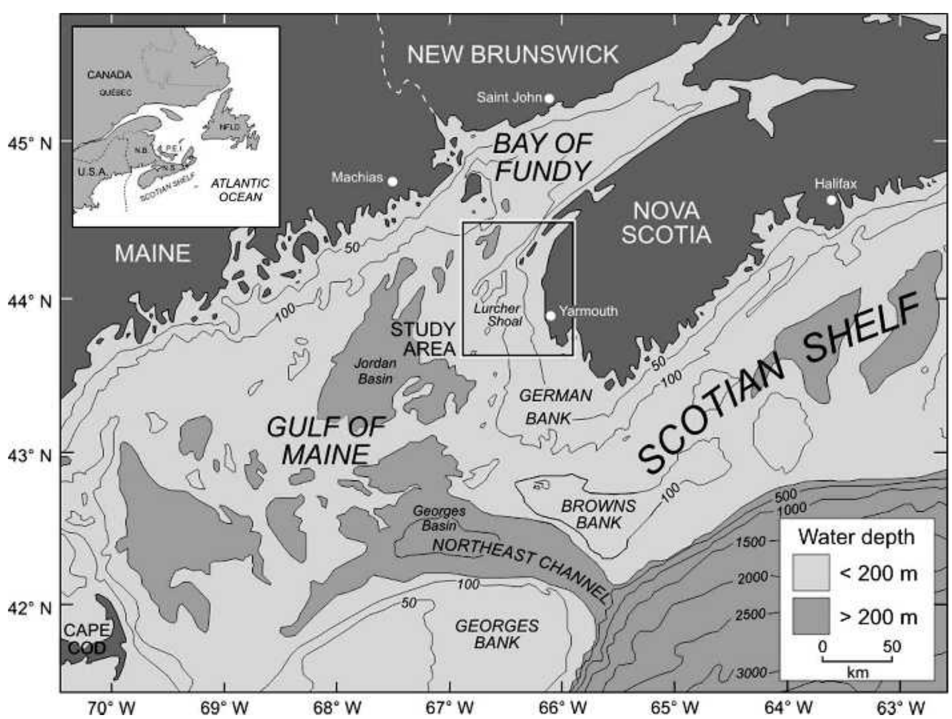
The sea scallop (*Placopecten magellanicus*) population in the Gulf of Maine off southwest Nova Scotia, Canada, supports a multimillion dollar commercial fishery. This resource is managed by the Government of Canada in cooperation with fishing groups. An interdisciplinary study is ongoing to improve the understanding of the sea scallop habitat, and specifically the relationship between sea scallop distribution, oceanographic conditions, and sea floor geomorphology and surficial geology. Study results will be used to improve sea scallop management in the Gulf of Maine and to reduce the impact of scallop fishing on other important commercial species like American lobster (*Homarus americanus*).

In the study area of Lurcher Shoal (see map below), the population of sea scallops has been traditionally assessed as one stock. However, the 1996–2006 spatial distribution of commercial sea scallop catch rates, and distribution of survey catches of commercial size animals and recruits, suggests the presence of an inshore population (within 30 km of shore) and an offshore population. The two populations may be associated with the oceanographic regime across the shoal or different characteristics of the sea floor. Recently-acquired single-beam sonar bathymetric



data in the Gulf of Maine indicate that the sea floor geomorphology associated with the inshore sea scallop population is relatively smooth. For the offshore population, the sea floor geomorphology is irregular (on the scale of hundreds of metres to a kilometre). Future sea floor investigations of the sea scallop habitat study will encompass geophysical and geological groundtruthing integrated with towed-video observations of scallop habitat. These large-scale observations will be extrapolated to underpin a regional habitat map of the Gulf of Maine.

CULTURING NORTHERN CHILEAN SCALLOP *ARGOPECTEN PURPURATUS* LARVAE IN CLOSED AND RECIRCULATING AQUACULTURE SYSTEMS. **Gaspar Soria[1,3], Germán Merino[2], Elisabeth von Brand[1]** and **Eduardo Uribe[2]**. [1]Universidad Católica del Norte, Departamento de Biología Marina. Coquimbo, IV región, Chile; [2]Universidad Católica del Norte, Departamento de Acuicultura. Coquimbo, IV región, Chile; [3]Present address: School of Natural Resources, University of Arizona, Biosciences East 325D, P.O. Box 210043, Tucson, Arizona, 85721 USA.

In Chile aquaculture is the main source of production of *Argopecten purpuratus* and the activity relies on an efficient, year-round, larvae supply. Scallop larvae are generally produced in closed aquaculture systems (CAS) and shows high variability in survival rates (from 0 to 80%), growths (vary by up to 800%), and periods of larval development (from 8 up to 40 days). These characteristics make larval production an uncertain venture. The use of recirculating aquacultural systems (RAS) could provide a method to increase production and significantly reduce seawater requirements and the mechanical stress of the larvae because there is no need of seawater exchange and sieving. In addition, seawater quality changes appear to be less dramatic. The main goal of this study was to compare, in terms of growth rates, the rearing of scallop larvae, subjected to a chemical treatment to induce a ploidy, in CAS and RAS obtained from several trials through 2004–2005. Mature scallops were obtained from Tongoy Bay (30°15′S) and induced to spawn. Oocytes were fertilized (sperm-to-oocyte ratio 10:1) and zygotes were chemically treated to induce the required ploidy level. In the CAS zygotes and larvae were incubated in flat-bottomed fiberglass tanks (4000 L). Light aeration was provided at all times, and 24-h after fertilization larvae were fed *Isochrysis galbana* (5×10^3 cells/mL). Seawater was fully renewed daily. Larvae were sieved onto 35 µm mesh throughout the trials. Algae were added on a single day delivery and ration was adjusted (up to 30×10^3 cells/mL) by observing the gut content of the larvae. The RAS consists of four rearing units (three 500 L conical plastic tanks, two 1000 L conical plastic tanks) and one 1500 L tank as biofilter (0.5 m^3 of Kaldness® media). Seawater was circulated through to each rearing tank (2–5 L/min for an 8 h period) and partial flow was UV treated. Zygotes were transferred to 500 L or 1000 L conical plastic tanks. Larvae were daily fed *I. galbana* and food allotment was divided and provided in the morning and evening. Concentrated algae were harvested from a photobioreactor (25×10^6–45×10^6 cell/mL) in order to minimize culture seawater make up. After algae addition inlet flows were stopped (1 h) and then reestablished. Larvae were never sieved and the seawater was not fully exchanged during the experiment. Salinity, temperature, DO, TA-N, alkalinity were measured in both systems. NO_2-N and NO_3-N were determined only in the RAS. Larvae shell lengths ($n = 30$) were determined under microscope. Growth rates were estimated assuming a linear model (shell length (µm) = a + b × day). Equality of growth rates among regression lines was tested and then compared by T' method. Shell larvae were

TABLE 1.

