Eco Fish

- environment friendly fish farming and use of cleaner fish

Northern Periphery Programme
2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

UNIVERSITY OF NORDLAND

eco-fish.org

About EcoFish

EcoFish is a 3 year transnational project financed by the European Regional Development Fund/Northern Periphery Program and national private and governmental grants. This project focuses on the production and use of ballan wrasse to solve problems with sea lice in salmon farms.

SALMON FARMING

The project is anchored firmly to the salmon aquaculture industry which is making a significant contribution to the culture and economy of many North European societies particularly marginal coastal communities. However, the rapid expansion of salmon farming has focussed attention on problems caused by sea lice which is the major health issue limiting the further expansion of the industry in all countries of the NNP area.

SEA LICE INFESTATION AND STATUS

The problem of sea lice infestation of farmed salmon has become a major issue not only for the salmon farmers themselves but also for environmentalists, retailers and consumers who are concerned about the potential effects of the transfer of sea lice to wild populations of salmon and the effect that treatments to remove the lice may have both on the environment and on the quality of the fish produced. Consequently, an alternative method of controlling this parasite is urgently needed.

BIOLOGICAL SOLUTION

One solution to the problem is to use the cleaner fish ballan wrasse to clean salmon of sea lice infestations during the production in sea cages. However, the wild capture of the large numbers of wrasse needed by the salmon farming industry has also come under consideration by environmentalists, whereas farmers and regulators remain concerned about other diseases being transferred from the wild wrasse to the salmon.

A SUSTAINABLE SOLUTION

Thus, the production and use of ballan wrasse may be a sustainable and innovative approach to solve a substantial problem in fish farming, enhance the possibilities for organic farming, and increase economic growth whilst simultaneously having a considerable positive effect on the environment. This solution is the main focus of the EcoFish project.

THE AIM OF ECOFISH

The objective of the EcoFish partnership is to minimise the environmental impact of salmonid aquaculture by the use of hatchery produced cleaner fish to remove parasitic sea lice, thereby reducing the use of therapeutic treatments.

"The project will deliver methods and technology needed to produce cleaner fish for use by the salmon farming industry in all of the partner countries. Farmed wrasse from production will be used for field application and for testing the technique on fish farms in partner countries".

Several technical and biological obstacles have to be overcome before ballan wrasse hatchery production techniques are fully developed, and farmed juveniles can be stocked into salmon sea cages.

To develop an efficient and sustainable production and use of farmed ballan wrasse the project is divided into several work packages;

- The first work package, on broodstock management, egg production and larval rearing, aims to develop techniques for the maintenance of productive ballan wrasse broodstocks capable of providing year-round supplies of eggs, and to use these eggs to develop commercially applicable methods for the continuous production of post larvae for on-growing.

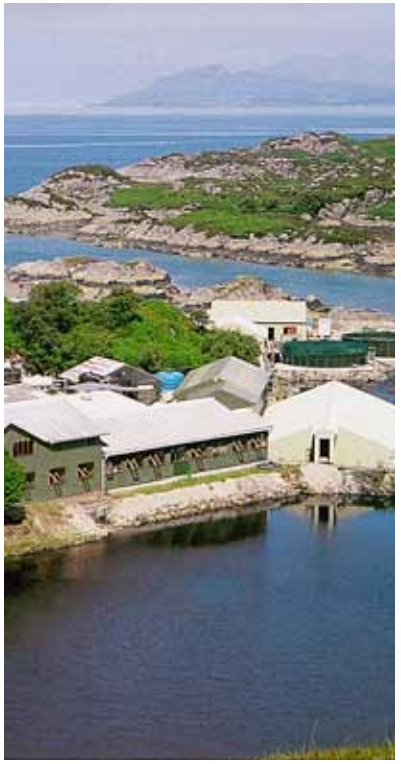
- The second work package is concerned with the rearing of wrasse from weaning to sizes suitable for transfer to sea cages are developing procedures for rearing wrasse in the hatchery to ensure maximum survival and rapid growth to enable wrasse to be stocked after a short on growth period.

- A third work package focuses on the field application and testing of ballan wrasse for lice control in salmon and includes trials to assess the effectiveness of ballan wrasse to control sea lice in salmon in real-time under working conditions in aquaculture environments.

Preliminary results are being reported regularly. After the termination of the project in March 31, 2012, project results, including technology, protocols and recommendations will be reported and disseminated to the industry.

