Report of the Joint NAFO/ICES/PICES Symposium

Reproductive and Recruitment Processes of Exploited Marine Fish Stocks

This joint symposium by NAFO, PICES and ICES was held at the Altis Hotel in Lisbon, Portugal during 1–3 October 2007. The objective of this Symposium was to highlight recent advances in fish reproduction and early life stages and how these influence recruitment of a wide variety of species across a broad spectrum of marine ecosystems. The co-convenors were Ed Trippel (NAFO-Canada), Ric Brodeur (PICES-USA) and Mark Dickey-Collas (ICES-Netherlands). The Scientific Steering Committee consisted of Suam Kim, Fritz Köster, C. Tara Marshall, M. Joanne Morgan, and Tony Thompson.

The Chair of NAFO Scientific Council opened the meeting by welcoming participants and explaining the role of Scientific Council. The Chair also introduced the work plan and objectives. Co-convenor Ed Trippel also welcomed participants and gave a brief overview of the theme sessions and meeting arrangements.

Four theme sessions were held: 1) Age and Size at Sexual Maturation, 2) Fecundity and Spawning Success, 3) Survival of Eggs and Larvae and 4) Stock Assessment and Management Implications. Each theme session had two keynote speakers. Summaries of each session, as well as the symposium wrap-up, are contained below. A total of 151 people from 23 countries, and 52 papers were presented orally, and 70 as posters. Presenters were invited to submit their papers for publication, by 31 October 2007, in a special issue of the *Journal of Northwest Atlantic Fishery Science* (scheduled print date April 2009).

Ed Houde (USA) provided the symposium keynote address, which was very well received, outlining the historical evolution of research on recruitment processes and how we have only recently deviated from the single-purpose focus of searching for the holy grail of Johan Hjort's critical period hypothesis developed in the early part of the 20th century.

Session 1: Age and Size at Sexual Maturation. (Session Convenor: Ed Trippel)

The first session began with a theme keynote quantifying the relative influence of maturation on stock recovery. The next talk presented a model describing the relation between growth and reproductive investment for North Sea plaice and was given in the context of fisheries-induced evolutionary change and recruitment dynamics. The anticipated recovery of Flemish Cap cod was reported to be stifled in part due to low reproductive potential from the ever declining age at maturity, despite a ban on fishing in 1994. However, in recent years, size at maturity remained constant. The second keynote address of this theme session was then given, which reported declining trends in onset of maturation in accordance with predictions from life history theory under increased mortality, although it was acknowledged that conclusive evidence for evolutionary changes in fish stocks can never be obtained through this quantitative approach. Following this, a reaction norm analysis was described that included Fulton's condition factor in addition to body length and weight and explored the use of liver weight as an explanatory variable. An interesting study on cod in the Kattegat and the Sound (eastern North Sea) revealed how ecological conditions (bottom temperature and mean length at age) in the first year of life were largely responsible for regulating incidence of sexual maturity. Following this evidence, using an ecogenetic model, support was given for fisheries-induced rapid evolution of multiple life history traits, and how these responses have consequences for fishery landings. Warning was given that reversal of evolutionary changes in maturation is not always certain or equally rapid. A report was then made of the need to recognize stock structure when interpreting evolutionary fisheries-induced changes in age and size at maturation of Icelandic cod, since this stock is comprised of geographically distinct sub-stocks. In Baltic Sea cod stocks, it was reported that continued significant declines have occurred in the size at 50% maturity, with males being mainly smaller than females. In recent times, the spawning stock biomass has been highly dominated by males. The annual maturity ogives have been used to replace the constant ogives in stock assessments for three cod stocks in the Baltic Sea. Seven British Columbia herring stocks were examined for their mortality and catch curve data. Since the early 1980's, behavioural differences were recorded of virgin herring indicating they may not aggregate with older mature fish, and may actually spawn at different locations. Spatial segregation of herring based on age can violate assumptions underlying estimates of SSB and fishing harvest rates that now seem to be based on a flawed catch curve analysis. As a result, additional harvest pressure is being placed on older fish (4+) than should be. The final presentation reported on biochemical composition of oocytes and maternal fat reserves of sardines off western Portugal. Overall, the session reflected two main drivers in the area of fish maturation: (i) recent development of the probalistic reaction norm and modelling exercises that support fisheries-induced evolution and (ii) challenges to this new thinking by more traditional bio-energetic analysis of growth processes that regulate maturation and continued evidence that a wide phenotypic plasticity in maturation exists.

Session 2: Fecundity and Spawning Success. (Session Convenor: Gudrun Marteinsdottir)

The first keynote presentation given in this session gave compelling evidence of why governmental fishery departments should be closely monitoring fish fecundity and establishing methods to estimate fecundity annually. This will enable the estimation of intrinsic rate of population increase, *r*, used to estimate stock recovery and determine sustainable harvesting rates. This was followed by a monthly assessment of horse mackerel ovarian development and led to the species' characterization as an indeterminate spawner (*i.e.*, vitellogenic oocytes present at all times). The largest cod stock, Northeast Arctic Cod, has been reduced to spawning primarily in the Lofoten area and no longer uses more southerly spawning banks. The earlier use of more southern banks by large adults (now fished down) had warm water benefits not afforded remaining adults spawning in the north and has implications for reproductive success. An interesting study on sperm cell reserves of female snow crab in the Eastern Bering Sea revealed that

insufficient sperm are available for egg fertilization of the second clutch and this may be linked to the male-only fishery. Severe declines in the snow crab stock's mature biomass prior to 2000 has had severe consequences to natural recruitment and the fishery. Further studies are under way to assess male depletion and its ubiquitous nature.