Summary for all batches larval of *A. purpuratus* in CAS (C1 to C4) and RAS (R1 to R7).

System	C1	C2	R1	R2	R†	C3	R3	R4	R5	C4	R6	R7
Genetic aspect *	3n	3n	4n	2n	3n	3n	3n	3n	3n	3n	4n	4n
Number of scallops	50		48	30	70	60	95				50	
Incubation density	20	20	40	8.2	55	2.1	39	78	150	90	72	28.5
Initial density	2.3	3.1	0.8	0.6	0.6	0.5	5.2	10.6	2.5	20	1.2	0.9
Final density	2	2.5	0.3	0.14	0	0.23	1.8	1.7	1.2	1.6	0.56	0.63
Growth rate (µm/day)	4.44	4.49	11.21	11.00	4.91	7.30	12.90	13.15	11.73	5.54	10.74	9.56
Culture days[1]	27	32	12	12	17	20	13	13	13	25	15	15
Survival from egg[2] (%)	10	12.5	0.32	1.76	0	8.24	2.4	2.1	0.78	1.11	0.56	0.63
Survival from D-larve[3]	85	80.2	65	24	0	46.6	35.3	15.7	45.72	8.0	48.2	68.5
Temperature (°C)	13.8	13.7	20.8	20.8	23.3	15.5	19.7			14.7	18.2	

[1] Determined from the day of spawning until the beginning of settlement.
[2] Survival was determined from the day of spawning until the beginning of settlement.
[3] Survival was determined from D-larvae stage until the beginning of settlement.
† A mass mortality was recorded on 17th day.
* Refers to ploidy induction experiments.

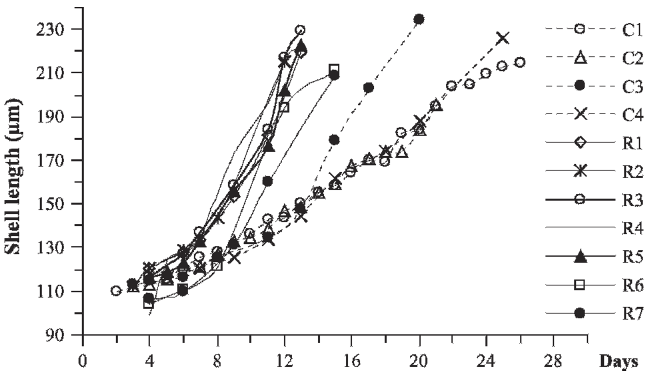


Figure 1. Growth curves for all batches of *A. purpuratus* larvae reared in CAS (C1 to C4) and RAS (R1 to R7).

photographed using Scanning Electron Microscope for further analyses of damage or abnormalities. Larvae survival (from zygote until the beginning of settlement) reared in CAS ranged between 1.1 and 10.6% and in RAS between 0.32 and 2.4%. Larval survival (from D-stage until the beginning of the settlement) in CAS had values between 8.0 and 85% and in RAS values between 15.7 and 65.8% (Table 1). Growth rates were significantly different ($F_{11,2840} = 274.66$; $p < 0.001$) among groups (Fig. 1). All scallop larvae cultured in CAS showed lower growth rates (4.49 to 7.30 $\mu m \cdot day^{-1}$) and protracted period of culture (20 to 32 days) than larvae reared in RAS (9.56 to 13.15 $\mu m \cdot day^{-1}$). Larvae reared in RAS reached the settling stage within 12 and 15 days. Significantly higher growth rates (12.90 and 13.15 $\mu m \cdot day^{-1}$) were recorded in batches of scallop larvae reared in RAS (Table 1 and Fig 1). Analysis of larval shells did not suggest differences in shells damaged between systems. Higher growth rates observed in RAS could be attributed to a reduction larval manipulation and to the higher algae amount and availability. The relationship between TA-N levels (<0.01 mg/L) and growth or survival rates does not show a clear pattern. Neither nitrite nor nitrate was recorded in CAS. In RAS, nitrite concentration ranged between 0.005 and 0.02 mg/L and nitrate between 1.2 and 2 mg/L. Survival is strongly influenced by the amount of viable zygotes after the chemical ploidy induction method. Therefore, survival percentages obtained in this research cannot be clearly attributed to the culture method used. However, survival rates from D-larvae until the beginning of settlement appears to be highly variable. Although the reduction in larval rearing time in RAS was high, the comparison between systems is more significant in view of the reduction obtained for seawater requirements. In this study a gross estimate of the make up seawater requirement per day needed for a batch of larvae reared in a RAS having a total culture volume of 5 m^3 ranges from 15 to 30 L in contrast to the 80 to 128 m^3 (tank volume × days of culture: 4000 × 20) needed for an equivalent amount of larvae reared in a CAS with a 4 m^3 tank volume. All batches of larvae have the particularities that were air-provided from egg incubation and feeding began within the first 24 h of incubation. Those procedures can lead a surplus in D-larvae survival during this early stage. Furthermore, it could be possible to reduce the cost of seawater heating from ambient sea temperature to culture temperatures, since the RAS was able to keep temperatures between 7°C and 10°C higher than CAS (13.7°C to 15.5°C). The information reported in this paper will be useful for the improvement of culture techniques for larval scallops under controlled conditions.

VIDEO SURVEY-BASED SEA SCALLOP STOCK ASSESSMENT ON THE USA CONTINENTAL SHELF. **Kevin D. E. Stokesbury, Bradley P. Harris** and **Michael Marino II**. University of Massachusetts - School of Marine Science & Technology, Department of Fisheries Oceanography, 838 South Rodney French Blvd., New Bedford, MA 02744 USA.

