Darwin Initiative – Final Report

*(To be completed with reference to the Reporting Guidance Notes for Project Leaders (http://darwin.defra.gov.uk/resources/reporting/) - it is expected that this report will be a **maximum** of 20 pages in length, excluding annexes)*

Darwin project information

Project Reference	162/15/020
Project Title	Reducing the Impact of Exotic Aquaculture on Chilean Aquatic Biodiversity
Host country(ies)	Chile
UK Contract Holder Institution	Swansea University (formerly University of Wales Swansea)
UK Partner Institution(s)	NERC Centre for Ecology & Hydrology, Banchory UK)
Host Country Partner Institution(s)	University of Victoria (BC, Canada) US Geological Survey (USA) Oregon State University (USA) Victoria University of Wellington (New Zealand)
Darwin Grant Value	£193,844
Start/End dates of Project	01 October 2006 / 31 December 2009
Project Leader Name	Carlos Garcia de Leaniz
Project Website	www.biodiversity.cl
Report Author(s) and date	Carlos Garcia de Leaniz, Gonzalo Gajardo, Sofia Consuegra, Jose Sanzana, Ana Maria Cerda January 2010

1 Project Background

Chile is the second world's largest salmon producer, yet salmonids are not naturally present in the Southern Hemisphere and pose a threat to native species. Our project based at region X **(Figure 1)** drew attention to the potential impacts of salmon farming to Chile's unique aquatic ecosystems, with a view of raising public awareness and making the industry more sustainable. We developed a molecular and isotopic toolkit for the identification of salmonid escapees, trained Chilean workers on its use, and quantified the spread and impacts of salmonids upon native fish fauna. We also developed a Code of Best Practices aimed at reducing escapees, produced an interactive online Atlas on the distribution of native and exotic fishes, and built capacity to deal with other non-native threats in the future.

2 Project support to the Convention on Biological Diversity (CBD)

Chile is a signatory of CBD, but also of several trade agreements with the US, EU, and Asian-Pacific (APEC) countries that will likely promote the further expansion of exotic aquaculture. An urgent compromise for CBD subscribers is to halt the loss of biodiversity by 2010. Our project has given Chilean researchers and government officials the capacity to assess and monitor the impact of exotic fish species on local aquatic biodiversity, and to identify and reduce escapes from fish farms, thereby supporting the Chilean Government's implementation of articles 8h, 10, 12-14, and 18 of CBD, with special emphasis on Introduced Species (30%), Biosafety (10%), Inland Waters Biodiversity (20%), Marine and Coastal Biodiversity (20%), and Sustainable Use (20%) themes. By developing (in collaboration with industry and other stakeholders) a Code of Best Practices to reduce salmonid escapees, we have ensured that any future developments in sport fisheries or in fish farming in Chile's unique aquatic habitats will be carried out in a sustainable way, with due consideration to the environmental threats posed by non-native species.

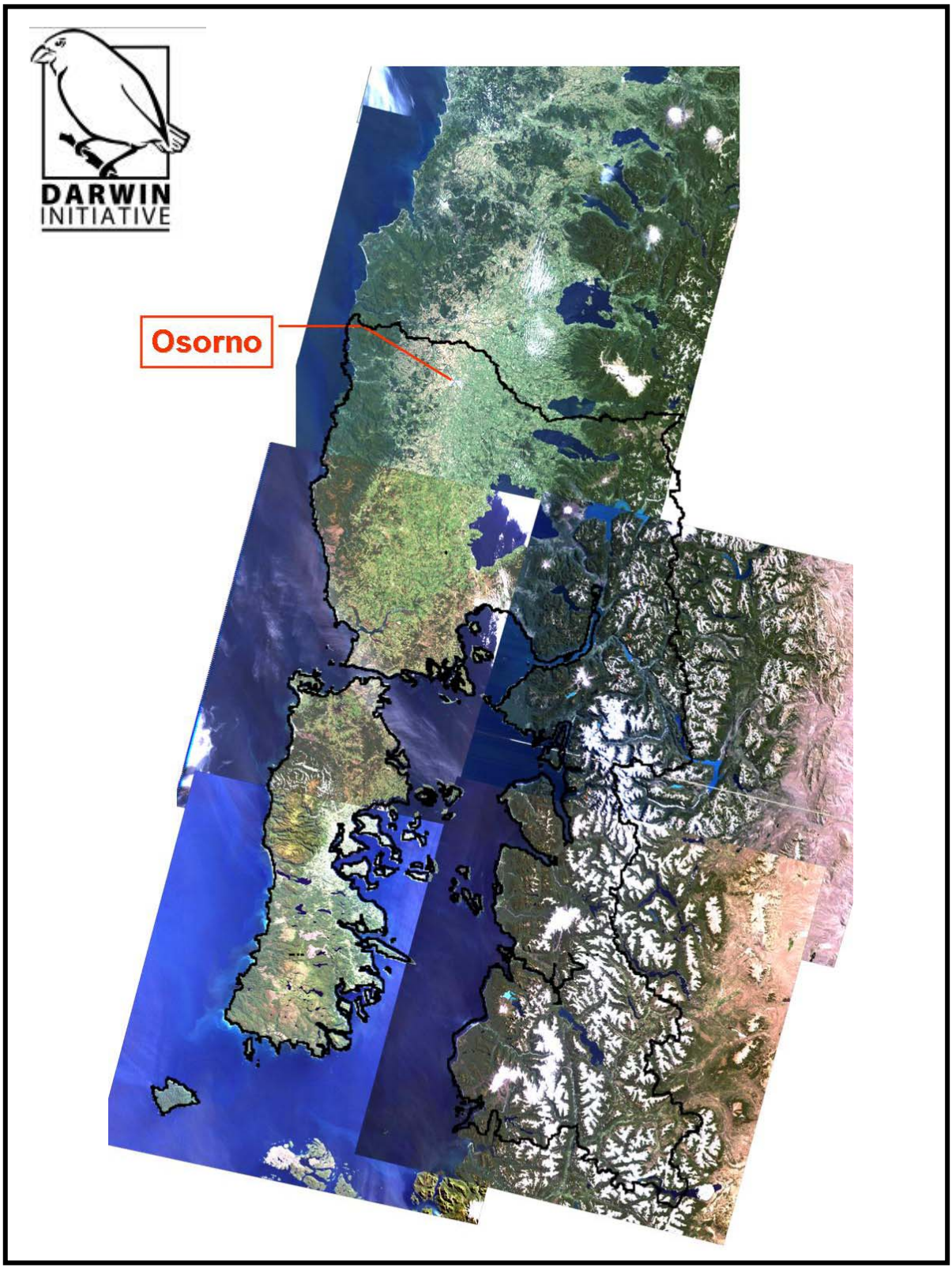

Figure 1. Satellite map of Region X (Los Lagos) where most of the Chilean salmon farming is concentrated

Liaison with the CBD national focal point was established and maintained throughout the project through regular contacts with CONAMA (the Ministry of the Environment) and other Government Agencies who supported and participated in all our workshops.