The second keynote address was given and focused on snow crabs in the North Pacific, Eastern Bering Sea (EBS) and eastern Canada. The environmental conditions have been altered such that remaining snow crab in the depleted EBS stocks are now located down current of their historical distribution. How they may re-establish themselves from this location is unclear. A study has indirectly shown that Norwegian spring-spawning herring exhibit skipped spawning. That is, some individuals do not mature annually in one of the largest fish stocks in the world (up to 50% may skip the second year). Further gonadal sampling is underway to estimate specific levels. A second study on skipped spawning was given, this time for Northeast Arctic cod, and focused on energy reserves available at a critical time window during early vitellogenesis. Potential fecundities of three species of Northwest Atlantic flatfishes were reported for the 1993 to 1998 period, and represent the first fecundity data for these populations in the past 30–40 years. It was revealed for Icelandic cod that parental selection of spawning sites may be a crucial factor in determining offspring survival probabilities. To this end, an atlas of spawning sites was constructed which described egg production at each site. The dispersal of Icelandic cod eggs and larvae were estimated with tracking models and 0-group origin models based on back-calculated hatch data and offspring genetic composition. Using captive Japanese flounder, under a wide range of temperatures, a method was developed to accurately estimate spawning fraction at different water temperatures, which is essential to properly estimate SSB using the daily egg production method for indeterminate spawning species. The reproductive success of male cod was evaluated and males were determined to exhibit higher fertilization success when sperm motility and GSI were high. This trend was examined in relation to cultured and wild cod stocks. A combination of modeling and field experiments was used to demonstrate that size selective harvesting that protects rather than targets large female teleosts is a practical strategy that contributes to sustainable fisheries. An interesting study on the depleted Pacific Ocean perch off the western USA demonstrated that older females tend to spawn with multiple males, and that young females may abort maturation highlighting two factors that may have important implications to the establishment of old-age populations.

Session 3: Survival of Eggs and Larvae. (Session Convenor: Mark Dickey-Collas)

A keynote address was made that alerted us to how information on effects of fishing (*via* removal of spawning biomass and production of new eggs) and ecosystem variability can be used in the context of ecosystem-based management in predicting future fishery yields. It was made clear that we are only in the early stages of applying recruitment process knowledge to fisheries management. A talk was given on the significance of large, old spawners in increasing the breadth of the stock's spawning season, in particular the associated start of an individual's second spawning season can be critical to recruitment. By impacting the average lifetime spawning duration within a fish stock, fishing pressure could be increasing the variability in reproductive success and reducing its long-term reproductive potential. A mesocosm experiment showed that positive correlations exist between egg and larval size of cod. Moreover, at times of lowered food supply, growth suffered more of offspring which had previously attained larger size which suggests that large initial size may not always be advantageous. A report indicated that haddock egg mortality is greater than of cod, inferring that spawner abundance estimates from egg surveys based on a gadoid-wide equivalent egg mortality rate may be inaccurate. At the time of high haddock abundance, it is possible then to inflate the estimation of cod SSB. In the Baltic Sea, juvenile settling areas were determined by wind-induced drift of larval cod, which is controlled by local atmospheric conditions. Apparently, egg predation exists at these settling areas that coincide with high-density sprat and herring aggregations. A study on Japanese sea bass revealed the operation of density- dependent regulation through competition for prey resources during the post recruit period.

Modelling was performed to explore fitness consequences of time and place of birth, including larval behavioural strategies in which they frequently have to choose between maximizing growth-survival or retention through habitat selection. Analysis of recruitment processes of Baltic herring populations showed that spawning biomass in general is the most important factor in explaining recruitment variation, however recruitment is also affected by variable hydrography probably *via* its shaping of zooplankton abundance and species composition. The complexity of growth and temporal origin of juvenile sprat in the German Bight (North Sea) was documented from otolith microstructure analysis and indicated a mixing area comprised of juvenile sprat from a range of different North Sea areas. Otolith microstructure analysis was again used, this time for late larval and early juvenile Pacific sardine, to elucidate that larvae spawned in late May grew faster than those spawned earlier in the season and comprised a greater fraction of fish sampled as juveniles and pre-recruits. The recruitment dynamics of small pelagic fishes, particularly Pacific sardines, were documented through a rise and fall over the previous 20 years. Warming and cooling of the epipelagic ecosystem in the nursery grounds seemd to be linked to the recruitment fluctuations off Japan. A talk was given on the winter recruitment of YOY bluefish in northeastern Florida where habitat use, feeding ecology and energetics were studied to reveal heavy foraging on large mullet in inlets during winter residency. Report was made of an interesting seasonal field study over 4 years that tracked and sampled Icelandic cod eggs and larvae (2–4 weeks old) from the main southwest spawning grounds to the nursery grounds of the northern part of the island. Water temperature was found to influence growth, whereas larval retention occurred in low saline waters of coastal waters. The physical-biological interactions in the life history of small pelagic fishes (*e.g*., sardine and anchovy) in the western Iberian upwelling ecosystem were described. Processes were related to the ocean 'triad' (enrichment, concentration, and transport/retention) that could explain recruitment fluctuations of these populations. The match-mismatch hypothesis of availability of adequate prey during the larval stage as a key determinant of survival was approached from a finer-resolution perspective of