The future of fisheries includes ecosystem level assessment supported by absolute population measures with estimates of total assessment uncertainty. Presently, the USA sea scallop fishery uses a spatially specific management strategy employing rotational area closures, and a combination of effort and harvest controls.

In 1999, the University of Massachusetts School for Marine Science and Technology (SMAST) and members of the USA commercial sea scallop industry developed a cooperative research partnership with the goal of estimating spatially specific, absolute sea scallop abundance, size composition, natural mortality, growth and meat yield as well as surveying the Northeastern continental shelf benthos.

Abundance and Size Distribution: A centric systematic video survey with a multi-stage sampling design was used to assess spatially specific sea scallop abundance, and size distribution (Figure 1). Scallops, other macrobenthos and surficial substrates were evaluated in each 3.2 m^2 quadrat.

Natural Mortality: Spatially specific sea scallop natural mortality was examined using clapper to live scallop ratios observed in the video survey. In addition, we estimated total mortality by compared size structured abundance data from consecutive years and natural mortality by subtracting catch. Further, we examined the distribution of sea stars (scallop predator) using video surveys inside and outside of closed areas to assess the impact of closures on sea star distribution.

Growth: Approximately 90,000 scallops were tagged to examine spatially specific shell growth on Georges Banks and in the Mid-Atlantic. Five study locations were selected based on shell height frequencies sampled in broad-scale video surveys. High resolution video surveys were used in conjunction with tagging to assess scallop density, size distribution and benthos characteristics associated with shell growth.

Biomass: Temporal and spatial variations in shell height to meat weight relationships (meat yield) were examined by dissecting live scallops (>20,000) sampled during the fishery. Meat yield and video survey shell height frequencies were used to estimate area-specific biomass. Further, video surveys provide the spatially

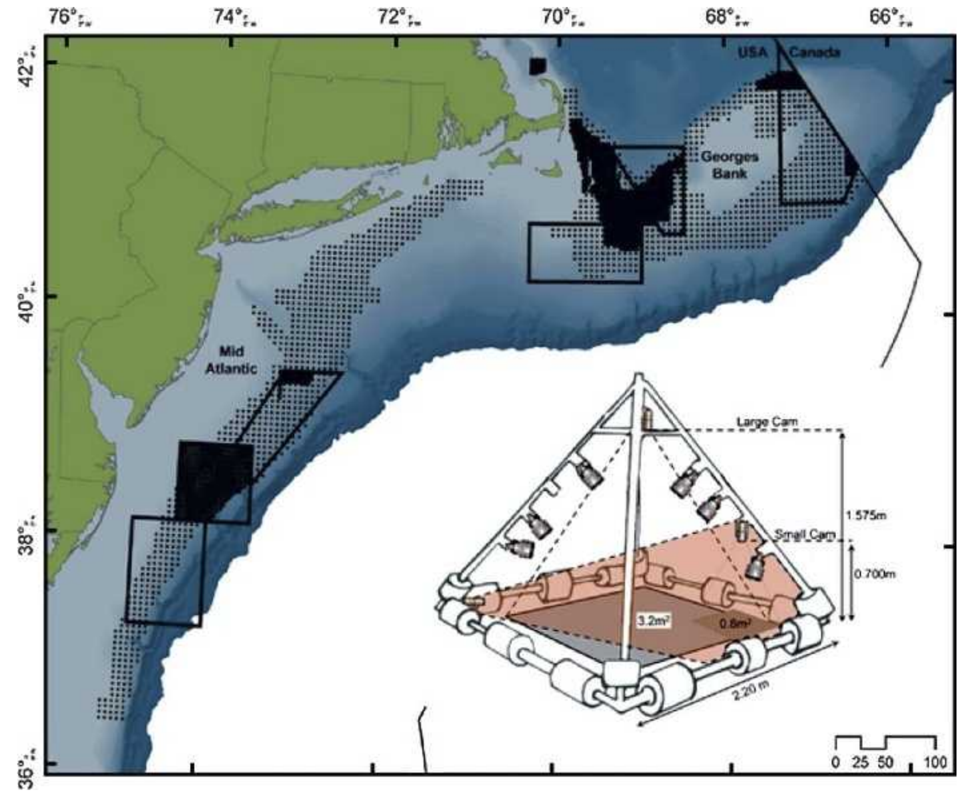


Figure 1. Video survey map showing broad scale (5.56 km grid) and fine scale (1.57 km grid) stations (dark areas). Since 1999, we have collected 172,848 video quadrats along 60,000 km^2 of continental shelf. The survey sampling pyramid employs three live-feed S-VHS video cameras and one high resolution digital still camera.

specific scallop density and benthos information to examine potential causes for spatial variations in meat yield.

The grid-based, quadrat sample scallop video survey design supports spatially specific scallop stock assessment and is robust to management changes which influence scallop distribution (e.g., closed areas). The optics-based survey method samples in absolute units (i.e., scallops m^{-2}) versus traditional fisheries relative sampling units (i.e., kg meat tow^{-1}). The video survey-based method supports straight-forward estimation of total uncertainty by avoiding the numerous steps required to convert from relative sampling units to measures meaningful to spatially specific fisheries management.

IMPACT OF FENCED SCALLOP (*PECTEN MAXIMUS*) SEA RANCHING ON THE BENTHIC FAUNA? **Øivind Strand** and **Tore Strohmeier**. Institute of Marine Research, Nordnesgt 50, 5817 Bergen, Norway; **Per Johannessen** and **Helge Botnen**. Section of Applied Environmental Research, University of Bergen, Bergen, Norway.

Sea ranching of the great scallop (*Pecten maximus*) in Norway is done by releases of hatchery-reared spat to the seabed, which is bordered by fences to prevent predatory crabs (*Cancer pagurus*) access to the scallops. A fence (50 cm high) of solid plates mounted on a concrete foot is shown to be sufficiently efficient to obtain high scallop survival. The new Act on Sea Ranching aims to contribute to a sustainable development of the industry. It sets specific conditions to environmental issues as genetics, disease control, habitat protection and ecological effects. Using fences on the seabed to prevent a target predator access to the area may also obstruct other mobile fauna. The fence combined with high scallop density within the farmed area may influence the benthic fauna assemblage. It is also questioned whether increased biodeposition of organic matter by the farmed scallops may affect the benthic environment. The present study is carried out to determine how the benthos in a fenced scallop sea ranching area was changed after a full seabed production cycle of *P. maximus*.