EcoFish partners

Carna Research Station, Ryan Institute, National University of Ireland. Galway, Ireland



Viking Fish Farms Ltd,
Ardtoe Marine Laboratory, Ardtoe, Scotland, UK

University of Nordland, Faculty of Biosciences and Aquaculture, and Bioforsk Nord, Bodø, Norway

Indigo Rock Marine Research Centre, Bantry, Cork, Ireland

Associated partners

- Scottish Salmon Producers' Organisation (SSPO), Durn, Scotland, UK
- The Scottish Salmon Company Ltd, Inverary, Scotland, UK
- Bord Iascaigh Mhara. Dun Laoghaire, Ireland.
- Daithi O'Muruchu Marine Research Station, Bantry, Ireland
- Fjord Industrial Research Station Ltd Dønna, Norway
- Kvarøy Fish Farm Ltd, Kvarøy, Norway
- Murmansk Marine Biological Institute, Murmansk. Russia

Project co-ordinator and lead partner
Oddvar Ottesen and Åsbjørn Karlsen, Norway

Country coordinators/WP leaders
Jim Treasurer, Scotland
Julie Maguire, Ireland
Richard Fitzgerald, Ireland

Summary of activities and preliminary results in EcoFish

- Productive Ballan wrasse broodstocks have been established in the three partner countries.
- Techniques for the maintenance of productive ballan wrasse broodstocks capable of a stable supply of eggs through several years have been developed.
- The establishment of season spawning stocks through photoperiod and thermoperiod control is under development. Broodstock management practices for optimal egg production and a constant and reliable supply of wrasse eggs have, for the most part, been developed.
- The evaluation of health and welfare requirements of broodstock, including treatments for ecto-parasites and atypical furunculosis, has been conducted.

- The acquisition of broodstocks, the sex determination of spawners, and water re-use systems for holding wrasse broodstocks have been developed.

- Small/medium scale wrasse production facilities for rearing of ballan wrasse have been established in Ireland, Norway and Scotland.

- The design of egg incubation and larval rearing facilities, and the production techniques for rearing wrasse larvae through to the post larval stage have been developed.

- Novel information on embryo and larvae development under normal conditions and under different temperatures and salinities has been obtained through standard production systems and experimental conditions.

- Protocols for egg and larval rearing are established, whereas optimising rearing conditions to increase survival, development and growth of wrasse larvae is an ongoing activity in the project.

- A procedure for weaning from live feed to dry feed of ballan wrasse is under development in the hatchery to ensure maximum survival and rapid growth. This will make it possible to stock ballan wrasse in sea cages after a short period of on-growth. Trials have been conducted during different life history stages of ballan wrasse, and are ongoing.

- Continuing work includes optimizing systems, feeding strategies and diets, rearing densities, developing vaccination protocols, and a regime for weaning wrasse from dry to live feed.

- The partnership has commenced trials to assess the effectiveness of farmed ballan wrasse in controlling sea lice in salmon. These trials include important aspects such as effects on sea lice distribution when using different ratios of ballan wrasse to salmon, and feed and feeding strategies for wrasse during periods when ecto-parasite load is minimal.

- After field tests on the effects of cleaner fish on aquaculture production at one or more sites, the final results will be used to recommend a lice control system for the salmon farming industry.

- All results have been presented, or under preparation for presentation, in reports, scientific publications, posters and articles

Figure 1: Ballan wrasse broodstock.

A selection of preliminary results of EcoFish

BROODSTOCK MANAGEMENT

Broodstock ballan wrasse (Figure 1) were obtained from the wild, quarantined, and acclimated to captive conditions. Cover for the fish was provided using plastic sheets shaped as natural seaweeds.

Ectoparasites on the skin of ballan wrasse have been observed and repre-

sent a potential danger. Treatments using formaldehyde has proved effective.

Male claims own territory in tanks. Aggression between males is often observed, particularly during spawning season: these results in skin damage and sometimes in secondary infections. Thus, it may be advisable to use one male with each harem of females.

Natural spawning is a complex process that needs to be understood and facilitated in the hatchery. Mating behaviours often observed for many hours before spawning and the interaction between different females and the male in a spawning tank is largely unknown.

Figure 2: Inspection of maturity status of ballan wrasse broodstock.

The maturity and sex of all the existing brood fish were assessed by ultrasound examination (Figure 2 and 3) and size to distinguish females from males fish were distributed in tanks at an approximate ratio of 1:9, male:female. Fish were removed periodically from the tanks to confirm the accuracy of ultrasound sex determination and also to check egg and milt production.