taxonomy for mackerel in the Magdalen shallows (eastern Canada). The importance of *Pseudocalanus* sp. nauplii and cladocerans were key in density compensation and it was made clear that inappropriate use of the entire prey field concept in the assessment of match-mismatch can sometimes occur.

Session 4: Stock Assessment and Management Implications. (Session Convenor: Ric Brodeur)

The first keynote of this session gave an excellent overview of variation in reproductive characteristics in commercial fish species. It examined the impact of variable reproductive output on scientific advice to managing fish stocks. A stimulating talk was then given on the adequacy of biological reference points presently used by ICES to provide advice on Baltic cod stock status and the associated difficulties in providing this information for an ecosystem characterized by wide changing environmental conditions. A plea was made to include environmental variation such as present adverse environmental conditions for reproduction in scientific advice to assist with steps towards stock recovery as present methods are inadequate to lead to recovery. The potential application of marine protected areas was modelled to evaluate their effectiveness in avoiding evolutionary effects of fishing using a probability function of fish movement between protected and fished areas. It was found that the use of a reserve could reduce the chances of losing old large fish but was highly dependent on fish migratory patterns. An excellent field study was undertaken in Lofoten, northern Norway that found that cod embryonic lethal malformations occurred in areas dominated by first-time spawning female cod. The decline in age and size at maturity and increase of virgin spawners in the stock together with these results have consequences for the estimation of reproductive capacity and biological reference points.

The second keynote talk focused on the design of MPAs and how they protect stocks and increase fishery yields. It was shown that the MPAs operate well when the protected species has a dispersal distance up to the width of the MPA and that a network of MPAs covering a certain fraction of the coastline will protect species with all dispersal distances. The use of pelagic egg abundance estimates (1986–present) was made to estimate population size of Baltic cod using three methods. Despite a number of assumptions (*e.g.*, batch fecundity and spawning frequency) the population size estimates matched well with expected numbers which supports provision for this approach for situations where VPA-based stock assessments are weak. A talk was given on the influences of maternal age of spawning, life history patterns, and recruitment variability on fisheries reference points of rockfish and cod. It was pointed out that mis-specified management reference points may result from the unrecognized effect of spawner age on larval viability. A meta analysis of anchovy egg production parameters revealed that daily egg production and SSB per unit surface area are 6 and 9 times higher respectively for species/populations in upwelling systems (California, Humboldt and Benguela current stocks) compared to those in less productive European Seas (Meditteranean and Bay of Biscay).

A talk on North Sea herring used medium-term simulation techniques to investigate whether changes in carrying capacity or productivity is more influential in determining risk to the population due to exploitation both inside and outside a precautionary approach. This stock has suffered recent poor recruitment despite a large SSB. Trends in intrinsic rate of increase *r* were compared among nine Atlantic cod stocks with time series ranging between 22–56 years. Cod west of Scotland had the highest *r* and northern Gulf of St. Lawrence the lowest *r* indicating significantly different potential for stock recovery which may be based in part on environmental conditions. Modeling effects were made using simulated data on 16 age classes of Norwegian spring spawning herring to explore how uncertainty about the stock abundance estimate affects factors like mean annual yield and risk of the population falling below a biomass limit reference point (B_{lim}). Reproductive habits were presented of the most important flatfish species along the Portuguese coast. These included differences in the timing and duration of spawning and GSI. In general, the highest fisheries landing from these species were recorded during the spawning period due to behavioural patterns of spawning aggregations.

Summing-up. (Keith Brander)

A summary was made of each session highlighting the findings made of presentations including general conclusions and recommendations. A large number of posters were given in each of the four sessions and were displayed throughout the symposium with the first evening evening devoted to poster presentation. The goal of having a single, non-overlapping session combined with the large interest in the symposium resulted in insufficient time to properly view and discuss all posters in one evening. However, the posters were available for viewing throughout the symposium. The symposium theme area has grown considerably in recent years and in particular the area of fish reproduction and how this knowledge can be used for fishery management. The next ten years should be a critical period in the study of recruitment processes as many stocks are depleted and are not showing signs of recovery.

SYMPOSIUM SCHEDULE

Reproductive and Recruitment Processes of Exploited Marine Fish Stocks

Monday, 1 October 2007

0830-0900	Registration
0900-0915	Welcome by Antonio Vázqez, NAFO Scientific Council Chair
0915-1000	*Keynote Address* - Emerging from Hjort's Shadow - Houde, E.
1000-1005	**SESSION 1 – ORAL - Age and Size at Sexual Maturation**
1005-1035	1-1 *Keynote Address* - MARSHALL, C. TARA. Quantifying the relative influence of maturation on stock recovery.

