Some Possible Ways Forward Development of Aquaculture

Abstract
Aquaculture has concentrated on the production of some high commercial value species. Other species may be high success, but we do not control their biological cycles. It is important to know precisely the optimal combinations of salinity and temperature at each stage of their life cycles. It is suggested to bring together into a common system available information, past and present, currently disparate and dispersed, and direct future research towards common goals, with a harmonisation of methods. Moreover the composition of the new compounds foods require new basic research efforts. Restocking operations from hatchery production will pay the utmost attention to the consequences of restocking on the ecosystems in which these are carried out restocking.

Introduction

Place of aquaculture in food consumed by humans

Today, more than half of what humanity consumes as aquatic food comes from aquaculture. That activity produces 70 million tonnes per year, while global fisheries leveled for over 10 years at around 90 million tonnes 11 million tonnes for inland and 79 million tons for sea fishing (FAO, 2014). Due to the continued exploitation of natural populations through fisheries, aquaculture will continue to grow ineluctably, under the combined effects of the increasing world population, a higher protein consumption per capita better information for consumers who want a balanced diet. Aquaculture is developing in many countries of the world, and it causes significant efforts in scientific research, progress in animal husbandry and breeding techniques. Despite the experience gained in previous decades to achieve new knowledge in biology, in technical and economics of aquaculture enterprises, it is always risky to engage in farming of new marine species because they require new progress in basic sciences, original farming techniques and a new coastal management, adaptation to market needs, physical and financial infrastructure, etc. Curiously, several areas of this research were not sufficiently developed in recent years, so they could provide very important information to enhance the success of aquaculture, both in the field of basic knowledge in commercial applications. In addition, some of the new results obtained could also be used to analyze the functioning of natural ecosystems. The purpose of this short review is to attract the attention of researchers on few subjects that should allow for better progress in the results of aquaculture. It is necessary to clearly differentiate extensive aquaculture, in which the higher organisms must feed themselves from the natural environment resources, intensive aquaculture, in which these organizations receive food provided by humans. When the species reared receive, indirectly or directly, their food provided by humans in addition to those they find in nature, we are dealing with a semi-intensive aquaculture. The hyper intensive aquaculture is one in which the animals reared only receive food provided by humans, and in a closed environment, whose characteristics are well controlled. In practice, there are no clear boundaries between these different types of aquaculture, some operations taking place in the open sea, or in more or less closed bays or lagoons. In any case, we must rely on more fundamental research results, including physiology, biochemistry [1] and molecular biology.

Knowledge of biological cycles of aquatic species

Our knowledge about species that have been well studied because they are consumed by humans, are sometimes not sufficient. And they are even less for species that are not consumed. In many cases, we do not even know the life history of species yet mundane structure marine ecosystems and often fished. And when we know empirically some biological cycles, we do not control in artificial conditions controlled. Then, when these biological cycles are mastered in the laboratory new steps (mass production, optimization) to be reached significant productions and organizations for trade and consumption. So far, marine aquaculture was mainly confined to high demand species that are not, and therefore under the direct influence of eating habits, which vary greatly from country to country. Thus, Western consumers rather consume sea bass, sea bream, red mullet, sole, flounder, turbot, penaeid shrimp, lobsters and lobsters, while in Japan, for example, in addition to these species, many other varieties are eaten. These specific requests have led, in this country, the creation of special aquaculture enterprises, like certain species of seaweed (nori, wakame) of puffers (fugu), tunicates (hoya), sea urchins (uni), which are raised by producers, let alone species from fisheries that are rarely consumed in other countries, such as cod gonads (mentaiko), whale meat (kujira), gonads males of many species of fish (Shirako), fry sardines (chirimen jako), jellyfish (kurage), sea cucumbers (namako) and all sorts of crabs, fish and shellfish. For each species which are already high in aquaculture, it was necessary to know in great detail each step of the life cycle of the species, to reproduce in hatcheries in artificial conditions. Control of biological cydes of sea bream, sea bass, penaeid shrimp, sea urchins, abalone,
For example, are well known and controlled, requiring only a few minor improvements. For other species, work is under development such as sea cucumbers Apostichopus japonicus in Hokkaido (Sakai, 2015) and in the prefectures of Miyagi and Iwate.