The investigation was conducted in a scallop farm in Toskasundet, western Norway. The fence (40 × 50 m) was mounted in autumn 2000, and 8000 scallops (50 mm shell height) were seeded. In 2004 survival was 80% and scallop densities were estimated to 8–20 individuals m^{-2}. In October 2004, June and October 2005 and August 2006 macro fauna were sampled by grab hauls, ejection pump, trap net and diving from the farmed area and compared with reference stations. Results are presented from these first investigations.

FEEDING BEHAVIOUR AND BIOENERGETIC BALANCE OF *PECTEN MAXIMUS* AND *MYTILUS EDULIS* IN A LOW SESTON ENVIRONMENT. **Tore Strohmeier** and **Øivind Strand**. Institute of Marine Research, Nordnesgt 50, 5817 Bergen, Norway; **Peter Cranford**. Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS, Canada; and **Cathinka Krogness**. Institute of Marine Research, Bergen, Norway.

Low seston environments occur under natural oligotrophic conditions and where high bivalve culture densities cause seston depletion. Bivalve culture in such conditions may suffer low growth or tissue wasting due to reduced feeding and a negative net energy balance. A positive net energy balance in bivalves requires a certain level of seston consumption, which depends on seston concentration, composition and transport rate. Norwegian fjords and coastal waters are considered as low seston environments compared to sites where most studies on mussel feeding on natural seston have been carried out. Regulation or cessation in feeding activity at low seston concentration is likely to be related to optimising energy cost of food absorption. The principal objective of this study is to elucidate the relationship between feeding behaviour and bioenergetic balance for *P. maximus* and *M. edulis* in a low seston environment.

Initial results from laboratory and field experiments on feeding physiology in response to natural low seston concentrations will be presented.

ICELAND SCALLOP STOCKS IN THE SVALBARD AREA – 20 YEARS AFTER THE FISHERY COLLAPSE. **J. H. Sundet.** Institute of Marine Research, Sukehusveien 23, P.O. Box 6404, N-9294 Tromsø, Norway; **Ø. Strand.** Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway.

Iceland scallop beds in the arctic Svalbard area were heavily fished upon from 1986 to 1992. In total 29 large scallop dredgers were participating in this fishery and almost all areas of any commercial interest were depleted. The Institute of Marine Research were surveying the scallop beds in this area annually in the period from 1986 to 1990, once in 1996 and latest in 2006 some 20 years after this fishery started. The sampling was carried out using a common triangular dredge with a 1 m edge. The aim of this study is to reveal if two of the main scallop beds in the Svalbard area, one close to the Bear Island and one at the island Moffen north of Svalbard, have recovered both in scallop density, and in recruitment to the stocks.

The catch rates (CPUE) was 5–7 times lower when the scallop fishery stopped in the beginning of the 1990s than when the scallop fishery started, and still some 12 years after the end of this fishery the CPUE is low. Shell height distribution show that the recruitment situation has improved at both beds, particularly at the Bear Island bed. Relative number of legal scallops (shell height > 65 mm) is at the same level as at the end of fishery at Bear Island, while it has increased at Moffen. Fitting von Bertalanffy growth model to age and shell height data from the two beds show no differences in individual growth rates in 1986 and 2006. The survey in 2006 show that the recovery of the scallop beds back to the situation before the extensive fishery will still take many years. Probably due to slow individual growth and rarely abundant year classes.

SWIMMING PERFORMANCE, METABOLIC RATES AND THEIR CORRELATES IN THE ICELAND SCALLOP, *CHLAMYS ISLANDICA*. **Isabelle Tremblay** and **Helga Guderley**. Université Laval, Département de Biologie, Québec, Qc, Canada G1P 7P4; and **Marcel Fréchette**. Institut Maurice Lamontagne, Ministère des Pêches et Océans, Mont-Joli, Qc, Canada.

Scallops can escape their predators by swimming using jet propulsion. The escape response of the scallops *Chlamys islandica*, *Euvola ziczac* and *Argopecten purpuratus* can be modified by reproductive investment (Brokordt et al. 2000a,b) and the escape response of *Placopecten magellanicus* changes with ambient temperature (Lafrance *et al*. 2002). Identification of the causes of these changes in escape performance requires knowledge of the underlying physiological determinants. Much is known about the physiology underlying the escape response, but little is known about the functional link between escape response performance, metabolic rates, and tissue metabolic capacities. We utilized Iceland scallop (*Chlamys islandica*) to examine these relationships, measuring metabolic rates (standard and maximal), aerobic scope, escape response behaviour (initial and repeat performance), tissue mass, condition index, protein content, and enzymatic activities (glycolytic and mitochondrial); then examining the relationships between these parameters.

TABLE 1.

Comparisons of escape response performance of small (2.4–3.6 cm) scallops *Chlamys islandica* in our study with that of large (8.0–9.5 cm) scallops reported by Brokordt et al. (2000a).

	Present study	Brokordt *et al.**
Size of scallop (cm)	2.4-3.6	8.0-9.5
n	48	Behaviour:40; enzyme: 7-12
Total number of contractions	52 (1.6)	26 (1)
Contraction rate (cont.·min^{-1})	33.8 (1.2)	13 (1)
Closure time (min)	9.8 (0.6)	33.2 (2.7)
Contraction time (min)	1.5 (0.5)	2.0**
Enzyme activity (U·g^{-1} wet mass):		
Pyruvate kinase	5.2	16
Arginine kinase	841.5	360
Octopine dehydrogenase	7.4	21
Glycogen phosphorylase	0.257	0.395
Citrate synthase	2.8	1.4

Note: Means ± (S.E.); enzymes measured in the adductor muscle.
* Scallops with immature gametes. Temperature for behaviour and enzymes: 6°C.
** Calculated as: total number of contractions/contraction rate.

Postexercise oxygen consumption (PEOC) gave metabolic rates 12 fold standard metabolic rates. PEOC rates were positively linked with contraction rate (repeat test) and with pyruvate kinase activity in the adductor muscle. PEOC rates were negatively linked to digestive gland wet mass. Swimming performance characteristics were mainly related to the activity of glycolytic enzymes while enzymatic activities were related to the anatomic parameters. Scallop behaviour and physiology changed with size, both within our sample and on a larger scale (when compared with results obtained by Brokordt et al. 2000a). When compared with larger scallops, small scallops showed more intense swimming performance and had higher arginine kinase activities but lower glycolytic enzymatic activities in the adductor muscle. This corresponds to the ontogenetic change in susceptibility to predation and in habitat use observed in *C. islandica* by Arsenault and Himmelman (1996).