1035-1055 1-2 MOLLET, F. M., T. BRUNEL, B. ERNANDE, and A. D. RIJNSDORP. Estimating onset of reproduction, reproductive investment and growth rate from individual growth trajectories in fish.

1055-1115 1-3 SABORIDO-REY, F., R. DOMÍNGUEZ-PETIT, A. ALONSO-FERNÁNDEZ and A. PÉREZ-RODRÍGUEZ Age and size at maturity of Flemish Cap cod: where is the limit?

1115-1135 **Break**

1135-1205 1-4 *Keynote Address* - MIKKO, H. Disentangling sources of variability in age and size at maturation.

1205-1225 1-5 MCADAM, B. J. and C. T. MARSHALL. Hepatosomatic index and the probabilistic maturation reaction norm of cod.

1225-1245 1-6 SVEDÄNG, H., F. VITALE, and A.VAINIKKA.Trends in age and size based probabilistic maturation reaction norms of cod (*Gadus morhua* L.) in the Kattegat and Sound correlate with variability in juvenile growth.

1245-1305 1-7 DUNLOP, E. S., K. ENBERG, M. HEINO, and U. DIECKMANN. Effects of fisheries-induced adaptive changes on the reproductive characteristics of exploited stocks.

1305-1425 **Lunch**

1425-1445 1-8 PARDOE, H., E. DUNLOP, G. MARTEINSDÓTTIR, and U. DIECKMANN. The influence of stock structure on fisheries-induced evolution in age and size at maturation of Icelandic cod.

1445-1505 1-9 STORR-PAULSEN, M., J. TOMKIEWICZ, and F. KÖSTER. Changes in maturation pattern and reproductive potential of Baltic cod stocks.

1505-1525 1-10 HAY, D., T. THERRIAULT, and B. MCCARTER. Catch curves are misleading, gonads are revealing: age of sexual maturation versus recruitment in Pacific herring (*Clupea pallasi*).

1525-1545 1-11 GARRIDO, S., R. ROSA, R. BEN-HAMADOU, M. E. CUNHA, M. A. CHÍCHARO, and C. D. VAN DER LINGEN. Effect of maternal fat reserves on the fatty acid composition of sardine (*Sardina pilchardus*) oocytes.

1545-1605 **Break**

1605-1610 **SESSION 2 – ORAL - Fecundity and Spawning Success**

1610-1640 2-1 *Keynote Address* - LAMBERT, Y. Reproductive success in marine fish populations: why should we closely monitor fish fecundity?

1640-1700 2-2 NDJAULA, H. O. N., T. HANSEN, M. KRÜGER-JOHNSEN, and O. S. KJESBU. Reproductive strategy of Atlantic horse mackerel *Trachurus trachurus* and the regulatory role of surplus energy and condition indices.

1700-1720 2-3 OPDAL, A. F., F. VIKEBØ, and Ø. FIKSEN. Can temperature benefits justify extensive up-current migrations in the Northeast Arctic cod?

1720-1740 2-4 SLATER, L. M., K. A. GRAVEL, and D. PENGILLY. Sperm reserves of primiparous snow crab (*Chionoecetes opilio*) females in the eastern Bering Sea: inter-annual variation and spatial patterns relative to available males.

1800-2100 Poster Display and Reception

Tuesday, 2 October 2007

0900-0930 2-5 *Keynote Address* - ARMSTRONG, D., L. ORENSANZ, B. SAINTE-MARIE, and B. ERNST. Eggs and larvae are starting ingredients in a menu of recruitment that often goes wrong: lessons from Hhigh latitude Majid crabs.

0930-0950 2-6 KENNEDY, J., J. E. SKJÆRAASEN, R. D. M. NASH, A. SLOTTE, and O. S KJESBU. .Frequency of skipped spawning in Norwegian spring-spawning herring.

0950-1010 2-7 SKJÆRAASEN, J. E., J. KENNEDY, A. THORSEN, R. NASH, and O. S KJESBU. Timing and determination of skipped spawning in Atlantic cod.

1010-1030 2-8 RIDEOUT, R. M., and M. J. MORGAN. Relationships between maternal body size, condition and potential fecundity for Northwest Atlantic flatfishes.

1030-1050 2-9 MARTEINSDOTTIR, G., C. PAMPOULIE, D. BRICKMAN, L. TAYLOR, K. LOGEMANN, and D. RUZZANTE. An attempt to trace the contribution of different spawning components to the surviving population of juvenile cod in Icelandic waters.

1050-1110 2-10 KURITA, Y., Y. FUJINAMI, and M. AMANO. A method to accurately estimate the daily spawning fraction of Japanese flounder *Paralichthys olivaceus* considering a wide range of ambient temperature.