3 Project Partnerships

The partnership between the UK lead institution (SU) and the Chilean host partner (ULA) was established through a MoU and worked very well during the project, benefiting from fluent and frequent contacts by email, telephone, and skype videoconferencing, as well as from visits by staff in both directions. Thus, in addition to our project meetings and workshops in Chile, there were visits by Chilean staff (Dr. Gajardo, Dr. Young) to the UK, and two extensive training periods by Chilean workers (Jose Sanzana, Ana Maria Cerda) at the UK host institution towards the end of the project. We also gave six joint Departmental Seminars in the UK, US, Canada and Spain and presented project results at two international conferences *Managing Alien Species for Sustainable Development of Aquaculture & Fisheries* (MALIAF, Florence, Italy 04-08 Nov. 2008) and at the *European Society for Evolutionary Biology* (ESEB 2009, Italy, 24-29 August 2009) full details of which were given in our annual reports.

Contacts between partners were also fruitful in other ways. For example, several partners commented and gave valuable feedback on **five** peer-reviewed manuscripts, three already published or in press (Young et al. 2009. *Biological Invasions* **11**: 1955-1961; Buschmann et al 2009. *Ocean & Coastal Management* **52**: 243-249; Young et al. 2010. *Animal Conservation* in press), and three currently under review (Garcia de Leaniz & Gajardo, Schröder & Garcia de Leaniz; Gomez et al*.).* Partners also gave advice on GIS, development of the online fish Atlas database, and experimental design.

Partnership and collaborations made during the Darwin Initiative were also instrumental in helping to develop joint UG and PG student projects at the University of Valparaiso (Prof K. Whitlock), and at the Falkland Islands (Dr. Brendan Gara). In total, the partnership has been directly involved in the production of 4 Undergraduate final year projects, 5 MSc theses, and 2 PhD's currently under way, summaries of which have been uploaded into the project webpage

Throughout the duration of the project we have continued advising national stakeholders (e.g. CONAMA, Subpesca) as well as international NGO's involved in the protection of freshwater biodiversity in Chile. Thus, Mrs. Paula Moreno, the aquaculture coordinator for the World Wildlife Fund Chile, commissioned a report on the impacts of aquaculture escapees in Chile based on an outline proposed by Dr. Young (see previous annual report), and this information has now been incorporated into a Report from the *Salmon Dialogue* (Thorstad et al 2008. Incidence and impacts of escaped farmed Atlantic salmon *Salmo salar* in Nature. NINA, 110 p). We provided WWF with a qualitative summary of the Darwin Project results to date and identified outstanding questions for future research. We also advised other NGO's such as *Pure Salmon Campaign* and *International Rivers,* and Dr. Young prepared a technical assessment of the 'Aquatic Ecosystem' section of the Environmental Impact Statement in relation to hydroelectric development in southern Patagonia.

Through our partnership we developed a Darwin Fellowship with Cristián Correa, a Chilean PhD student at McGill University (Canada), and helped him secure a Research and Exploration grant from the National Geographic Society to study the freshwater fish fauna in Patagonia (see (http://biology.mcgill.ca/grad/cristian/). We are currently developing a similar Darwin Fellowship with Ana Maria Cerda, one of the Chilean staff at the ULA laboratory at Osorno. We also discussed with various Chilean workers (Dr. Brian Dyer, Dr. Evelyn Habit) how best to combine our different data sets into a common Chilean atlas of native and exotic fish species, a beta version of which is now available online through our project website. We also helped a Chilean PhD student from PUCV at Valparaiso (Daniela Atria Gomez) to secure funding to come to Dr. Consuegra's laboratory at University of Wales to work on MHC screening of Chilean farmed salmonids, and have recently established a collaboration with *AquaInnovo* in Chile for this purpose. Likewise, the Darwin Initiative supported a grant application by Dr. Guido Plaza (also from PUCV) to the Chilean funding agency FONDECYT. Finally, our partnership was

successful in obtaining a 3 year PhD studentship (£45,000) for Delphine Vanhaeke (University of Wales Aberystwyth) entitled 'Landscape genetics of salmonid invasions in the southern hemisphere'. During 2009 Delphine went to sample in Chile for two months under the umbrella of the Darwin Initiative, and has recently presented her first project results at the 2010 Population Genetics Group Meeting (PopGroup, Liverpool 5 January 2010) Other collaborations developed through the project partners included contacts with GESA in Argentina (Dr. Javier Ciancio, Dr., Migue Pascual), U. La Laguna in Spain (K. Toledo, Prof. A. Brito), and Dr. Arismendi and Brooke Pennaluna (OSU), and these have been influential in shaping the project and helping us meet our various objectives

4 Project Achievements

4.1 Impact: achievement of positive impact on biodiversity, sustainable use or equitable sharing of biodiversity benefits

The project's purpose was (as per logframe) '*To build, in collaboration with government, industry and other stakeholders, the capacity for assessing, monitoring, and reducing the impact of the accidental or deliberate introduction of exotic fish species on Chilean aquatic biodiversity*'

Progress towards this ultimate goal must be considered highly satisfactory as all major project objectives were fully met: tools were developed (and capacity was built) for identifying exotic fish escaping from fish farms, studies were conducted for assessing and monitoring the spread and impact of exotic salmonids upon native fish fauna, and mitigation measures were developed and recommended for reducing the negative impacts of escapees, and halt therefore the loss of native biodiversity.