But for many other species, for which a large market potential exists, like lobster or tuna, for example, the complete life cycle has rarely been achieved and controlled. This is the case for all larval stages of five species of lobsters, which Palinurus elephas, successfully by Kikuta et al. [2] and, more or less completely, according to the different species of this zoological group [3-5].

It is therefore necessary, even essential, to have available a larger number of experimental laboratories sufficiently advanced, controlling many abiotic factors, breeding of marine species so that we can ascertain the full life cycle many species. Evidently, there are already some very good research aquariums in many countries USA, Canada, Great Britain, France, Japan, Australia, Japan, New Zealand, Spain, etc. But the experimental conditions do not allow to precisely regulate the variables that are subject marine species in their natural environment and especially in the new current conditions.

This is all the more necessary that the natural environment will see their temperature increase, salinity vary accordingly, and that their pH will acidify. Despite some important fundamental ancient and recent work [6-13] there is still much research to achieve to establish the life cycles of many marine species. Moreover it is essential to know the optimal conditions for survival and growth of each larval and juvenile stages of many species. Finally, to complete the cycle, we must ensure the most favorable environmental factors to condition females (temperature, lighting food, environment) to get them to produce good quality eggs, which will give perennial larvae. There is an obvious gap in our knowledge. Finally, the results obtained in this work-oriented aquaculture will better know the duration of each larval stage, and therefore their distribution by currents in the marine space, over time [14,15], ensuring the recruitment of the species.

Survival and growth based on the salinity and temperature

In general, the growth and survival of marine animals are better when they live in slightly desalinized sea water: they must fight against the invasion of their internal medium by salt and maintaining the physiological function has a high energy cost. A decrease in the salinity is favorable. Serrano et al. [16] showed experimentally that the fish Lutjanus griseus chose the less salty waters and that choice varies with circadian light.

Conversely, marine species poorly regulate when placed in hypersaline waters, which is for them a very harmful environment. Many studies have been devoted to the maximum thermal limit at which the different marine species were able to survive. But this temperature sensitivity varies depending on the salinity. Their adaptation to different temperatures varies with different zoological taxa and sometimes even within the same genus, according to the different species [17,18]. While many data exist in the literature [19-21] they need to be much more accurate.

Changes of physiology and osmoregulation are very well known in salmon, shad, eels and other migratory species. But on a smaller scale, physiology successive stages of development of many organisms also varies depending on the larval stages considered [10,22] which often explains the migration of these stages in the areas of estuaries, less salty, which move in seeking their optimum salinity for a given temperature [23].

Others have pointed out that the biology of the animals was amended by the pH and by air CO₂ content by decreased oxygen [24-26]. Which is valid in the natural environment, but will also be true in the water used in aquaculture. It should not be forgotten too, as aquaculture in the study of unconfined ecosystems, the possible arrival of parasites some stages swimmers can be active or inactive according to the characteristics of the environment where they are [27-30]. New work, very important, open in this field of research.

This new field is of utmost importance because of global warming seriously affecting marine areas, particularly coastal areas. It is important now to establish precise graphs and abacus of survival and optimal growth for each species and each larval stage, taking into account both changes in temperature and salinity. It is from this database that we can better understand the effects of changes in water quality and dissolved gases as well as in aquaculture to better analyze trends in ecosystems.

Progress in the formulation of foods for intensive breeding

Food is one of the major problems in aquaculture, which is becoming more and more for a number of years with no real good solution. Most high marine species are currently fed compound feed containing fishmeal from the operation of natural stocks of “forage fish” pelagic relatively low cost (sprat, anchovy, sardine, blue whiting, etc.) serving as prey to predatory species [31] and enriched in marine oils in polyunsaturated fatty acids omega-3. It is estimated that fishing of “forage fish” represent in the world, about a third of the tonnage of professional fishing. It became too much and today, as it is currently overfished, it must be controlled and limited. Furthermore, withdrawals by humans in natural populations strongly disturbs, now, the balance of pelagic ecosystems, depriving natural predators (carnivorous fish, birds, sea turtles, marine mammals, etc.) of their usual prey [32,33]. Fishing, which is suitable for use, even rational, wild ecosystems, necessarily enter into decline. It is therefore urgent to establish and use reliable indicators to measure this reduction and identify the critical phases of such future imbalances before serious irreversible crises occur. A more accurate assessment of global needs for fish meal should be carried out based on global aquaculture development in the world and potential of natural ecosystems to provide forage fish.