1110-1130 **Break**

1130-1150 2-11 PECQUERIE, L., P. PETITGAS, and S. A. L. M. KOOIJMAN. Understanding the effect of seasonal forcing on the reproductive traits of a multiple-batch spawner in the context of the Dynamic Energy Budget (DEB) theory: the Bay of Biscay anchovy (*Engraulis encrasicolus*) -

1150-1210 2-12 VENTURELLI, P. A., C. A. MURPHY, T. A. JOHNSON, P. J. VAN COEVERDEN DE GROOT, P. T. BOAG, J. M. CASSELMAN, W. C. LEGGETT, R. MONTGOMERIE, M. D. WIEGAND, and B. J. SUTTER. Maternal effects and the sustainability of exploited fish stocks.

1210-1230 2-13 PARKER, S. J., R. W. HANNAH, D. M. VAN DOORNIK, S. R. MILLARD, E. A. BERNTSON, and P. MORAN. Maternal age-related influences on larval production of Pacific ocean perch (*Sebastes alutus*).

1230-1250 2-14 MAYER, I., J. J. MEAGER, J. E. SKJÆRAASEN, G. RUDOLFSEN, Ø. KARLSEN, O. MOBERG, A. STABY, O. KLEVEN, and A. FERNØ. Is spawning success of Atlantic cod escapees influenced by differences in sperm competition?

1250-1410 **Lunch**

1410-1415 **SESSION 3 – ORAL - Survival of Eggs and Larvae**

1415-1445 3-1 *Keynote Address* - MACKENZIE, B., Oceanography meets fisheries conservation - Opportunities for success.

1445-1505 3-2 WRIGHT, P., E. TRIPPEL, and J. TOMKIEWCZ. Fishery-induced demographic changes in the timing of spawning; consequences for reproductive success.

1505-1525 3-3 PAULSEN, H., V. BÜHLER, R. A. J. CASE, C. CLEMMESEN, G. CARVALHO, W. F. HUTCHINSON, O. S. KJESBU, E. MOKSNESS, H. OTTERÅ, A. THORSEN, and T. SVÅSAND. Effects of egg size, parental origin and feeding conditions on growth of larval and juvenile cod (*Gadus morhua* L.).

1525-1545 3-4 LOUGH, R. G., L. O'BRIEN, and L.J. BUCKLEY. Differential egg mortality of Georges Bank cod and haddock -

1545-1606 3-5 HINRICHSEN, H.-H., and G. KRAUS. Identification of Eastern Baltic cod nursery grounds: a hydrodynamic modeling approach.

1605-1625 **Break**

1625-1645 3-6 SHOJI, J., and M. TANAKA. Density-dependence in post-recruit Japanese sea bass in the Chikugo estuary, Japan.

1645-1705 3-7 FIKSEN, Ø. Behavioural adaptations of larval fish to vertical gradients and oceanography: predictions from evolutionary models.

1705-1725 3-8 CARDINALE, M., V. BARTOLINO, C. MÖLLMANN, M. CASINI, G. KORNILOVS, and T. RAID. Recruitment process of Baltic herring populations.

1725-1745 3-9 BAUMANN, H., A. M. MALZAHN, R. VOSS, and A. TEMMING. Growth and temporal origin of juvenile sprat in the German Bight (North Sea).

1745-1805 3-10 TAKAHASHI, M., and D. M. CHECKLEY, JR. Selection for fast development and growth for late larval and early juvenile Pacific sardine, *Sardinops sagx*, in the California Current region.

1805- ???? Poster Display

Wednesday, 3 October 2007

0900-0930 3-11 *Keynote Address* - WATANABE, Y., M. TAKAHASHI, A. TAKASUKA, and Y. OOZEKI. Recruitment variability of small pelagic fish populations in the western North Pacific.

0930-0950 3-12 JUANES, F., J. MURT, and P. CLARKE. Winter recruitment of young-of-the-year bluefish: habitat use, feeding ecology and energetics.

0950-1010 3-13 JÓNASSON, J. P., K. LOGEMANN, B. GUNNARSSON, D.BRICKMAN, and G. MARTEINSDÓTTIR. Abundance and growth of larval cod around Iceland - Passive transport under variable environmental conditions and modelling approaches.

1010-1030 3-14 SANTOS, A. M. P., A. CHÍCHARO, A. DOS SANTOS, T. MOITA, P. B. OLIVEIRA, Á. PELIZ, and P. RÉ. Physical-biological interactions in the life history of small pelagic fish in the Western Iberia Upwelling Ecosystem.

1030-1050 3-15 ROBERT, D., A. TAKASUKA, S. NAKATSUKA, H. KUBOTA, Y. OOZEKI, H. NISHIDA, and L. FORTIER. Predation dynamics of mackerel foraging on populations of larval and juvenile anchovy: is survival of anchovy linked to growth?

1050-1110 **Break**

1110-1115 **SESSION 4 – ORAL - Stock Assessment and Management Implications**

1115-1145 4-1 *Keynote Address* - MORGAN, M. J. Integrating reproductive biology into scientific advice for fisheries management.

1145-1205 4-2 KÖSTER, F., M. VINTHER, B. MACKENZIE, and M. PLIKSHS. Eastern Baltic cod recruitment depends on environment, can scientific advice on fisheries management ignore this?

1205-1235 4-3 MIETHE, T., C. DYTHAM, and J. PITCHFORD. Evolutionary effects of fishing and marine reserves on size at maturation and movement.