4.2 Outcomes: achievement of the project purpose and outcomes

The project achieved its main purpose and delivered nearly all its set outcomes, allowing the Chilean host partner to gain access to (a) knowledge, (b) money, (c) physical resources and (d) social networks. Specifically, the project (1) equipped a diagnostic laboratory at the host University for monitoring the origin and spread of exotic fish, (2) developed field protocols for monitoring the spread of exotic fishes and for assessing their impacts, (3) trained staff and volunteers, (4) raised public awareness and disseminated the project results, and (5) engaged the various stakeholders, initially through a declaration of intent at the beginning of the project and then through the development of a code of best practices.

4.3 Outputs (and activities)

With the exception of the launch of the joint MSc degree on Sustainable Aquaculture between the project institutions (which has suffered a delay) the project achieve all its outputs, as laid out in the logical framework, and as reported in the annual reports.

Valuable links, based on mutual trust, respect and the need for rigorous scientific data, were forged with the salmon industry and other key stakeholders, including NGO's and Government. Continuing dialogue with stakeholders was essential for the development of the draft CBP towards the end of the project. A lot of useful and timely data was collected during the project, and as much of it has already been published or is being published, we are in this way filling important gaps in knowledge and making this information available to the end users. By publishing and presenting our results we are ensuring that the project is properly disseminated and that the information is freely available to the public via our website. Considerable effort was spent in the training of students, personnel and volunteers. We are satisfied that the education and training programme met or surpassed our targets, and that our student engaged in quality projects, as their marks and achievements testify.

On November 2009, two of the Chilean staff from the ULA lab came to the UK to receive two months of further training. Ana Maria Cerda received training on genetic stock identification and microsatellite DNA screening with Dr. Consuegra at U. Wales Aberystwyth, while Jose Sanzana received training on isotope and fish scale analysis with Dr. Garcia de Leaniz at Swansea University.

Activity 1. *Research & monitoring of exotic and naturalized fish species*, in relation to **Output 1** (Assessment of abundance, distribution, and impact of exotic and naturalized salmonids). We monitored the distribution and abundance of native fish in relation to exotic and naturalized salmonids, and prepared two manuscripts on the impact of exotic salmonids on native fish biodiversity. We also experimentally investigated prey-predator interactions between exotic salmonids and native galaxiids, initiated several studies on the trophic ecology of salmonids, and began applying the molecular toolkit to the identification of salmonids escaping from fish farms.

(1). Monitoring the impact of exotic salmonids on native fish biodiversity. We carried out an extensive field monitoring program on Chiloe Island, as this has the highest concentrations of net pen aquaculture in Chile, and also around the Osorno area. Amongst native galaxiids, *Aplochiton zebra* and *Galaxias maculatus* dominated our sampling sites, whereas rainbow trout (*Oncorhyunchus mykiss*) and brown trout (*Salmo trutta*) were the most locally abundant exotic species in our sampling sites. We found a large variation among sites in the relative abundance of wild (naturalized) and escaped salmonids. It is apparent that some streams supported self-sustained salmonid populations, whereas others were probably in the initial stages of a salmonid invasion (**Figure 2**).

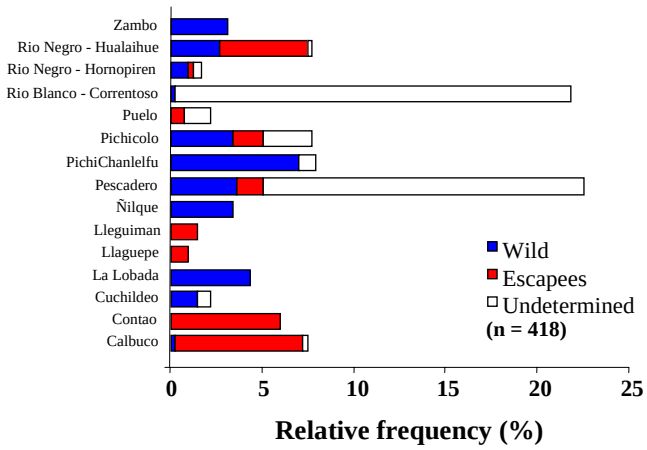

Figure 2. Likely origin of 418 free-living salmonids sampled at 15 locations during February 2009 based on external appearance and internal dissection. Overall, 30% of salmonids were classified as wild (naturalized) fish, 24% were classified as recent escapees, and 46% could not be classified.

We completed a manuscript entitled "A trial of two trouts: comparing the impacts of rainbow and brown trout on a native galaxiid." This paper was presented at the recent MALIAF conference in Italy (http://www.dbag.unifi.it/maliaf/MALIAF_abstracts.pdf) and is now in press in *Animal Conservation* (Young et al 2010). It provides to our knowledge the first quantitative comparison of the impacts of rainbow and brown trout on a native fish (abstract in **Annex 7**). We also compiled all the information on the distribution of exotic and native freshwater fish in our *Online Darwin Fish Atlas*, which is now available at our website (beta version) and which represents an important tool for assessing the impact of salmonid invasions.

(2). Trophic ecology of exotic salmonids escaping from fish farms. Ecologically similar species may compete through interference competition for habitat and/or exploitation competition for consumable resources. We examined the scope for trophic competition between exotic salmonids and native galaxiids in two ways, indirectly through the analysis of stable isotopes in muscle tissue, and directly through stomach analysis.

Analysis of stable isotopes. First we compared isotopic signatures of farmed and wild-caught salmonids and found significant differences between them, which may make it possible to identify farm escapes from wild (naturalized) fish. This approach has been the basis of two theses and a MS currently under review (Schroder & Garcia de Leaniz; see **Annex 7**).