It will aim to limit catches to adjust aquaculture production to the possibilities of production by the ecosystems exploited for making fishmeal, as a first step towards global management of marine natural resources.

It has therefore become imperative to replace the marine components of compound feed for rearing fish and shellfish, with land-based components mainly from agriculture soybean meal, corn, rapeseed, sunflower, pea, lupine beans, sesame, sorghum, etc. experienced in many countries of the world, depending on their availability, their price, their composition, for example, and consumption time experimental diet [34-36]. The issue is whether;
when they have been consumed by animals, digestive enzyme equipment of these species will be suitable for optimal digestion of basic compounds from agriculture. Inside the same zoological group, as among the penaeid shrimp for example, protein needs can be very different from one species to another and it would be interesting to establish a quantitative measure of their carnivoricity. Dupont Nivet et al. [37] found genetic variations in the response of trout consuming more or less rich in compound feed fishmeal. Moreover, these very new foods to their diets modify the flora of the digestive tube [38-40], opening paths to new research. For carbohydrates, marine species have evolved out of contact with starches from seeds from land, usually graminaceae. Also feed efficiency starches in compound feed is not very high [41]. It seems that animals like lobsters grow better when they consume glycogen from other marine organisms such as mussels [42]. Finally, we must know precisely the extent and composition of the residues of uneaten food that have passed through the digestive tract and which will inevitably end up in the marine environment, often changing, more or less strongly, the normal functioning of ecosystems where farms are installed. The food in excess and feces are most often used as food for other species outside the cages, which increases biodiversity and biomass in natural environments. Other solutions are moving towards the installation of individual artificial reef located below or adjacent cages, offering specific habitats to ecosystem species considered most requested by the market. The integration of aquaculture in the natural environment deserves renewed attention, deeper than the salmon cages in the fjords of Scandinavia.

Aquaculture Restocking

When some species have been too much exploited, one can imagine that we can sometimes build up populations by restocking swarming in large amounts of post-larvae or juveniles who grow up in areas that have been overfished [43]. There is no need to stress here the great stocking operations taking place in the US Canada and Japan for salmon. Good progress has been made in this area in the past [44,45]. However, we are still far replenish forage fish populations, which are generally close to the base of the food web, but we do not control mass production of larval forms, post-larval and juveniles. For a long time, Japan has an extensive network of dozens of hatchery production and stocking, which for many years [46,47] rejected billions post-larvae and juveniles at sea of different marine species appreciated by the domestic market, especially salmon and more recently other species such as red sea bream, shrimps, gray sea bream, abalone, sea urchins, etc. Restocking of juvenile crabs Portunus trituberculatus are performed every year by Japanese production hatcheries in Osaka Bay, using established techniques [40].

These operations were carried out under pressure from fishermen and the political and administrative power without first giving precise estimates of the effects of these massive releases on local ecosystems that have been affected [49]. These ecological studies were undertaken later, relying in particular on the identification of populations by DNA markers [49-52]. Much remains to be done and urgently if we do not want to destroy so perhaps ultimately these pelagic ecosystem.

Future development of the coastline necessarily include restocking operations from hatchery production. But it will first choose and decide on major orientations choice of species to produce and disseminate, preparation of habitats needed for good survival of the species, releases of fry or post-larvae in marine protected areas, or equipped not of artificial reefs influence of releases on the functioning of natural ecosystems.