1235-1255 4-4 KORSBREKKE, K., V. MAKHOTIN, and P. SOLEMDAL. Variations in proportions of lethal malformations observed in recently spawned eggs from North East Arctic Cod explained by population parameters.

1255-1415 **Lunch**

1415-1435 4-5 *Keynote Address* - BOTSFORD, L. Larval Dispersal and MPAs: Implications of the distance between reproduction and recruitment for spatial management.

1435-1455 4-6 KRAUS, G., H.-H. HINRICHSEN, R. VOSS, J. TOMKIEWICZ, E. TESCHNER, M. SCHABER, and F. W. KÖSTER. Estimating Baltic cod (*Gadus morhua* L.) population sizes from egg production.

1455-1515 4-7 SPENCER, P. D., and Y. LUCERO. The influences of maternal age of spawning, recruitment variability, and life-history pattern upon harvest reference points and fisheries management.

1515-1535 4-8 SOMARAKIS, S., E. SCHISMENOU, and A. MACHIAS. Meta-analysis of anchovy egg production parameters.

1535-1555 4-9 SIMMONDS, J., M. DICKEY-COLLAS, and R. NASH. When recruitment regimes vary, can we still manage North Sea herring in a precautionary manner?

1555-1615 **Break**

1615-1635 4-10 O'BRIEN, L., N. YARAGINA, Y. LAMBERT, G. KRAUS, T. MARSHALL, G. MARTEINSDOTTIR, H. MURUA, F. SABORIDO-REY, J. TOMKIEWICZ, and P. WRIGHT. Using life-history models to explore environmental effects on stock reproductive potential of several cod stocks.

1635-1655 4-11 MYRSETH, J., Ø. FIKSEN, and M. HEINO. Managing fluctuating populations: what is the value of stock assessment?

1655-1800 **SUMMING UP - KEITH BRANDER**

POSTERS

P0-1 COST – FRESH. Saborido-Rey, F.

P1-1 Critical timing for reproductive allocation in an over-wintering capital breeder: experimental evidence from sandeels. Boulcott, P., and P. J. Wright

P1-2 Probabilistic maturation reaction norms of sockeye salmon spawning populations of Bristol Bay, Alaska. Kendall, N., M., and U. Dieckmann

P1-3 Assessing the accuracy of macroscopically assigned maturity stages and the potential for skipped spawning in Northwest Atlantic Greenland halibut (*Reinhardtius hippoglossoides*). Rideout, R.M., M. J. Morgan, A. M. Cohen, and J. H. Banoub

P1-5 Reproductive attributes of three exploited skate species on the Grand Banks and in surrounding Canadian waters. Kulka, D. W., C. Miri, and M. Simpson

P1-6 Comparative analysis of fecundity in Coastal cod (*Gadus morhua*) along the Norwegian coast. Blom, M., A. Thorsen, and O. S. Kjesbu

P1-7 Description and incidence of ovary cysts in two gadoids from the North Atlantic: *Merluccius merluccius* and *Gadus morhua*. Domínguez-Petit, R., A. Alonso-Fernandez, and F. Saborido-Rey

P1-8 Energy allocation related to spawning season in a temperate fish, *Trisopterus luscus* (Linnaeus, 1758). Alonso-Fernandez, A., R. Dominguez-Petit, and F. Saborido-Rey

P1-9 Addressing the influence of environmental and density-dependence factors on juvenile growth and maturation of anchovy (*E. encrasicolus*). Reglero, P., D. Alvarez-Berastegui, M. Iglesias, and A. Giráldez

P1-10 Size at sexual maturity in females in the introduced red king crab (*Paralithodes camtschaticus*) from Finnmark, Norway. Hjelset, A. M., J. H. Sundet, and E. M. Nilssen

P1-12 Assessment of the Red Seabream (*Pagellus bogaraveo*) off the Strait of Gibraltar: Sensitivity to the Application of Different Age Length Keys. Gil, J., and DEEPER Team (J. Baro, C. Burgos, J. Canoura, V. Díaz del Río, C. Farias, L. M. Fernández-Salas, Mª. C.Fernández-Puga, T. García, D. Palomino, V. Polonio, J.M. Serna-Quintero, and M. Sayago)

P1-15 Minimum Size at Sexual Maturity of Mediterranean Swordfish Stock (*Xiphias Gladius*): A comparison with North Atlantic

List of Participants

CONVENORS

Edward A. Trippel
Fisheries and Oceans
St. Andrews Biological Station
Canada
TrippelE@mar.dfo-mpo.gc.ca

Richard D. Brodeur
Estuarine and Ocean Ecology Program
Northwest Fisheries Science Center
USA
Rick.Brodeur@noaa.gov

Mark Dicky-Collas
IMARES
Wageningen University Research
The Netherlands
Mark.dickeycollas@wur.nl