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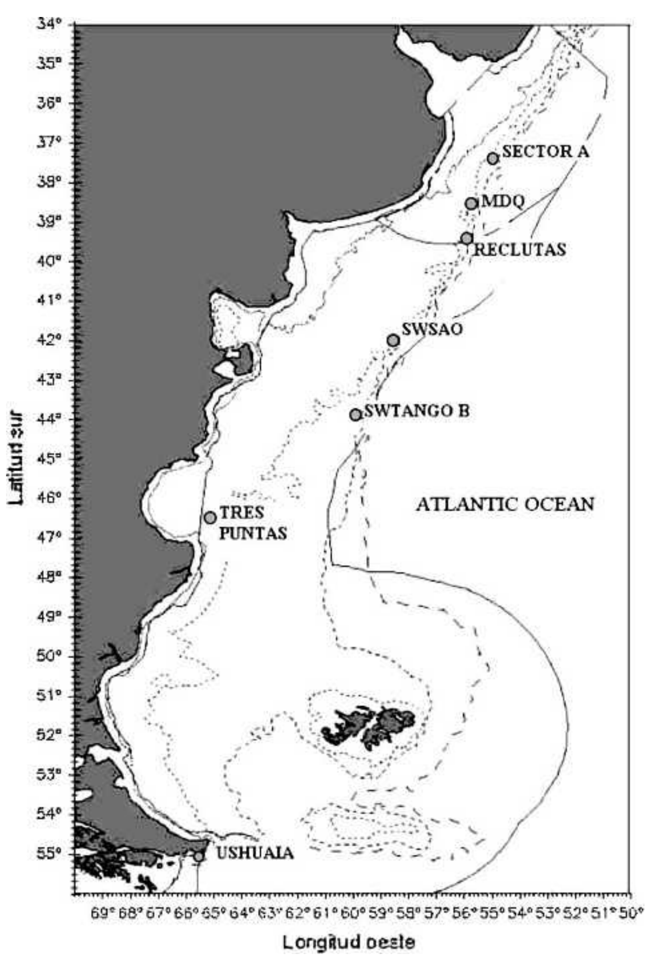
GENETIC VARIATION IN THE PATAGONIAN SCALLOP *ZYGOCHLAMYS PATAGONICA* REVEALED BY ISSR MARKERS. **M. I. Trucco** and **M. Lasta**. Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Paseo Victoria Ocampo N°1. B7602HSA, Mar del Plata, Prov. Buenos Aires, Argentina.

Zygochlamys patagonica (King & Broderip, 1832) is distributed in the Atlantic Ocean from the northern limit of the Rio de La Plata estuary (36°15′ LS) down to Cabo de Hornos (56° LS), in oceanic grounds where the most important commercial beds are located along the 100 m isobath. Since 1996, a commercial fishery for the patagonian scallop operates in the Argentinian shelves. Thus, the maintenance of genetic variation is an important objective in this native species. In order to begin a study of the population genetic structure of *Z. patagonica* as well as to provide useful information for the management of this resource, suitable molecular markers are needed to reliably assess genetic diversity.

The objective of this study was to determine the levels and distribution of genetic polymorphisms of *Z. patagonica* using Inter Simple Sequence Repeats (ISSRs) as the marker to assess genetic variation. These markers are a microsatellite-derived method based on the amplification of DNA segments occurring in the genome in regions where a particular SSR (short sequence repeat) motif occurs on opposing strands within a short distance. ISSRs have recently become widely used in population studies because they are highly variable; require less investment in time and money than other methods and exhibit Mendelian inheritance.

As a preliminary study ten individuals from each of seven beds were selected from northern, middle and southern locations of its distribution range: Sector A, MDQ, Reclutas, South West SAO, South West Tango B, Tres Puntas and Ushuaia. Out of ten, six ISSR primers gave reproducible bands and four are presented in this study. The ISSR profiles were scored for each individual as present (1) or absent (0) on the basis of size comparison with external standards. To describe genetic variation the program TFPGA v 1.3 was used. Genetic divergence between beds was



studied using Nei's unbiased genetic distances calculated for all population pairs and used to construct an UPGMA tree. The program Barrier version 2.2 was used to highlight geographical areas with genetic barriers between populations. This method, using Delaunay triangulation which combines geographical coordinates and genetic differentiation, determines where breaks in gene flow might occur.

The four primers selected yielded 60 polymorphic loci out of 65 loci (92.3%) in *Z. patagonica*. In individual populations, the percentages of polymorphic loci (P) ranged from 55.4% to 72.3%, with an average of 63.2%. Heterozygosity (h) varied from 0.215 to 0.272. Among the seven populations investigated, population South West SAO exhibited the highest level of variability while population South West Tango B possessed the lowest value of variability. Although preliminary, the analysis of the population genetic structure revealed a low percentage deviation from Hardy-Weinberg equilibrium due to population subdivision (GST, 0.182) among beds of *Z. patagonica*. But the barrier analysis identified two main zones of possible lower gene flow. The most robust barrier is placed south of Sector A, which suggests a genetic change between this bed and others. The second barrier separated MDQ from the rest of the Argentine beds. In view of Sector A and MDQ being located in the northern zone of the scallop range and that a spatial correspondence with latitudinal shifts of frontal systems has been described in *Z. patagonica*, a retention of larvae associated could be a possible explanation for the barriers described. At present, samples from five more beds are being analyzed that could yield a better understanding of the population structure of *Zygochlamys patagonica*. Genetic data from this study will provide a baseline for future, more intensive investigations.

FEASIBILITY OF USING SEAWATER RECIRCULATION TECHNOLOGY FOR CULTURING CHILEAN SCALLOP, *ARGOPECTEN PURPURATUS* FROM LARVAE TO SEED.