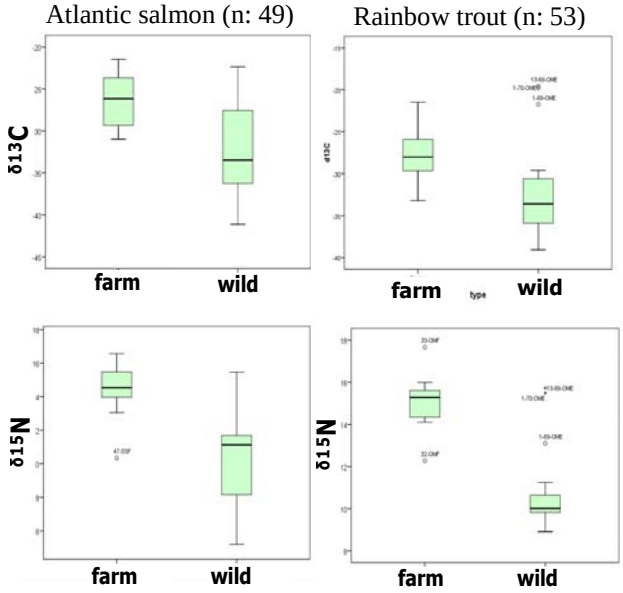

Figure 3. ^{13}C and ^{15}N isotopic signatures for Atlantic salmon and rainbow trout collected in Chiloe. Farmed salmonids show significant carbon and nitrogen enrichment compared to free-living fish (V. Schröder. 2009, Exotic salmonids in Chile – A stable isotope approach. Marine Biology dissertation, Swansea University).

Our data also indicates that there is some overlap in isotopic signatures between naturalized salmonids and native galaxiids, particularly between rainbow trout (*Oncorhynchus mykiss*) and *Aplochiton zebra* at $\delta^{15}N$ (**Figure 4**). This may be indicative of trophic overlap, and perhaps of competition for resources.

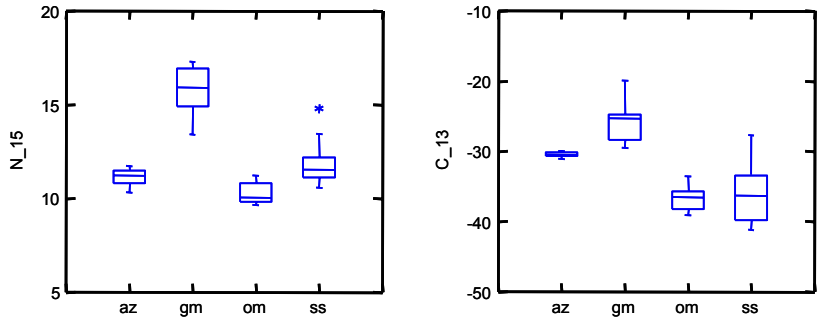

Figure 4. Muscle isotopic signatures ($\delta^{15}N$ and $\delta^{13}C$) of two native galaxiids (az: *Aplochiton zebra*; gm: *Galaxias maculatus*) and two exotic salmonids (om: *Oncorhynchus mykiss*; ss: *Salmo salar*) collected in streams in Chiloe.

Stomach analysis. While the marine ecology of exotic salmonid escapes has been studied in British Columbia and Chile, to our knowledge there are no published reports on the impacts of escapees in freshwater. To address this question Gabriel Orellana, a 3rd year aquaculture student at Universidad Austral (Puerto Montt) , did his thesis on the freshwater ecology of salmonid escapees within the framework of the Darwin project (summary in **Annex 7**) . Gabriel project compared the stomach contents of wild (naturalized) and escaped salmonids, to gain an indication of likely trophic impacts. These data, in addition to that obtained previously by two MSc students (Ben Perry, Paul Howes), is being analyzed and will be compared with indirect evidence obtained from isotopic analysis. It is expected that this will form the basis of a publication on the trophic ecology of salmonid escapes in freshwater.

(3). Genetic assignment of salmonid escapees.Over the last year we developed and field-tested a molecular toolkit for discriminating farmed fish in Chile, both for Atlantic salmon and rainbow trout. This was greatly aided by collaborations between Chilean and UK partners, and also by input and contributions from an EU-funded project. Preliminary results for A. salmon are encouraging and indicate that there may be enough genetic structuring amongst salmon farms to be able to identify escapees, and perhaps also to assign them to the farm of origin (**Figure 5**).