Many of these items were discussed in Japan, for example when stocking penaeid shrimp in various parts of coastal zones, or gray sea bream on the coast of Hiroshima or sea urchins in various sites of the coast of Hokkaido or abalone (Haliotis) in several parts of the country choice of the date of the releases, optimal size at which it will perform restocking, artificial management to create habitats. Similar consultations took place in France during the lobster restocking trials, species whose detailed behavior is not yet very well known despite numerous observations. After several programs of restocking, recently, some release of a few dozen individuals took place in France or in connection with the activities of the Océarium Croisic. On another scale, and after numerous releases programs in Canada, Nova Scotia ans United States, recently, experts from New Brunswick as a precaution, release at sea each year 300,000 post-larval lobsters, to try to stabilize the recruitment of this species. To ensure good survival of post-larval lobsters just after metamorphosis, artificial reefs trials were conducted in Canada [53,54]. On a smaller scale, small concrete shelters were made in France and experimentally, Japan, Sanriku. The management of sea bottoms is a prerequisite because it is necessary that young forms, which molt frequently, can find shelter against predators to pass the time during which their exoskeleton is very soft and they are defenseless [55-59].

Final Thoughts

To continue to grow in various areas, aquaculture still has progress to make. Control of breeding new species require good knowledge of the life cycles of many aquatic species, whether sought today by man or are later used in human food. Some species such as rock lobsters are characterized by numerous larval stages, and little is yet known on their general physiology and digestive biochemistry. New well equipped laboratories will have to address the original research programs to develop such knowledge’s. To complete biological cycles it will be necessary also to know the best possible conditions for maintaining females and parents, in order to obtain eggs and larvae of good quality. Moreover, it is surprising that there has not established mostly survival charts and abacus and optimal growth of larval, juvenile and adult based on combinations of salinity and temperature. Many scientific studies (see above) approached this area in very different disparate point of views. One might suggest that all existing data are collected in order to have general summary information for each larval or juvenile stage, species by species. This information will be extremely useful for both aquaculture and for the evolution of ecosystems, when water temperatures continue to rise and as their characters (pH, dissolved gases, etc) vary with global change. Replacing fishmeal in compound feed for aquaculture should be made at very short notice, otherwise it will be pelagic ecosystems that will be heavily affected and with them, all marine populations that depend on them will suffer. A global management of these natural richness of the oceans become necessary. Moreover, restocking fish farms intended to modify natural ecosystems for species requested by the traditions and culture of human populations consuming, must be carried out.
with maximum care so as not to disrupting the functioning of natural ecosystems. The ecological impact of aquaculture cages that receive all usable food supplement should be studied carefully to quantitatively measure their effects on biodiversity and local production, which will necessarily be changed. Finally this modest work has deliberately left out several aspects that are part of the foundations of aquaculture as the functioning of the digestive tubes, pigmentation, the role of light, chronobiology, to mention only these important areas of research.