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Larval production usually is an unsatisfied need for commercial scallop hatcheries in Chile and scallop larvae for commercial purposes are traditionally obtained from nature (Farías *et al.* 1998). However, these larvae come with natural cycles tied to seasonal conditions, which makes the scallop business to depend excessively from environmental conditions. Additionally, in Chile there is mainly one bay, Bahia Tongoy, with an important natural scallop spawning which was able to provide enough larvae to support the local industry in the 90's (von Brand *et al.* 2006). Today natural spawning from Bahia Tongoy is not enough to satisfy the national industry demand for scallop seeds. Chilean hatcheries are rearing scallop larvae mainly using batch technology (Uriarte et al. 2001), which requires an important amount of man-labor and seawater volumes. So far, most Chilean scallop hatcheries are not able to operate all year round. During the summer season due to algae blooms and during winter time due to storms which affect negatively the water quality within the rearing units. The object of this paper is to show partial results obtained by a FONDEF D02I1095 research project were the Universidad Católica del Norte and two commercial scallop growers took the first step towards developing a recirculating technology (RAS) to raise scallops from larvae to seeds up to 50 mm shell height.

Batch technology

Total rearing tank water exchanges are occurring everyday with the use of screens to take out larvae before discarding the water. Culture tanks are then filled again with natural seawater, prefiltered between 50 and 10 μm, radiated with UV and sometimes heated up to 18°C, plus the addition of algae to feed the larvae. The larvae, which were retained in the screen, are then poured back into the culture tank. The batch technology process, determines the hatchery location and most hatcheries are built nearest to the ongrowing ocean sites to facilitate the transference of settled larvae from the hatchery to a long-line nursery system. Natural events such as storms and red tides affect the quality of the water source and within the rearing unit. Storms and algal blooms (red and brown tides) might increase the amount of suspended solids near to the seawater intake, which will first reduce the efficiency of the UV treatment and second, clog the sand-filters and hence stop the water flow. An increase in suspended solids in the water system will end up with an important amount of organics within the rearing unit, which will increase both DBO and bacterial levels. A short-cut of water flow strongly affects the required water exchanges for culture systems running under a batch mode. Most scallop hatcheries have faced different problems in larval production affecting their reliability as an artificial seed supplier.

System description and operation

At the Universidad Católica del Norte two RAS were set up, one exclusively to manage rearing early scallop stages from fertilized eggs up to 10 mm seed (RAS1, Fig. 1a) and the other one was focused on nursery and ongrowing stages (RAS2, Fig. 1b).

The RAS1 is within a room with no environmental control. The RAS1 is composed by five conical tanks for animal rearing, with two 1000 L and three 500 L tanks. Each tank has two banjo filters which allow a water exchange, while keeping the larvae within the rearing unit. There is another tank which works as a sump-biofilter with a volume of 1500 L (Fig.1a). The biofilter is a submerged moving bed composed by Kaldness media 10 mm diameter (0.5 m^3). Two submersible pumps (Pedrollo Top 2, 80 L/h) are pumping the seawater from the sump-biofilter to a distribution piping. From the distribution piping seawater is delivered to each one of the culture tanks. There is a UV unit (model UV5, Aquatic Ecosystems) which turns back treated seawater to the sump-biofilter.

Figure 1. General view of experimental facilities. a) RAS1 for stages between egg and 10 mm seed; (b) RAS2 for nursery up to 50 mm.

All tank effluents and the UV effluent are filtered up to 50 µm by a bag filter before going into the sump-biofilter.

The RAS2 systems are located outdoors and they were designed as a two equal recirculating systems (Fig. 1b). Each RAS2 has a head tank (1500 L), a submerged moving bed biofilter (1500 L), two raceways (35 L each), eight experimental tanks (50 L each), a heater pump (2.0 Kw), UV treatment (80 Watt, Aquatic Ecosystems), three centrifugal pumps (1 Hp, Jacuzzi), and two blowers (1.5 Hp, Sweetwater) (Fig. 2).

Larvae rearing

Larviculture tanks attached to the RAS1 are filled with filtered (1 µm) and UV treated seawater at 15 °C. At this time the larviculture tanks are not within the recirculating seawater loop. Gentle aeration is provided into each tank. Then each tank is stocked with fertilized eggs at a ratio of 50 eggs/mL. After 24 hours of batch condition incubation trochophore larvae are seen and D-shape larvae at 48 h after egg fertilization. Rearing tanks are switched to recirculation mode only when D-shaped larvae are observed at a flow rate between 1 and 3 L/min. Banjo filters with a 35 µm screen are set up at the effluent standpipe. Live *Isochrysis galbana* (T-ISO) and *Chaetoceros calcitrans* (CHAE) are given twice a day to keep a minimum of 20,000 cells/mL. In about 12 and 15 days after fertilization scallop larvae end the settling process which began when they reached a size over 240 µm. Daily controls are kept to register larval growth and survival, algal concentration, water quality (temperature, pH, TAN, alkalinity, DO, salinity). Scallop larvae were analyzed through image analysis using the Software Image Pro Plus 4.0, and pictures taken from a microscope Nikon Eclipse E 600 with a Cohu video camera to determine their growth.

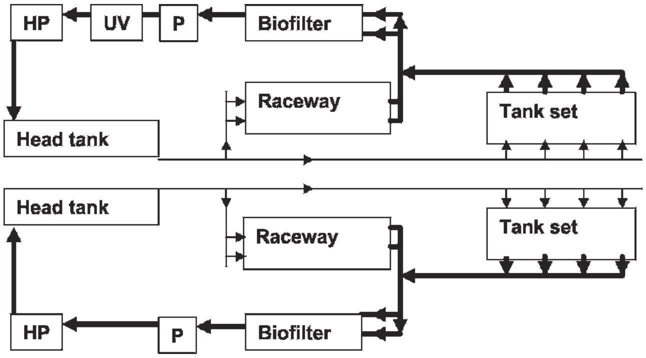

Figure 2. Scheme (not at scale) showing RAS2 configuration and main components.

Juvenile rearing

Settled post-larvae on the netlon mesh are kept within the larval rearing tank attached to the RAS1 during about 60 more days at an average water temperature of 23°C. At this time, banjo screen sizes were 300 µm and the water flow rate has been increased from 3 L/min up to 7 L/min. The amount of algae is still given twice a day to keep a minimum of 40,000 cell/mL. Two months after fertilization, scallop juveniles reached a size between 5 and 10 mm shell height.