Figure 3: Gonad development in ballan wrasse using ultrasound equipment.

Broodstock feed was composed of fish oil, shrimps and fish meal/commercial broodstock feed (Figure 4).

The broodstocks spawned naturally in the holding tanks. The sticky benthic eggs were spawned on plastic sheets to which the eggs adhered. Additionally, eggs for some experimental purposes were hand-stripped (Figure 5) and fertilized with sperm from one male.

Figure 4: Feed prepartionfor ballan wrasse broodstock. Photo: OH Ottesen

Figure 5. Manual stripping of ballan wrasse eggs. Photo: M. Yusof

EGG INCUBATION

Eggs were incubated at temperatures of 8° to 110° C in 70 or 280 litre cylindro-conical polythene tanks with flow through of seawater.

Specific investigations showed that;

- Embryonic development is typical of demersal marine finfish species
- Eggs are small and spherical with an adhesive covering
- In their embryonic development, the eggs display standard features through a series of key developmental events giving 8 distinct stages
- Temperature is probably the single most important factor influencing the development of Ballan wrasse eggs.
- Ballan wrasse egg diameter was 1.05±0.04mm, and 0.87± 0.05mm, with and without the gelatinous layer, respectively.

A small-scale experiment using different temperatures (10, 15 and 20°C) and salinities (26, 30, 33‰), in different combinations indicated that fertilized eggs of Ballan wrasse develop till hatching in a wide range of salinities, and that the optimal temperature for successful development of fertilized eggs lies between 10°C to 15°C, where highest egg hatching rate, and lowest incidence of abnormalities among larvae were observed.
aThe morphological development and hatching under different temperatures of eggs are shown in Figure 6 and Figure 7, respectively.

Figure 6. Ballan wrasse eggs. Photo: NUIG, UiN.

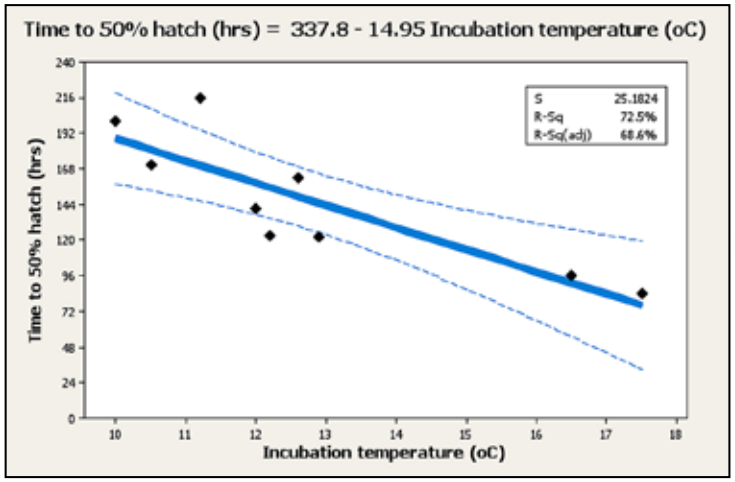


Figure 7. Time of hatching of ballan wrasse larvae held under different temperatures.

Figure 8. Development of ballan wrasse larvae from hatchery to metamorphosis.

a. 0 DPH.

c. 33 DPH.

b. 13 DPH.

d.

LARVAL GROWTH AND DEVELOPMENT

Ballan wrasse larvae hatched at c. 72°d. The hatching length was 3.64±0.05 mm and larvae attained a length of 10.52±0.82 mm at day 49 post hatching .At hatching, the mouth and anus were closed, eyes were not pigmented, and the digestive tract was an undifferentiated and straight tube. Larval development (Figure 8) with reference to the main external morphological characteristics was divided into four stages and related to age in days post hatch (DPH): Yolk sac larva (0-9 DPH), Preflexion larva, (10-25 DPH); Flexion larva (26-33 DPH); Postflexion larva (34-49 DPH).

Different sized tanks were tested for larval rearing. Good results were obtained when larvae were stocked in 1.5 m diameter black circular tank of 60 cm depth. The larvae were reared using a green water technique, and were fed initially on rotifers and then on Artemia after 30 days, and were weaned gradually to dry feed over a period up to 10 months. Large difficulties remain in the rapid and effective weaning of ballan wrasse larvae and the co-feeding of live feed is currently required for several months. Survival from hatch to weaning was 2 -7%. During the first 49 days, the larval growth in standard length and myotome height followed an exponential curve. Different working operations are illustrated in figures 9, 10, 11, and 12.