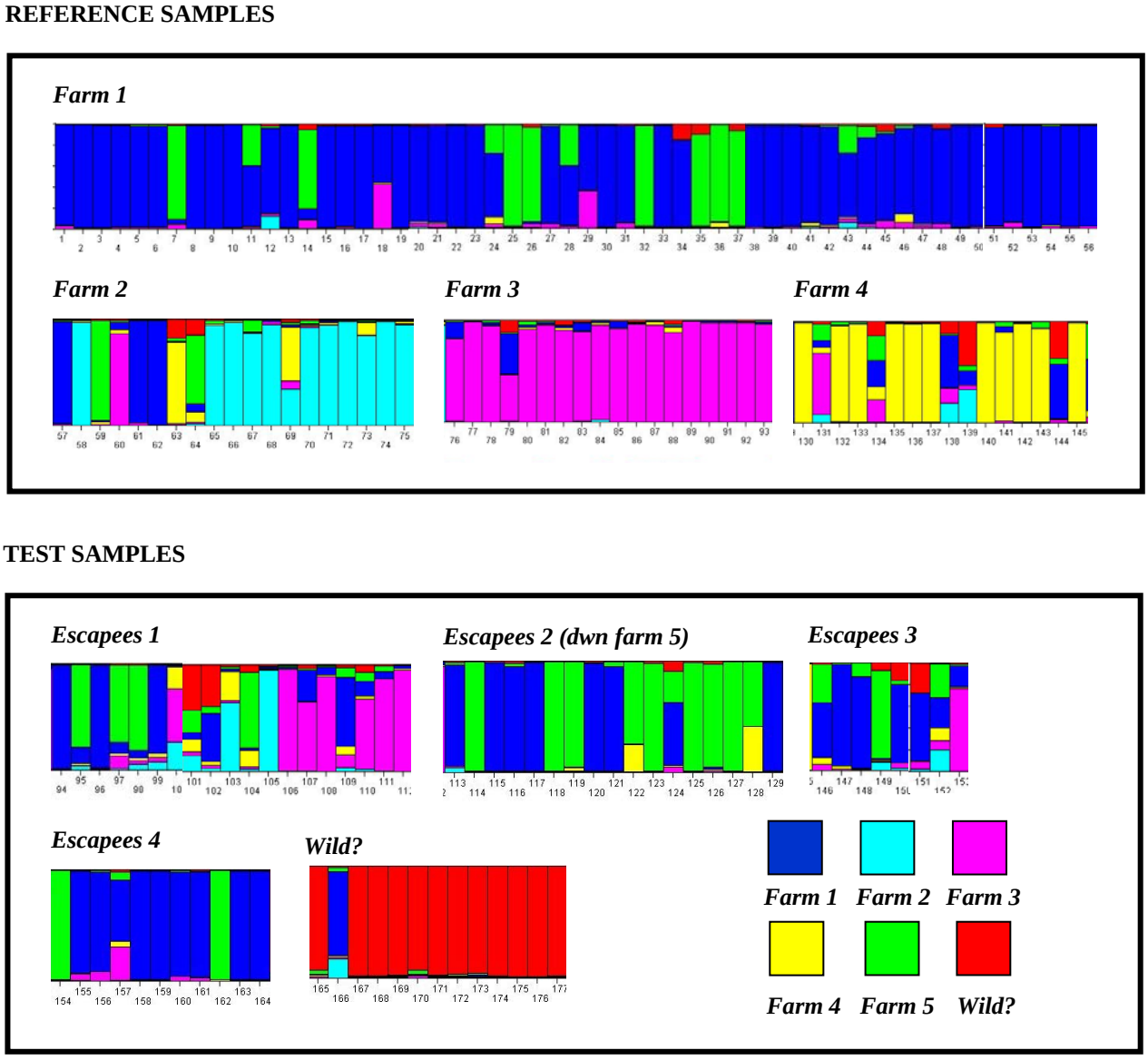

Figure 5. Genetic structuring of 177 Chilean Atlantic salmon screened with 16 microsatellite DNA loci. Genetic variation was screened for samples from 4 farms (plus one downstream of a hatchery) and 5 batches of free-living fish (presumed escapees or wild) captured in the study rivers by electro-fishing. Maximum likelihood suggests that the most likely number of distinct groups in the sample is 6, represented by six different colours. Each bar represents one fish, the height of each colour being proportional to the probability of belonging to one of the six putative origins. Preliminary assignments of 55 salmon escapees indicate that 49% of escapees probably originated from Farm No. 1, 29% originated from farm No. 5, 14% from farm No. 3, and 4% from farm No. 2. No escapees were assigned to farm No. 4. and 4% of fish could not be reliably assigned.

3.1. Genetic screening of Atlantic salmon populations

Summary Points : All Populations screened with 17 microsatellite DNA loci

- 16 populations analysed (467 individuals), 14 from farm samples origin and 2 from individuals caught in the river, 17 microsatellite loci.

- Population allelic richness between: 5.73-8.22
    - Farms: 6.00-8.22
    - River: 5.73-8.13

- Population Observed Heterozygosity between: 0.75-0.84
    - Farm: 0.75-0.84
    - River: 03.75-0.83

- Mean population allele number between: 8.31-12.06
    - Farm: 8.31-12.00
    - River: 8.88-12.06

- Population Expected heterozygosity between: 0.72-0.81
    - Farm: 0.74-0.81
    - River: 0.72-0.81

- Global genetic differentiation (FST) for all populations: 0.0486
    - Global FST Farm: 0.0458
    - Global FST River: 0.0462

- STRUCTURE analyses in progress to determine population grouping and number of founder populations.

3.2. Genetic screening of Rainbow trout populations

Summary Points : All Populations screened with 7 microsatellite DNA loci

- 19 populations analysed (438 individuals), 4 from farm origin and 15 “naturalised” (named as wild), 7 microsatellite loci.

- Population allelic richness between: 0.3788 – 0.6788
    - Farms: 0.5491 – 0.6491
    - Wild: 0.3788 – 0.6788

- Effective population size (Ne): All below 50 except for one wild population Rio Aitoy

- Population Observed Heterozygosity between: 0.545 – 0.824 (higher than expected from the estimates of Ne)
    - Farm:0.647 – 0.780
    - Wild: 0.545 – 0.824

- Mean population allele number between: 5 – 9
    - Farm: 8- 9
    - Wild: 5- 9

- Population Expected heterozygosity between: 0.567 – 0.804
    - Farm: 0.711 – 0.798
    - Wild: 0.567 – 0.804

- Global genetic differentiation (FST) for all populations: 0.0797
    - Global FST farms: 0.06443
    - Global FST Wild: 0.7250
    - Much higher differentiation between wild than farm populations

- Only two populations with evidence of bottleneck: Rio Aitoy and unnamed 55A. Unnamed 55A may be an artifact since it has a low number of gene copies (20 gene copies). NO other populations in bottleneck.

- STRUCTURE analyses in progress to determine population grouping and number of founder populations.

These data were the basis of a MSc thesis (Philips 2009) and the paper 'Salmonid invasions in the Southern Hemisphere: testing the "genetic paradox" hypothesis' to be presented at the forthcoming Luarca conference this summer (abstract in **Annex 7**) .

Activity 2. *Capacity building and training in assessing impact of exotic invasions* in relation to **Output 2** (Development of monitoring and impact assessment programme with trained personnel).

During the course of the project we trained and supervised numerous personnel, students and volunteers both in the field and in the laboratory (details in output measures below). This included national and international volunteers, as well as UG and PG students from 5 different universities. We also provided extensive training in the UK to two Chilean workers at the end of 2009 (Ana Maria Cerda, Jose Sanzana) and also to one Chilean PhD student (Daniela Gomez), the latter resulting in a MS currently under review. We are also developing a Darwin Fellowship application.

Activity 3. *Education programme and dissemination of results in relation to **Output 4** (Educational events and media coverage for local people, fish farmers, and rest of stakeholders).*

The activity milestones were the development of a joint MSc curriculum in Sustainable Aquaculture, the presentation of results at international conferences, and the maintenance and updating of the project website with access to results and material from the workshops, and the development of a Code of Best Practices and Management Action Plan. With the exception of the launch of the joint degree which has suffered delays, the other objectives have all been met (see output measures).