* Denotes Keynote Speaker

Name	Country	E-Mail address
Alexandre Alonso-Fernandez	Spain	alex@iim.csic.es
Ricardo Alpoim	Portugal	ralpoim@ipimar.pt
Katie A. Anderson	USA	kaanders@forwild.umass.edu
Maria Manuel Angélico	Portugal	angelico@ipimar.pt
David Armstrong*	USA	davearm@u.washington.edu
Janet Armstrong	USA	janeta@u.washington.edu
Antonio Avila de Melo,	Portugal	amelo@ipimar.pt
Vladimir Babyan	Russia	vbabyan@vniro.ru
Michelle M. Bachan	Canada	michellebac@gmail.com
Walter Basilone	Italy	water.basilon@irma.pa.cur.it
Marisa Batista	Portugal	mibatista@fc.ul.pt
Loïc Baulier	Norway	loicb@imr.no
Hannes Baumann	Germany	hannes.baumann@uni-hamburg.de
Martin Blom	Norway	martin.blom@hials.no
Joana Boarido	Portugal	joanaboarido@sapo.pt
Louis Botsford*	USA	lwbotsford@ucdavis.edu
Keith Brander	ICES	keith@ices.dk
Thomas Brunel	The Netherlands	Thomas.brunel@wur.nl
Rikke Hagstrøm Bucholtz	Denmark	rhb@difres.dk
Mike Canino	USA	Mike.Canino@noaa.gov
Massimiliano Cardinale	Sweden	massimiliano.cardinale@fiskeriverket.se
Corina Chaves	Portugal	corina@ipimar.pt
Ana Maria Costa	Portugal	amcosta@ipimar.pt
Joana Cruz	Portugal	jcruz@ipimar.pt
Deborah Davidson	Scotland	deborah.davidson@abdn.ac.uk
Rafael Duarte	Portugal	rduarte@ipimar.pt
Erin Dunlop	Norway	erin.dunlop@imr.no
Inger-Britt Falk-Petersen	Norway	ingerf@nfh.uit.no
Ines Farias	Portugal	ifarias@ipimar.pt
Diana Feijó	Portugal	dfeijo@ipimar.pt
Øyvind Fiksen	Norway	oyvind.fiksen@bio.uib.no
Susana Garrido	Portugal	sgarrido@ipimar.pt
Patrícia Gonçalves	Portugal	patricia@ipimar.pt
Fernando Gonzalez-Costas	Spain	fernando.gonzalez@vi.ieo.es
Leonel Serrano Gordo	Portugal	lsgordo@fc.ul.pt
Agnes C. Gundersen	Norway	agnes@mfaa.no
Holger Haslob	Germany	hhaslob@ifm-geomar.de
Doug Hay	Canada	hay.doug@shaw.ca
Juan Gil Herrera	Spain	juan.gil@cd.ieo.es
Hans-Harald Hinrichsen	Germany	hhinrichsen@ifm-geomar.de
Ann Merete Hjelset	Norway	ann.merete.hjelset@imr.no
Ed Houde*	USA	ehoude@cbl.umces.edu
Arne Johannessen	Norway	arne.johannessen@bio.uib.no
Jónas P. Jónasson	Iceland	jonasp@hafro.is
Francis Juanes	USA	juanes@forwild.umass.edu
James Kennedy	Norway	james.kennedy@bio.uib.no
Suam Kim	Korea	suamkim@pknu.ac.kr
Olav Sigurd Kjesbu	Norway	olav.kjesbu@imr.no