Growth curves of larvae from different productions and partner countries are shown in Figure 13.

Figure 9. M. Mommen counting rotifers for startfeeding of ballan wrasse larvae. Photo: SAA Eriksen.

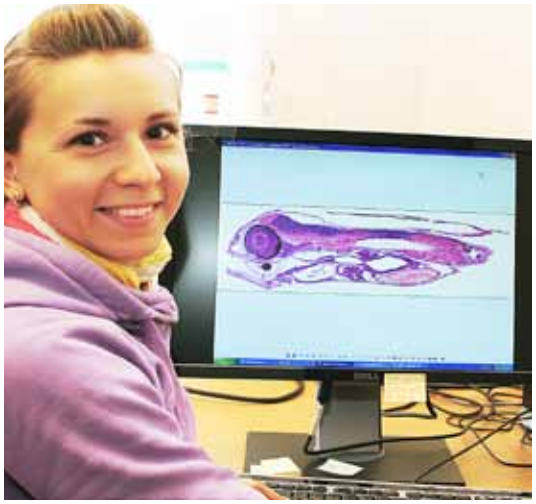


Figure 10. E. Duanaevskaya studing organ development of ballan wrasse larvae. Photo: SAA Eriksen.

Figure 11. Live feed department - M. Røkke checking quality of rotifers.
Photo: SAA Eriksen.

Figure 12. Startfeeding tanks and sampling of ballan wrasse larvae. Photo: O. Ottesen

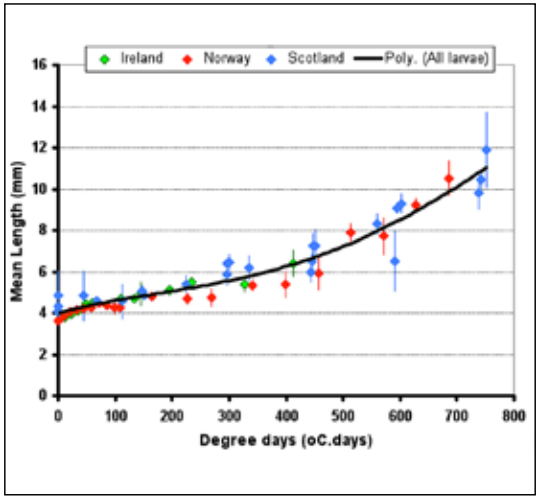


Figure 13. Growth in standard lenght in ballan wrasse larvae. Ireland, Scotland and Norway.

USE OF MICROALGAE UNDER STARTFEEDING OF BALLAN WRASSE

Initially, a desk study review was prepared and published (see Rebours C., Novoa-Garrido M 2009) on the potential of microalgae to reduce the bacterial loads of wrasse in captivity and several new microalgae species have been isolated for possible future use. In subsequent experiments, a series of bacterial isolates from wrasse were obtained, including *Vibrio* spp and *Aeromonas* spp, and the antimicrobial affect of 'green water' microalgal cultures on these strains has been evaluated. In addition, the effects of various commercial microalgal products e.g Rotigreen® from Reed Mariculture AS, have been tested and these show positive impacts in reducing the microbiome, illustrated in figure 14.

GROWTH AND PHYSIOLOGICAL STUDIES ON BALLAN WRASSE

Some general information is also being gathered on the general growth performance of wild populations for comparison with the observed growth capacity of hatchery reared stocks. Balan wrasse juveniles are shown in figure 15 and 16. Grown in different tank set up as illustraded in figure 17. This includes profiling (see figure 15 and 16) the general haematological parameters of wild and farmed fish and seasonal changes in sex hormones (Figure 18 and 19).

Fig. 15: Ballan wrasse juvenile.
Photo: A. Dykes

Fig. 16: Ballan wrasse juvenile, size after low temperature (≈8^{O}C) culture for 22 months. Photo: SAA Eriksen

Fig. 16b: End product of EcoFish project; ballan wrasse juveniles shortly ready to be stocked into sea cages with sea lice infected salmon.

Figure 17. Circular tanks (1 m diameter x 0.6 m height) containing experimental fish.
Photo: R. Fitzgerald

Figure 18. Blood sampling of ballan wrasse. Photo: M. Yusof, Mohd, NUIG

Figure 19. Ballan wrasse blood serum samples. Photo: M. Yusof, Mohd.