Regarding the MSc, the lead partner and the Chilean coordinator met with the Academic Registrar (Mr. Huw Morris) and the Head of the School of Environment & Society at Swansea University on October 2008, signed a declaration of intent, and discussed the development of the joint MSc curriculum, in particular with respect to the recently announced Erasmus Mundus II scheme (see http://eacea.ec.europa.eu/). We also met with Chilean teaching staff during the final project workshop on September 2009 and drafted a curriculum with input from several partners. In particular, Dr Guillermo Giannico assisted in the development of the joint MSc programme capitalizing on his outreach and third mission experience at OSU. It is envisaged that we will continue to interact on this topic after the project is finished, though the legal validation of the joint degree remains the most important obstacle.

Our project website has been visited frequently (details in presentation attached in **Annex 7**) and has been kept regularly updated and linked to all partners, stakeholders and sponsors. A number of dissemination material (flyers, fact sheets) have been produced and distributed during seminars and conferences in UK, Italy, Spain, USA and Canada. A powerpoint slide show outlining the background, aims and methodology of project was developed and presented at several seminars. During the project we numerous national and international presentations in relation to the project (full details are given in output measures), and attended three international conferences.

During the course of the project, 3 UG and 5 MSc theses were produced, several of which received top marks and were awarded *Distinction.* Summaries of these are posted in the project website and are also attached in **Annex 7**. In each year, Swansea MSc Students were asked to write Darwin Initiative grant applications modelled on our current project, as part of their course work for a module in Conservation Biology. In total, 32 Darwin grant applications were submitted to a University panel and posters summarising the various student Darwin Initiatives were posted on campus. This has served to disseminate the Darwin Initiative in general, and our project in particular.

Finally we organized the third training workshop at Puerto Varas on 2 to 5 September 2009, and this resulted in a draft of a *Code of Best Practices* ,which is now posted at our website and also attached in **Annex 7.**

4.4 Project standard measures and publications

The success of the project can be quantified against the following standard measures :

Training measures
1a. Three people to submit PhD theses (Delphine Van Haecke, Daniela Gomez, Ana Maria Cerda)
2. Five Masters qualifications obtained (Anne Rees, Ben Perry, Elgan John, Nia Phillip, Paul Howes)
3. Three final year UG dissertations completed (Gabriel Orellana, Hector Venegas, Viviene Schröder) and one soon to be completed (Edward Hamilton)
4a. Forty two UG students receiving training (including attendance to three Darwin training workshops)
4b. Seventy seven weeks of UG training over the duration of the project
4d. Fifty four weeks of PG training over the duration of the project
5. Three RA's trained
6a,b. Over 250 people receiving short term education through talks and seminars
7. Seven types of education/training material produced for use by host country: information leaflet, PowerPoint slideshow, protocols, website, flyers on exotic salmonids, and online database

Research measures
8. 12.1 weeks spent in Chile by UK partners, 8.2. weeks spent by other partners (US, Canada), and 17.1 weeks spent by UK PG students.
9. One MAP and CBP for use by Industry and Government
10. One interactive online Darwin Fish Atlas and database with information on distribution of exotic and native freshwater fishes in Chile's X and XI regions
11a. Three papers published or accepted for publication in peer-reviewed journals (Young et al. 2009. *Biological Invasions* **11**: 1955-1961; Buschmann et al 2009. *Ocean & Coastal Management* **52**: 243-249; Young et al. 2010. *Animal Conservation* in press). Two currently under review, and two other in preparation.
11b. Four popular science/newsletter articles
12a. One research database (Darwin Fish Atlas) available online (www.biodiversity.cl)

13b. Reference fish samples handed over to University and to museum in host country
14a. Three conferences and workshops organized in host country (Puerto Montt, Vina del Mar, and Puerto Varas) and one-day seminar organized in the UK (Swansea University) to disseminate project results
14b. Forty five individual presentations at conferences, seminars and workshops (by all partners and students) at which project findings were presented and disseminated.
15a,b. Nine nation\al/local press releases or publicity articles in host country
15c. Two publicity articles in UK (Darwin Newsletter)
18c. Two local TV interviews and one film coverage of different Darwin Workshops
19a,b. Three national/local radio interviews/features in host country

Physical measures
20. Physical assets handed over to host county estimated at £28,559 (capital equipment)
21. One permanent educational and research facility at Aquaculture and Genetics Laboratory in the host country
23. Additional resources raised for project valued at £206,864 (details in annual reports and section 7.2 below)

4.5 Technical and Scientific achievements and co-operation

Work carried out during this project has resulted in the joint publication with our Chilean colleagues of three peer-reviewed papers in *Biological Invasions*, *Animal Conservation*, and *Ocean & Coastal Management*, as well as in the submission of two more manuscripts currently under review. It has also resulted in the production of 8 student theses (many with top marks), as well as in presentations at two major international conferences and a number of seminars and workshops (details in **Annex 7**, and annual reports).

4.6 Capacity building

Our project built capacity in the host country to monitor the risks posed by exotic salmonids on native fish fauna (and therefore to meet CBD) in a number of different ways:

1. Chilean students, volunteers and staff were trained on ecological and molecular methods to recognize and assess salmonid impacts, both in the host country though workshops and training events, and in the UK through two, two-month long visits.

2. The Genetics and Aquaculture laboratory at the host institution (ULA) was equipped for microsatellite DNA screening, as well as for field work. Protocols were handed over to Chilean staff.

3. An online Fish Atlas and associated database was compiled and handed over to the host partner, to enable Chilean and other researchers to monitor the spread of invasive salmonids and to quantify their potential impacts upon native fish fauna.

4. Finally, our project was also instrumental in securing increased recognition of both the UK and host institutions in the field, though participation in conferences, disseminating activities and joint student projects and publications.

4.7 Sustainability and Legacy

We believe that the most lasting legacy of our project will be the quality of our scientific results regarding the impact of salmonids upon native aquatic biodiversity, the training of students, and the development and endorsement of a Management Action Plan and Code of Best Practices in relation to salmonid farming in Chile. The project has already helped change attitudes that have traditionally focused on immediate economic returns, without considering medium and long term goals that are needed for sustainability. The project has helped to permeate this vision to stakeholders and students, who see the project filling an empty niche in Chile (see statement after first workshop: www.biodiversity.cl/workshop, and our recent articles in La Nación at our website).