### References

1. Ceccaldi HJ (1982) Contribution of physiology and biochemistry to progress in aquaculture. Bull Soc Sci Fish Japan 48 (8): 1011-1028.
2. Kitaka J, Kudo R, Onoda S, Kanemaru K and Mercer JP (2002) Larval culture of the European spiny lobster Pandalus elegans. Mar Freshw Res 52(8): 1439-1444.
3. Kitaka J (1997) Culture of larval spiny lobsters: a review of work done in northern Japan. Mar Freshw Res 48: 923-30.
4. Kitaka J (1994) Culture of Phyllosomas of Spiny Lobster and Its Application to Studies of Larval Recruitment and Aquaculture. Crustacea 66 (3): 258-270.
5. Goldstein JS, Matsuda H, Takanouchi T, Butler MJ (2008) The Complete Development of Larval Caribbean Spiny Lobster Panulirus argus (Latreille, 1804) in Culture. J Crustacean Biology 28 (2): 306-327.
6. Braarud T (1961) Cultivation of marine organisms as a means of clustering of understanding environmental influences on populations. In: Sears M. (Ed), Oceanography: 271-298
7. Kinne O (1964) The effects of temperature and salinity on marine and brackish water animals: II. Salinity and temperature salinity combinations. Oceanogr Mar Biol Annu Rev 2: 281-339.
8. Brenko MH, Calabrese A (1969) The combined effects of salinity and temperature on larvae of the mussel Mytilis edulis. Mar Biol 4(3): 224-226.
9. Kingston P (1974) Some observations on the effects of temperature and salinity upon the growth of Cardium edule and Cardium glaucum larvae in the laboratory. J Mar Biol Assoc UK 54(2): 309-317.
10. Yagi H (1988) Variances de quelques facteurs physiologiques et chimiques chez les Crustacés Décapodes d'élégance, en fonction de variations contrôlées des facteurs du milieu extérieur: Thèse Université Aix-Marseille II 190.
11. Robert R, His E and Dinet A (1988) Combined effects of temperature and salinity on fed and starved larvae of the European flat oyster Ostrea edulis. Mar Biol 97(1): 95-100.
12. Verween A, Vinck M and De graer A (2007) The effect of temperature and salinity on the survival of Mytilopsis leucophaea larvae (Mytilus Bivalvia): The search for environmental limits. J Exp Mar Biol Ecol 349(1-2): 111-120.
13. Widdicombe S and Spicer JI (2008) Predicting the impact of Ocean Acidification on Benthos Biodiversity: What Can Animal Physiology Tell Us?. J Exp Mar Biol Ecol 366(1-2): 187-197.
14. Branford JR (1978) The effect of daylength, temperature and season on the hatching rhythm of Hymenocallis gammarus. J Biol March Ass UK 58: 639-658.
15. O’Connor MI, Bruno JF, Gaines SD, Halpern BS, Lester SE, et al. (2007) Temperature control of larval dispersal and the implications for marine ecology, evolution, and conservation. Proc Nat Acad Sci 104(4): 1266-1271.
16. Hurst TP and Conover D0 (2002) Effects of temperature and salinity on survival of young-of-the-year Hudson River striped bass (Morone saxatilis): implications for optimal overwintering habitats. Can J Fish Aquat Sci 59(5): 787-795.
17. Kelley AL, Rivera CE and Buckley BA (2011) Intraspecific variation in thermotolerance and morphology of the invasive European green crab, Carcinus maenas, on the west coast of North America. J Exp Mar Biol Ecol 409(1-2): 70-78.
18. Madeira D, Narciso L, Cabral RN, Diniz MS, Vinagre C (2012) Thermal tolerance of the crab Pachygrapsus marmoratus: intraspecific differences at a physiological (CTMax) and molecular level (Hsp70). Cell Stress Chaperone 17(6): 707-716.
19. Yagi H, Ceccaldi H-J (1985) Rôle de la température et de la salinité sur la mue, la métamorphose et la croissance à chaque stade larvaire de Palaemon serratus. Ann Inst Océanogr 611: 75-93.
20. Wuenschel M, Jugovich A and Hare J (2004) Effect of temperature and salinity on the energetics of juvenile gray snapper (Lutjanus griseus): implications for nursery habitat value. J Exp Mar Biol Ecol 312(2): 333-347.
21. Wuenschel M, Jugovich A and Hare J (2005) Metabolic response of juvenile gray snapper (Lutjanus griseus) to temperature and salinity: physiological cost of different environments. J Exp Mar Biol Ecol 321(2): 145-154.
22. Yagi H, Ceccaldi HJ, Gaudy R (1990) Combined influence of temperature and salinity on oxygen consumption of the larvae of the pink shrimp Palaemon serratus (Pennant). (Crustacea, Decapoda, Palinomidae). Aquat Biol 86(1): 77-92.
23. Pörtner HO et Langenbuch M (2005) Synergistic effects of temperature extremes, hypoxia, and increases in CO2 on marine animals: From Earth history to global change. J Geophys Res, 110: C9.
24. Shira yama Y (2002) Towards comprehensive understanding of impacts on marine organisms due to raised CO2 concentration, in Proceedings of the 5th International Symposium on CO2 Fixation and Efficient Utilization of Energy, Tokyo 1. 177-181.
25. Pörtner HO, Langenbuch M and Reipschläger A (2004) Biological impact of elevated ocean CO2 concentrations: Lessons from animal physiology and Earth history? J Oceanogr 60: 705-718.
26. Shira yama Y and H Thornton (2005) Effect of increased atmospheric CO2 on shallow-water marine benthos. J Geophys Res 110: C9.
27. Poulin R (2006) Global warming and temperature-mediated increases in cercarial emergence into metacercade parasites. Parasitology 132(1): 145-151.
28. Poulin R and Mouritsen KN (2006) Climate change, parasitism and the structure of intertidal ecosystems. J Helminthol 80(2): 183-191.
29. Glenn RR, Pugh TL (2006) Epizootic Shell Disease in American Lobster (Homarus americanus) in Massachusetts Coastal Waters: Interactions of Temperature, Maturity, and Intermolt Duration. J Crustacean Biology 26(4): 639-645.
30. Koprivnikar J and Poulin R (2009) Effects of temperature, salinity, and water level on the emergence of marine cercariae. Parasitol Res 2009:105(4):957-965.