When most scallops had 10 mm height shell, they were transferred from RAS1 to RAS2. Scallops were distributed at numbers between 1,000 and 1,500 per basket, within the raceways, or per 50 L tank. Both raceways and tanks are set at 7 L/min. Scallops are fed twice a day with *T-Isochrysis* and *C. calcitrans* at a density of 100,000 cell/mL.

Growth and survival of juveniles within RAS2

Juvenile scallop growth was monthly determined by analyzing a digital picture using image analysis techniques with the software Image Pro-Plus 4.0. Growth results showed that scallop grew more within tanks rather than within raceways, being the growth curves represented by $y = 10.951e^{0.17x}$ and $y = 10.481e^{0.10x}$, respectively, where y is shell height (mm) and x is time (months). Scallop juveniles grew up to 30.84 mm within tanks and up to 19.52 mm within raceways.

Scallop mortality was controlled every other day for each culture vessel. Mortalities were higher for scallops stocked within raceways, than for those reared within the tanks. An answer to this high scallop mortalities in the raceways could be due to the culture density (67.7% of covered area) that was higher than that one in the tanks (32.3% covered area), but more information is needed on this specific topic.

Water quality in RAS2

Water quality was determined every three days for temperature (°C), dissolved oxygen (percentage of saturation and in mg/L), salinity (g/L), total alkalinity (mg/L as $CaCO_3$), and pH. On the other hand, TAN (mg/L), Nitrite (mg/L) and Nitrate (mg/L) were controlled every week.

Temperature was decreased over time according to culture protocols. Oxygen levels were kept constant and at acceptable levels. Alkalinity was kept at 2.4 meq/L (natural seawater alkalinity), however it was increased up to 4 meq/L with addition of sodium bicarbonate to avoid any possible damages to the scallop shell. The pH ranged between 6.5 and 8.5.

TAN levels within the RAS2 system varied between 0.01 and 0.03 mg TAN/L, when the system was at 20°C. Nitrite levels were between 0.010 and 0.029 mg NO_2-N /L at 20°C. Nitrate levels ranged between 3.8 an 11.9 mg NO_3-N/L at 20°C.

Development of commercial Hatchery and Nursery RAS prototype systems

Aquatic animal production in inland systems based on recirculating water technology has the advantages of avoiding any natural risks (storms, red tides, among others) which could affect the profitability of the invested capital. Particularly for the Chilean scallop industry, the fact of producing 10 mm scallop seeds in inland systems would reduce significantly costs required by long-line technology, such as hydrowashing cleaning centers, repair of culture units (collector bags and pearl-nets), boats, man power, among others (Merino 1997, Merino et al. 2001), which might allow to save or make capital investments in other areas.

Typical nursery stages for Chilean scallop are carried out in long-lines in the ocean within a time line between three to four months, not including the month for the hatchery stage, to reach a seed size of 5 mm. In comparison, the RAS culture technology presented above was able to produce 5 mm seed in 40 days and 10 mm seed in only 70 days, starting from the time when fertilized eggs were stocked within the rearing unit. Consequently, the RAS can potentially save about 2 months to produce a 10 mm seed compared with traditional long-line technology.

The RAS scallop technology presented allowed acquisition a valuable know-how, unique in Latin America, in the matter of Hatchery and Nursery for Scallops ran under a RAS mode. The developed methodology allows the production of an important amount of competent settling larvae (250 μm) as well as 5 to 10 mm seeds.

Now there is a need to pursue economic studies to determine the commercial viability of this new culture methodology, which is also an environmental clean technology.

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GENETIC STRUCTURE OF FLORIDA BAY SCALLOP (*ARGOPECTEN IRRADIANS*) POPULATIONS BASED ON MICROSATELLITE ANALYSIS. **Ami E. Wilbur** and **Elizabeth M. Hemond.** Department of Biology and Marine Biology, Center for Marine Science, University of North Carolina Wilmington, 5600 Marvin K. Moss Lane, Wilmington, NC 28409 USA.

Previous studies have shown evidence of differing levels of differentiation among populations of Florida bay scallops (*Argopecten irradians*). Allozyme analysis (10 polymorphic loci, 30 samples from 11 locations over 4 years) suggests that significant structure among populations from the northwest, central and southern portions of Florida's Gulf coast in some years, but widespread homogeneity in others (Bert et al. in prep). Analysis of mitochondrial DNA diversity portrays a different picture in which RFLP analysis of a portion of the 12s and ND1 genes and sequence analysis of 450 base pairs of the ATPase 6 mtDNA gene showed little significant structure, with the exception of the southern-most population from Florida Bay. We have developed 5 microsatellite loci and in conjunction with 4 previously developed loci (Roberts et al. 2005), have revisited the question of genetic differentiation among Florida populations of bay scallops. Results to date reveal a surprising paucity of differentiation between samples collected from the northwest, central and southern coasts of Florida. Allele frequency distributions for all 9 loci do not significantly differ (Exact test $P > 0.05$). Global estimates of F_{st} (θ, Weir and Cockerham 1984) and R_{st} (Rousset 1996) are small and not significant (all pairwise comparisons result in $F_{st} \leq 0.0025$ and $R_{st} \leq 0.0021$), suggesting genetic homogeneity over much of the Florida Gulf Coast. Scallops from additional populations are currently being genotyped and the results from these analyses will be incorporated into a final evaluation of bay scallop microsatellite variation in Florida.

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SCALLOP BIOLOGY AND FISHERIES IN NORTHERN NEW ZEALAND. **James R. Williams**. National Institute of Water and Atmospheric Research Ltd. (NIWA), 269 Khyber Pass Road, P.O. Box 109695, Newmarket, Auckland, New Zealand.

Scallops (*Pecten novaezelandiae*) are an important component of many soft-sediment marine communities around New Zealand. They are patchily distributed in a variety of semi-estuarine and coastal habitats from low tide to around 60 m deep, but are more common in depths of 10 to 30 m. Scallops grow rapidly, have high fecundity, high natural mortality, and exhibit variable recruitment. Such a life history results in fluctuating populations, and reliance on relatively few year classes.