Knut Korsbrekke	Norway	knut.korsbrekke@imr.no
Maria Korta	Spain	mkorta@pas.azti.es
Fritz Köster	Denmark	fwk@difres.dk
Gerd Kraus	Denmark	gkr@difres.dk
Dave Kulka	Canada	kulkad@dfo-mpo.gc.ca
Yutaka Kurita	Japan	kurita@affrc.go.jp
Hiroaki Kurogi	Japan	hkuro@affrc.go.jp
Yvan Lambert*	Canada	lamberty@dfo-mpo.gc.ca
Josep Lloret	Spain	josep.lloret@udg.edu
Timothy Loher	USA	Tim@iphc.washington.edu
R. Gregory Lough	USA	glough@whsun1.wh.whoi.edu
Gustavo J. Macchi	Argentina	gmacchi@inidep.edu.ar
Pedro Bordalo Machado	Portugal	bmachado@ipimar.pt
David Macías	Spain	david.macias@ma.ieo.es
Brian MacKenzie*	Denmark	brm@difres.dk
Bart Maertens	Belgium	bart.maertens@ilvo.vlaanderen.be
Maria Manuel A. Barboza Martins	Portugal	mane@ipimar.pt
Tara Marshall*	UK	c.t.marshall@abdn.ac.uk
Gudrun Marteinsdottir	Iceland	runam@hi.is
Ian Mayer	Norway	ian.mayer@bio.uib.no
Bruce McAdam	United Kingdom	b.mcadam@abdn.ac.uk
Richard S. McBride	USA	richard.mcbride@noaa.gov
Justin Meager	Norway	justin.meager@bio.uib.no
Sonia Mehault	Spain	mehault@iim.csic.es
Cesar Meiners	Spain	cesar.meiners@ma.ieo.es
Isabel Meneses	Portugal	imeneses@ipimar.pt
Tanja Miethe	United Kingdom	tm518@york.ac.uk
Heino Mikko*	Norway	mikko.heono@bio.uib.no
Fabian Mollet	The Netherlands	Fabian.Mollet@wur.nl
Cristina Morgado	Portugal	cmorgado@ipimar.pt
Joanne Morgan*	Canada	morganmj@dfo-mpo.gc.ca
Teresa Moura	Portugal	tmoura@ipimar.pt
Marta Muñoz	Spain	marta.munyoz@udg.edu
Alberto Murta	Portugal	amurta@ipimar.pt
Hilario Murua	Spain	hmurua@pas.azti.es
Johanna Myrseth	Norway	johanna.myrseth@student.uib.no
Richard Nash	Norway	richard.nash@imr.no
Hilkka O.N. Ndjaula	Norway	hilkka.ndjaula@imr.no
Ana Neves	Portugal	amneves@fc.ul.pt
Cristina Nunes	Portugal	cnunes@ipimar.pt
Loretta O'Brien	USA	lobrien@whsun1.wh.whoi.edu
Roland Olbrich	Germany	roland.olbrich@uni-lueneburg.de
Anders Frugård Opdal	Norway	anders.opdal@bio.uib.no
Dave Orr	Canada	orrd@dfo-mpo.gc.ca
Renée Felicia Osborne	South Africa	Rosborne@deat.gov.za
Patrick Ouellet	Canada	OuelletP@dfo-mpo.gc.ca
Marcelo Pajaro	Argentina	mpajaro@inidep.edu.ar
Heidi Pardoe	Iceland	heidi@hafro.is
Steve Parker	New Zealand	s.parker@niwa.co.nz
Helge Paulsen	Denmark	hep@difres.dk
Laure Pecquerie	France	laure.pecquerie@ifremer.fr
Joao Pereira	Portugal	jpereira@ipimar.pt
Ana Ramos Martos	Spain	ana.ramos@vi.ieo.es
Barbara Pereira	Portugal	bpereira@ipimar.pt
Alfonso Pérez	Spain	fonsilei@iim.csic.es
Don Power	Canada	powerd@dfo-mpo.gc.ca
Gloria Ramos Viera	Spain	venade8@hotmail.com
Sergei Rebik	Ukraine	rebikst@mail.ru
Patricia Reglero	Spain	patricia.reglero@ba.ieo.es
Rick Rideout	Canada	RideoutR@dfo-mpo.gc.ca

Dominique Robert	Canada	dominique.robert@giroq.ulaval.ca
Toomas Saat	Estonia	toomas.saat@ut.ee
Fran Saborido-Rey	Spain	fran@iim.csic.es
A Miguel P Santos	Portugal	amsantos@ipimar.pt
Antonio dos Santos	Portugal	antonina@ipimar.pt
Louise Savard	Canada	SavardL@dfo-mpo.gc.ca
Vera Sequeira	Portugal	vlsequeira@fc.ul.pt
Fred Serchuk	USA	serchuk.fred@noaa.gov
Jun Shoji	Japan	jshoji@hiroshima-u.ac.jp
Alexandra Silva	Portugal	asilva@ipimar
Silver Sirp	Estonia	silver.sirp@ut.ee
Jon Egil Skjæraasen	Norway	jon.skjaeraasen@bio.uib.no
Laura M. Slater	USA	laura.slater@alaska.gov
Stylianos Somarakis	Greece	somarak@biology.uoc.gr
Paul Spencer	USA	paul.spencer@noaa.gov
Ingo W. Stuermer	Germany	ingo.stuermer@ior.bfa-fisch.de
Marie Storr-Paulsen	Denmark	msp@difres.dk
Henrik Svedäng	Sweden	henrik.svedang@fiskeriverket.se
Motomitsu Takahashi	USA	takahamt@coast.ucsd.edu
Ross Tallman	Canada	tallmanr@dfo-mpo.gc.ca
Susanne Tanner	Portugal	sertaanner@fc.ul.pt
Célia Teixeira	Portugal	cmteixeira@fc.ul.pt
Sakhile Tsotsobe	South Africa	stsobs@deat.gov.za
Antonio Vazquez	Spain	avazquez@iim.csic.es
Anatoly Velikanov	Russia	velikanov@sakhniro.ru
Catarina Vendrell	Portugal	cvendrel@ipimar.pt
Paul Venturelli	Canada	paul_venturelli@hotmail.com
Sílvia Vila	Spain	silvia.vila@udg.es
Ana Rita Vieira	Portugal	ana.vieira83@gmail.pt
Catarina Vinagre	Spain	cmvinagre@fc.ul.pt
Francesca Vitale		
Knut Wiik Vollset	Norway	knut.vollset@bio.uib.no
Yoshiro Watanabe*	Japan	ywatanab@ori.u-tokyo.ac.jp
Joel Webb	USA	joel.webb@alaska.gov
Margit Wilhelm	Namibia	mwilhelm@mfmr.gov.na
Peter Robin Witthames	United Kingdom	peter.witthames@cefas.co.uk
Peter Wright	United Kingdom	P.Wright@marlab.ac.uk
Natalia Yaragina	Russia	yaragina@pinro.ru
Michio Yoneda	Japan	myoneda@fra.affrc.go.jp
Jie Zheng	USA	jie.zheng@alaska.gov