31. De Silva SS, Turchini GM (2009) Use of wild fish and other aquatic organisms as feed in aquaculture - a review of practices and implications in the Asia-Pacific. In Hasan MR Halwart M (Eds.). Fish as feed inputs for aquaculture: practices, sustainability and implications FAO Fisheries and Aquaculture Technical Paper, No. 518. Rome, FAO, pp. 407.

32. Garcia SM, Zerbi A, Alioume C, Do Chi T, Lasserre G (2003) The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook. FAO Fisheries Technical Paper. Rome, FAO, 443: 71.

33. Garcia SM, Cochrane KL (2005) Ecosystem approach to fisheries: a review of implementation guidelines. ICES Journal of Marine Science. 62(3): 311-318.

34. Galgani F, Ceccaldi HJ, AQUACOP (1988) The effect of the incorporation of soybean and fish meals in the diet on the growth and digestive enzymes of Penaeus vannamei. Aquat Living Resour 1: 181-187.

35. De Francesco M, Parisi G, Médale F, Lupi P, Kaushik S, et al. (2004) Effect of long-term feeding with a plant protein mixture based diet on growth and body/fillet quality traits of large rainbow trout (Onchorhyncus mykiss). Aquaculture 236(1-4): 413-429.

36. De Francesco M, Parisi G, Perez-Sanchez J, Gomez-Reguenni P Médale F, et al. (2007) Effect of high level fish meal replacement by plant proteins in gilthead sea bream (Sparus aurata) on growth and body/fillet quality traits. Aquacult Nutr 13: 361-372.

37. Dupont-Nivet M, Médale F, Leonard J, Le Guillon S, Tiquet F, E et al. (2009) Evidence of genotype-diety interactions in the response of rainbow trout (Onchorhyncus mykiss) clones to a diet with or without fishmeal at early growth. Aquaculture 295(1-2): 15-21.

38. Silva FdCP, Nicol Jr, Zambonino-Infante JL, Kaushik SG and Gatesoupe FJ (2011) Influence of the diet on the microbial diversity of faecal and gastrointestinal contents in gilthead sea bream (Sparus aurata) and intestinal contents in goldfish (Carassius auratus). FEMS Microbiology Ecology 78(2): 285-296.

39. Deisai AR, Links MG, Collins SA, Mansfield GS, Drew MD, Van Kessel AG, Hill JE (2012). Effects of plant-based diets on the distal gut microbiome of rainbow trout (Onchorhyncus mykiss). Aquaculture 350: 134-142.

40. Gatesoupe FJ, Huelvan C, Le Bayon N, Sévère A, Aasen IM et al. (2014) The effects of dietary carbohydrate sources and forms on metabolic response and intestinal microbiota in sea bass juveniles,Dicentrarchus labrax, Aquaculture 412-413: 473-53.

41. Simon CJ (2009) The effect of carbohydrate source, inclusion level of gelatinised starch, feed binder and fishmeal particle size on the apparent digestibility of formulated diets for spiny lobster juveniles, Jasus edwardsii. Aquaculture 296(3-4): 329-336.

42. Radford CA, Marsden ID, Davison W and Jeffs AG (2007) Effects of dietary carbohydrate on growth of juvenile New Zealand rock lobsters, Jasus edwardsii. Aquaculture 273(1): 151-157.

43. Ceccaldi HJ, H Yagi (1990) Role of temperature and salinity on survival and growth of crustacean larvae. La Mer 28 (4): 260-265.