Scallops support regionally important commercial fisheries and an intense non-commercial interest off the northeast coast of New Zealand's North Island. Commercial scallop fishing using dredges has been carried out in this region since the late 1960s. A wide variety of effort controls and daily catch limits have been imposed in the past, but the fisheries have been limited by explicit seasonal catch limits since the early to late 1990s. Some additional controls remain on minimum legal size, dredge size, fishing hours, and non-fishing days. Non-commercial (recreational and Maori customary) fishers usually take scallops by scuba diving or snorkelling, although some use recreational dredges. Non-commercial fishing occurs mainly in enclosed bays and harbours, many of which are closed to commercial fishing.

Management of the northern scallop fisheries is based on a Current Annual Yield (CAY) harvest strategy, which requires annual pre-season research surveys to estimate start-of-season biomass. This approach provides flexibility by enabling management to respond to the observed variability in scallop abundance. However, there remains some degree of uncertainty in important aspects of the stock assessment, and the underlying processes that drive variations in scallop abundance are still poorly understood. This paper reviews biological and fisheries information for scallops in northern New Zealand, with a view to promoting discussion about future research directions that will advance our knowledge of scallop population dynamics.

SIZE-SELECTIVITY OF THE COMMERCIAL NORTHWEST ATLANTIC SEA SCALLOP (*PLACOPECTEN MAGELLANICUS*) DREDGE. **Noëlle Yochum** and **William D. DuPaul**. Virginia Institute of Marine Science, College of William and Mary, P.O Box 1346 Gloucester Point, VA, 23062, USA.

A size-selectivity curve was constructed to characterize the performance of the New Bedford style Atlantic sea scallop (*Placopecten magellanicus)* dredge when it is configured to meet the requirements of Amendment #10 to the Sea Scallop Fishery Management Plan. The curve was generated using the SELECT model on catch-at-length data, obtained by simultaneously towing a New Bedford style dredge and a non-selective National Marine Fisheries Service sea scallop survey dredge from commercial scallop vessels. Data were collected during three cruises in the Northwest Atlantic between 2005 and 2006. One cruise was completed in Georges Bank (Groundfish Closed Area II) and two cruises were completed in the mid-Atlantic (both in the Elephant Trunk Closed Area). The resulting selectivity curve for all cruises combined yielded a 50% retention length of 100.1 mm, a selection range of 23.6 mm and a relative efficiency value of 0.77. A length of 100.1 mm corresponds to an age of 4.6 years in Georges Bank and 5.8 years in the mid-Atlantic and a meat-weight of approximately 16 g. This implies that the current gear design is delaying entry into the fishery, and, therefore, potentially increasing yield-per-recruit and the population's total reproductive output. An additional cruise was completed in the Nantucket Lightship Closed Area (Georges Bank), where the sea scallop length frequency distribution was dissimilar to the other study areas, using dredges (both commercial and survey) that were configured differently than for the other cruises. The resultant selectivity curve for this area, however, was similar to the curve generated for the others combined, indicating that the curve is robust as well as representative of the fishery. The resultant selectivity curve can assist fisheries managers with stock assessments and with the interpretation of catch data from government and industry-based surveys. The curve can also be used to evaluate the effect of future changes to sea scallop dredge design.

GENETICS AND BREEDING OF THE BAY SCALLOP *ARGOPECTEN IRRADIANS* IN CHINA. **Guofan Zhang, Xiao Liu, Huaiping Zheng,** and **Haibin Zhang.** Institute of Oceanology, Chinese Academy of Sciences, 7 Nanhai Road, Qingdao, Shandong 266071, China; and **Ximing Guo.** Rutgers University, Port Norris, New Jersey, 08349, USA.

The bay scallop *Argopecten irradians* was first introduced into China from the USA in 1982, and it has become one of the most important mariculture species. By 2005, the annual production of bay scallops had reached about 700,000 tons. Studies on genetics and breeding of the bay scallop began at the beginning of this century, involving the establishment of inbred and hybrid lines, mass selection, hybridization and studies on inbreeding, effective population size, genetics of shell colors, population structure, and linkage mapping.

A large number of inbred and outbred lines have been established by self-fertilization and pair-crosses since 2001, respectively. In 2006, dozens of multi-generation successively selfed lines and many full- and half-sib families were produced and maintained in our laboratory.

Positive selective response for growth was obtained by mass selection in one of the lines with 10.20% and 10.63% improvement in the first and second generation, respectively. Significantly asymmetrical responses were observed by successive two-generation divergent selection based on a selfed line. By successive mass selection over several generations for orange shell color, a new variety named "Zhongkehong" was successfully developed and widely used in the culture industry.

To improve production by exploiting heterosis in the bay scallop, hybridization between divergent lines, stocks, or subspecies has been done in our laboratory. Hybrid crosses showed positive heterosis for all traits studied, and hybrid production was significantly improved.

Self-fertilization in the bay scallop is very common and results in inbreeding depression. The magnitude of inbreeding depression is significantly affected by cultured history, mating system, and level of inbreeding. Less inbreeding depression was found in offspring from the parents with longer cultured history and lower levels of inbreeding, whereas more inbreeding depression was found in offspring from the parents with shorter cultured history and higher inbreeding levels.

Effective population size (Ne) affects growth, survival, and genetic structure of offspring. Offspring from $N\text{e} = 1$ consistently had lower fitness than all others in F_1 ($N\text{e} = 2$, 10, 30, 50, and > 1000) and F_2 (Ne = 2, 10, 30, 50, and > 150), and significant differences were also observed between $N\text{e} = 2$ and $N\text{e} \geq 10$ in F_2. Offspring (F_1) from $N\text{e} \geq 10$ exhibited less genetic differentiation compared to those from $N\text{e} = 2$, which showed less differentiation than those from $N\text{e} = 1$.

Genetics of shell color in the bay scallop was studied by self-fertilization and pair-crosses. Different shell colors are controlled by different genes. Simple dominant-recessive relationship exists between orange and purple, orange and white, orange and black, but relationships between purple and white, brown and white, orange-purple and brown are more complex.

The genetic structure and genetic diversity of four cultured populations of the bay scallop were analyzed with AFLP (amplified fragment length polymorphism). The average heterozygosity was 0.1618, 0.1878, 0.1886 and 0.1265, respectively. Genetic distances ranged from 0.1188 to 0.0941.

Genetic linkage maps were constructed using AFLP and SSR (simple sequence repeat) markers, with 15 and 17 linkage groups in the female and male genetic maps, respectively. A gene controlling orange shell color and six QTLs controlling growth were identified and mapped.