Figure 14. C. Rebours preparing stock cultures of micro algae.
Photo: M. Novoa-Garrido

FARMED BALLAN WRASSE - AN EFFECTIVE CLEANER FISH?

The partnership has started a trial at Indigo Rock Marine Research Centre in Ireland to assess the effectiveness of farmed ballan wrasse in controlling sea lice in salmon. This is the first trial under controlled environmental conditions using farmed ballan wrasse as cleaner fish (Figure 20). Important aspects such as the feed and feeding strategies for wrasse during periods when ecto-parasite load is minimal is investigated. Different set ups will elucidate effects of using different ratios of ballan wrasse to salmon: Growth, behaviour and fin damage are also being monitored, as illustrated in figures 21 and 22.

Fig. 20: Experimental set up.

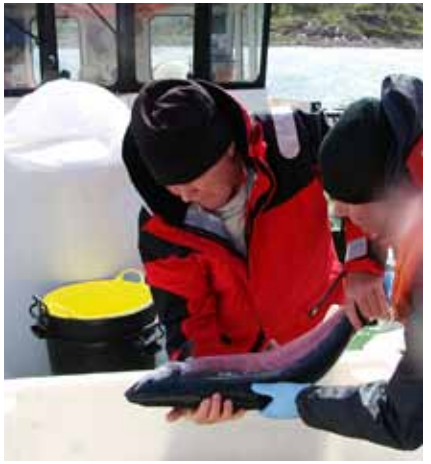


Figure 21. Sea lice counting at a fish farm.
Photo: J. Treasurer

Figure 22. Retrieving ballan wrasse from sea cage. Photo: J. Treasurer

Partners

UNIVERSITY OF NORDLAND (UIN)

Faculty of Biosciences and Aquaculture, Bodø, Norway. The faculty is conducting research on reproduction, genetics, fish diseases, nutrition and seafood quality and marine ecology. The University is lead partner/ project leader of EcoFish. In EcoFish UiN are focussing on broodstock management, egg productions and trials within startfeeding of ballan wrasse. Special emphasis has been put on growth, swimbladder inflation, organ development and deformities during the larval stage. http://www.uin/fba.no

CARNA RESEARCH STATION, RYAN INSTITUTE, NATIONAL UNIV OF IRELAND, GALWAY, IRELAND

The Carna Research Station is the Ryan Institute's base for large scale, exploratory aquatic investigations, and both applied and basic research, on existing and novel species for aquaculture. The range of species is prioritized to meet industry needs including finfish (e.g. salmon, trout, cod, turbot, and ballan wrasse), shellfish (e.g. abalone, sea urchin, and scallop) and seaweeds (Palmaria, Porphyra and Alaria). http://www.ryaninstitute.ie/facilities/carna-research-station/

THE NORWEGIAN INSTITUTE FOR AGRICULTURAL AND ENVIRONMENTAL RESEARCH (BIOFORSK)

Bioforsk is a national R&D institute with its main areas of competence are linked to food quality and safety, agriculture and rural development, environmental protection and natural resources management. Bioforsk Nord Bodø (BNB) has its expertise in plant growth physiology, phycology, microbiology and organic farming. BNB carries out consultancy work on marine resources, sustainable development of integrated aquaculture systems, algae aquaculture and organic farming and participates in research collaborative EU and national projects. (http://www.bioforsk.no)

ARDTOE MARINE LABORATORY

Viking Fish Farms is a research unit in West Scotland developing marine products for commercial use. This includes finfish production of cod, haddock, turbot, Dover sole, halibut and wrasse, and production of shellfish including oysters, and the rearing of sea urchins and seaweeds. The unit also carries out consultancy work on marine resources and participates in collaborative EU projects.
http://ardtoemarine.co.uk

INDIGO ROCK MARINE RESEARCH STATION

The Indigo Rock Marine Research Station is an independent research station with an experimental shellfish hatchery. Research at the station has focussed on aquaculture husbandry, minimising waste in the aquaculture and fisheries production process, developing new products from waste and environmental monitoring. It has close links with its sister companies that have commercial scale salmon and mussel farms with processing facilities. This has allowed us to conduct pre-commercial trials, which has included trials on the effectiveness of using reared ballan wrasse to control lice on farmed salmon.