44. Le Borgne Y (1981) Techniques de reproduction contrôlée des molusques bivalves pour les élevages extensifs ou le repeuplement: rôle des écosystèmes - natures. Journées d’étude Aquaculture extensive et repeuplement, Brest, 29-31 mai 1979. Publ. CNEXO, série: Actes de Colloques 12: 51-54.

45. Wahle R (1981) Impact of artificial propagation of salmon on the Pacific coast of the United States and Canada, 1872-1979, Journées d’étude Aquaculture extensive et repeuplement, Brest, 29-31 mai 1979. Publ. CNEXO, série Actes de Colloques 12: 143-150.

46. Uno Y (1981) Recent mariculture techniques in Japan. Journées d’étude Aquaculture extensive et repeuplement, Brest, 29-31 mai 1979. Publ. CNEXO, série Actes de Colloques 12: 63-77.

47. Fushimi H (1998) Developing a stock enhancement program based on artificial seedlings: activities of the Japan Sea-Farming Association (JASFA) in the last decade. JNRF Technical Report No. 26: 95-104.

48. Aileen TS-H, Zuziglar BHY, Fuji Y, Fukuda T, Tenzaki M (2000) SPS / UCC Report: Culture of Japanese blue crab (Portunus trituberculatus). The Center for International Cooperation, The Ocean Research Institute, Univ Tokyo pp. 29.

49. Nakajima K, Kitada S, Yamazaki H, Takemori H, Obata Y et al. (2013) Ecological interactions between hatchery and wild fish: a case study based on the highly piscivorous Japanese Spanish mackerel. Aquaculture Environment Interactions 5 : 231-243.

50. Perez-Enriquez R, Takemura M, Tabata K and Taniguchi N (2001) Genetic diversity of red sea bream Pagrus major in western Japan in relation to stock enhancement. Fish Sci 67(1): 71-78.

51. Umino T, Blanco Gonzalez R, Saito H and Nakagawa H (2011) Problems associated with the recovery on landings of black sea bream (Acanthopagrus schlegelli) intensively released in Hiroshima Bay, Japan. In: Global Change: Mankind-Marine Environment Interactions, Ceccaldi HJ & Dekeys er I (Eds.), 37-40, Springer Science.

52. Jeong D-S, Umino T, Kuroda K, Hayashi M, Nakagawa H, et al. (2003) Genetic divergence and population structure sea bream Acanthopagrus schlegelli inferred from microsatellite analysis. Fish Sci 69(5): 896-902.

53. Jensen AC, Collins KJ, Free EK and Bannister RQA (1994) Lobster (Homarus gammarus) movement on an artificial reef: the potential use of artificial reeves for stock enhancement. Crustaceana 67(2): 198-211.

54. Jensen AC, Collins KJ and Smith IP (1998) Le rôle des récifs artificiels dans les programmes d’amélioration des pêches de homard Dans L. Gendron (Eds.), Compte-rendu d’un atelier de travail dans les programmes d’amélioration des pêches de homard, tenu aux îles-de-la-Madeleine (Québec) du 29 au 31 octobre 1997. Rapp Can ind Sci 69(5): 896-902.

55. Anger K (1991) Effects of temperature and salinity on the larval development of the Chinese mitten crab Eriocheir sinensis (Decapoda: Grapsidae). Mar Ecol Prog Ser 72: 103-110.

56. Bissatini AM, Traversetti L, Bellavia Scalici G and M (2015) Tolerance of Increasing water salinity in the red swamp crayfish Procambarus clarkii (Girard, 1852). J Crustacean Biology 35 (5): 682-685.

57. Ceccaldi HJ (1990) Main concepts dealing with biological recruitment in the sea. La Mer, Tokyo 28 (4): 167-168.

58. Taniguchi N, Sumantadinata K, Jyama S (1983) Genetic change in the first and second generations of hatchery stock of black sea bream (Acanthopagrus schlegelli) in the sea of Japan. In: Global Change: Mankind-Marine Environment Interactions, Ceccaldi HJ & Dekeys er I (Eds.), 37-40, Springer Science.

59. Wang M, O’Rourke R, Nodder SC and Jeffs AG (2013) Nutritional composition of potential zooplankton prey of the spiny lobster phyllosoma (Jasus edwardsii) Mar Freshw Res 64: 1-13.