It is worth pointing out that important officers of governmental bodies, such as CONAMA (Natl. Commission for the Environment), and SUBPESCA (Undersecretariat for Fisheries), have continued to express to the UK and Chilean partners their full support and endorsement of the project. Likewise, support and collaboration from the Chilean salmon industry, most notably from Marine Harvest and Salmones MultiExport, have been instrumental in our sampling

surveys and we have recently started a collaboration with *Aquainnovo* (the R&D side of the Chilean salmon industry) aimed at reducing the impact of infectious diseases. By liaising with other groups working on reducing the impact of exotic species in Aquaculture (e.g. WWF, Fundacion Huinay, EU-Impasse project, NASCO, Pure Salmon Campaign) we are also ensuring that the results of our project are properly disseminated and transcend the Chilean scenario.

Chilean key staff have permanent jobs and will continue the work started during the Darwin Initiative at the host institution. We have recently applied for a Post-project award and are now developing a Darwin Fellowship. We keep (along with other project partners) in regular contact and will use the DI as a spring board for future grants.

5 Lessons learned, dissemination and communication

Sustainability and key lessons

Scarcity of suitable baseline data was highlighted by all stakeholders during our meetings as one of the most important threats to achieving sustainability in the Chilean salmonid industry. Thus, we feel that to a large extent the long-lasting success of our project will be measured by the quality and timeliness of our data on the origin and impacts of exotic salmonids upon native fishes. This, we believe, will in turn generate trust and interest and foster capacity for biodiversity. As the salmonid industry is facing serious problems due to the ISA virus and a blind faith in the continuous growth paradigm, our project has capitalized on the need to produce systematic and reliable science - not currently available to attack this problem.

We saw the main challenges and difficulties of the project in the logistics, which in Chile are particularly complicated, and the extreme difficulty of sampling remote aquatic ecosystems, particularly in autumn and winter. Massive escapes (Aysen, Calbuco), the ISA virus, and difficulties with the export market also made the Chilean salmon industry more cautious, and our sampling at commercial farms more difficult. The acquisition of a 4WD vehicle by ULA and a lease agreement with the project greatly facilitated our field work and increased our capacity for more extensive sampling and surveying. In addition, the skills gained during the first two years, and the help of additional volunteers and personnel, contributed to make our work more efficient towards the third year.

However, there were also some drawbacks, most notably with the hiring of personnel for the development and application of the molecular toolkit, which forced us to terminate the contract of one of the paid RA's in Chile, and with the departure of Dr Young on January 2009 who left the project to take up a job in the UK with the Environment Agency. The work of the molecular RA was taken up by staff at the Osorno Laboratory (Ana Maria Cerda, Patricia Beristain) with additional help and input from UK partners. Arrangements were also made during the visit of the host coordinator to the UK to ensure that the analyses of molecular data were carried out in accordance with the project objectives. To this end, additional human resources were committed to the project in the form of time spent by a Postdoc, a PhD and MSc student, with additional funding from other sources. In addition, Ana Maria Cerda received two months of training in molecular methods at Aberystwyth University, under the supervision of Dr. Consuegra towards the end of 2009. On the other hand, the departure of Dr Young in January 2009 was compensated by the recruitment of an eager and experienced Chilean fish biologist (Mr Jose Sanzana) who quickly assembled an efficient field team to carry out and expand the monitoring programme. An agreement with the Natural Isotopes Laboratory at the Millenium Centre (Swansea University) proved very successful for the analysis of our samples, and Mr Sanzana as well as three students were fully trained in the preparation and analysis of stable isotopes, also at te end of 2009. This work formed the basis of three dissertations, and resulted in one manuscript, currently under review .

We continued throughout the project to attract highly motivated international volunteers, and after initial delays, we also succeeded in recruiting Chilean volunteers to work in the field. There were also a number of Chilean students helping at the Osorno Laboratory, resulting in two UG theses at Chilean Universities (**Annex 7**). Finally, we found it very important to learn to

react to opportunities using the Darwin Initiative as leverage for securing additional funding and support for the project, and to encourage joint supervision of research students working on the project with colleagues in Chile and elsewhere.

Dissemination and communication

Dissemination activities during the duration of the project were numerous and substantial, and included the organization of several seminars, as well as newspaper articles, radio and film features, talks, posters and presentations by partners (details in annual reports). Progress in disseminating our project to the scientific community have also been successful: three peer-reviewed papers have been published or are in press, two are under review, and two more are in the final stages of preparation. We participated in two major Conferences (**'**Managing Alien Species for Sustainable Development of Aquaculture and Fisheries', and 'European Society for Evolutionary Biology' 2009) , and are now preparing our participation at a third International Symposium ('Advances in the Population Ecology of Stream Salmonids'), thus ensuring dissemination of results after project completion.

5.1 Darwin identity

Over the last three years, we have strived to advertise the Darwin Initiative by stressing three key issues: (1) how the project fulfilled the aims of the CBD, as well as the National Biodiversity Strategy, (2) the uniqueness and fragility of Andean Aquatic ecosystems and species, and (3) the socio-economic importance of the Chilean Aquaculture Industry and how the project would reduce its impact, helping it to become more sustainable. Because Chile is a world leader in salmon farming (an activity increasingly under attack), our project attracted considerable public attention (as evidenced by the number of visits to our website). In addition, an increasing number of tourists and anglers are being attracted to the rivers and lakes of southern Chile and this, along with the work of the University, provided numerous opportunities for promoting the Darwin Initiative and the dissemination of results. The Darwin name and logo have appeared in the ULL laboratory, in the 4WD vehicle, in all the dissemination outputs and contacts with the media, in presentations, publications, as well as in the project website (in English and Spanish). In addition, MSc students at Swansea University were asked to write Darwin Grant proposals as part of their course work for a module in Conservation Biology, an activity that proved very popular and which served to expose them to the Darwin Identity (after finishing the course, one of the students had to write a DI for real as part of her job with IUCN, finding the exercise invaluable).