List of publications; posters, articles

JOURNAL ARTICLES

Jack D'Arcy, E. Dunaevskaya , J. W. Treasurer , O Ottesen , J. Maguire , N. Zhuravleva , A. Karlsen , C. Rebours and Richard D FitzGerald. 2010. Embryonic development in ballan wrasse Labrus bergylta. Submitted.

Evgenia Dunaevskaya, Anil B. Amin and Oddvar H. Ottesen. Histological investigations of organs and tissues during organogenesis of ballan wrasse Labrus bergylta larvae. Submitted.

O. H. Ottesen, E. Dunaevskaya and J. D'Arcy. Development and growth in Labrus bergylta (Ascanius 1767) larvae, with special emphasis on swim bladder inflation. Submitted

POSTER AND ORAL PRESENTATIONS

Jack D'Arcy, E. Dunaevskaya , J. W. Treasurer , O Ottesen , J. Maguire , N. Zhuravleva , A. Karlsen , C. Rebours and Richard D FitzGerald. 2010. Embryonic development in ballan wrasse Labrus bergylta. EAS conference 2010 Porto Portogal. Sats på Torsk, Bergen , Norway.

Evgenia Dunaevskaya, Anil B. Amin, Oddvar H.Ottesen 2010.Histological investigations of organs and tissues development of ballan wrasse larvae during ontogenesis. EAS conference 2010 Porto Portogal. Sats på Torsk, Bergen , Norway.

Treasurer J, Ottesen OH, Fitzgerald R, Maguire J, Zhuravleva N, and Rebours C. 2008. Sea lice control utilising reared ballan wrasse (Labridae). Ecofish –NPP/EU. The 7th International Conference: Sea Lice 2008. 31st March and 1st April, 2008. Puerto Montt, Chile.

Ottesen OH, Treasurer J,Fitzgerald R, Maguire J, and Rebours C, Zhuravleva N and Karlsen, Å. Ballan wrasse (Labridae) offers efficient, environmentally friendly sea lice control. Magazine. Global Aquaculture Advocate. November/December 2008 .

Mark .D. Powell, Dalia. Dahle and Oddvar Ottesen. 2009. Pathology associated with atypical furunculosis in Ballan wrasse Labrus bergylta. Presentation at the EAFP conference in Prague September 2009.

Rebours C., Novoa-Garrido M., 2009. Antimicrobial activity of algae as solution for sustainable fish farming – a mini review. International Aquaculture Europe 2009 conference, Trondheim, Norway

Leppefisk er i vinden igjen. Norsk Fiskeoppdrett. Magazine for the fish farming industry. July 2009. (interview of Oddvar Ottesen) Elisabeth Nodland

Lucky lips mot lakselus. Bodø University College. Web news. www.hibo.no. December 4, 2008. Arne Finne (interview of Oddvar Ottesen)

Interessen for leppefisk er økende. News web. June 25, 2009. www.kyst.no. (interview of Oddvar Ottesen) Elisabeth Nodland.

STUDENTS

Several students at bachelor (5), master (4) and PhD level (1) involved.
Jack D'Arcy 2008-2011. Aspects of the Biology of Ballan Wrasse. PhD study, ongoing. University of Galway, Ireland.

Evgenia Dunaevskaya 2010. Histological investigations of organs and tissues development of ballan wrasse larvae during ontogenesis MSc Thesis Master thesis 2009 – 2011. Supervisor: Oddvar Ottesen. University of Nordland, Bodø Norway. May 20008 - 20100.

Larisa Shchepak 2011. Effects of different temperatures and salinities on development in fertilized eggs of ballan wrasse" Master thesis. University of Nordland, Bodø Norway. 2009 – 2011. Supervisor: Oddvar Ottesen.

Daria Rogozhina. The development of the gut of Ballan wrasse larvae from hatching through metamorphosis – a histology study. Master thesis. University of Nordland, Bodø Norway. Supervisor: Oddvar Ottesen Norway. 2009 – 2011. Ongoing.

DISTRIBUTION OF BALLAN WRASSE

Eastern Atlantic (red): Norway to Morocco, including Madeira, the Azores and the Canary Islands. Doubtful records (yellow) from Mediterranean, Adriatic and Marmara seas (www.aquamaps.org).

EcoFish received financial support from

Northern Periphery Programme. www.northernperiphery.eu

The Scottish Salmon Company

Scottish Salmon SSPO

HIE Highlands and Islands Enterprise Iomairt na Gàidhealtachd 's nan Eilean

Nordland FYLKESKOMMUNE