6 Monitoring and evaluation

Other than the difficulties outlined above, there were no changes to the logframe. The only objective which could not be fully met was the launch of the joint MSc in Sustainable Aquaculture, which has suffered delays. Although a curriculum has been developed, and much progress was made during the visit by the Chilean coordinator to the UK and during the final project workshop, the validation of the degree has proved a difficult and lengthy process and work still remains to be done. An additional challenge is also the need to find bursaries for Chilean students to study in the UK.

In general, logframe indicators have proved useful and effective, forcing us to remain focused to achieve the project objectives, as per annual reports. Much of our work has been published or is being submitted for publication in its various forms (theses, papers) and has therefore gone through extensive, independent evaluation.

6.1 Actions taken in response to annual report reviews

We took the necessary actions in response to previous comments made by the reviewer. The following new comments were to be addressed:

1. It is a crucial moment for the project to reinforce partnerships with NGOs and Government administrations in order to promote the project beyond the end of the Darwin funds. Please provide a summary of any intended continued collaborations with these groups at the end of the Darwin grant.

We see the development of the Darwin Online Fish Atlas and the education programme, as two of the main ways to reinforce partnership with NGOs and Government once the project is finished. We are actively working with stakeholders to merge various fish databases in Chile and make the information freely available to the public (see for example our input to the *Database of Freshwater Fishes of Chile,* http://biology.mcgill.ca/grad/cristian/database.html)

2. Please specify the reasons for the departure of the RA and Mr Young from the project.

This has been addressed above. The contract of the molecular RA was terminated due to poor performance; the work was initially taken up by ULA staff at Osorno, and later by committing UK staff time followed by training of two Chilean staff at Swansea and Aberystwyth Universities. Dr Young left the project to take up a job in the UK with the Environment Agency.

3. Please indicate whether a specific M&E plan exists for the project. If so, please describe it in the next report.

No specific M&E plans exist, but as we are aiming to publish most of our work, we are receiving, and expect to continue receiving, extensive independent evaluation.

4. A more formal commitment from local stakeholders, particularly the Salmon Industry, to endorse the results of the project and work towards a sustainable farming industry is desirable. Please indicate if there are any formal or discussed agendas with local stakeholders beyond the end of the Darwin Grant.

All local stakeholders were asked to comment on the draft agenda for the final workshop, actively participated in the formulation of the resulting CBP and will be asked to comment on a revised draft. There are specific agendas that extend beyond the end of the project, namely in relation to work planned for 2010 in relation to the CBD year in Chile, new contacts with industry (AquaInnovo), and developments of a Fellowship and new grant application.

7 Finance and administration

7.1 Project expenditure

Concept	Expenditure	Budget	Balance	% Difference
Printing				
Office				
Capital				
Conference				
Others				
Salaries				
Travel & S				
TOTAL				

The only significant (i.e. +/- 10%) differences in the final balance lie in an over-expenditure for the organization and attendance of conferences, which was in hindsight under budgeted, and in an under-expenditure for 'Others' which include field work and external laboratory analysis. The over-expenditure in the organization of conferences is in part motivated because printing costs (£2,352.70) were not separated per se, and were included in the overall organization of the various conferences (the same applies to general office costs). The under-expenditure in the field costs and external costs for isotopic and DNA sequencing is partially due the fact that these were done *in house* using facilities at Swansea and Aberystwyth Universities. Salaries, capital equipment, and travel and subsistence were broadly on budget. These figures are currently under going auditing.

Salaries breakdown

Name	Role	Total salary
Dr S Consuegra	Project management	
Dr G Zampicinini	Molecular RA	
Mr E John	Assistant Isotopic analysis	
Ms N Phillips	Assistant Molecular analysis	
Dr K Young	Ecology RA	
Mr C Flores	Molecular RA	
Mr J Sanzana	Ecology RA	
Volunteers & Assistants	Field & laboratory work	
Total salaries		

Capital equipment breakdown

Item	Cost
Toshiba Laptop Computer	
Smith Root Electrofishing gear	
Printer EPSON CX3900	
Centrifuge 5804 Eppendorf with accessories and Manifold vaccum	
DIM E520 Computer	
Vertical Freezer Consul	
Micropipettes Eppendorf	
Multichannel Micropipettes Eppendorf	
Digital Power source electrophoresis Consort	
Micropipette 8 channels Eppendorf	
Print Server-Link DP-301U.	
Desktop Support 6 pipettes Eppendorf	
Angular Rotor for 30 microtubes	
Visicoolers, Model 280 Lts	
Gel photodocumentation Digidoc 14	
Portable Flowmeter + various field accessories	
Total capital equipment	

7.2 Additional funds or in-kind contributions secured

Below is the yearly breakdown of in-kind (as well as some cash) contributions secured during the duration of the project

Year 1

Cash contribution by International Genetics Federation Contributions in kind by Fundacion Huinay (travel & subsistence field trip) ULA cash contribution to housing of volunteers and 1st workshop ULA cash contribution to lease of 4WD for duration of project Contribution by partners & stakeholders to participate in 1st workshop Time spent in project (all partners) **Total**	

Year 2

ULA cash contribution to 2nd workshop Courier Service Contributions from other projects (FONDEF) Contribution by partners & stakeholders to participate in 2nd workshop Time spent in project (all partners) **Total**	

Year 3

ULA cash contribution field work Courier Service & contributions from other projects (e.g. FONDEF) UWS contribution to stable isotope analysis (consumables) UWS contribution to molecular toolkit (3 man-months, consumables) Air fare and housing paid by FIDC and U. Valparaiso 3-year PhD studentship secured at U. Wales Aberystwyth Other contributions made by partners & stakeholders, including in kind **Total**	

7.3 Value of DI funding

DI funding was essential for this project; its main value was fourfold:

1. It provided the resources necessary for the development of a diagnostic toolkit for the identification of exotic salmonids escaping from fish farms, as well as for the field monitoring and assessment protocols
2. It enabled us to equip a modern laboratory in the host country and to hire and train staff who can now continue to carry the monitoring and diagnostic work
3. It facilitated meetings with stakeholders, as well as development of the training and education components of the project
4. It was instrumental in forging a network of national and international researchers working on the conservation of fish biodiversity in the host country, and to enable us to apply for further funding.

Annex 1 Report of progress and achievements against final project logframe for the life of the project

Project summary	Measurable Indicators	Progress and Achievements April 2007 - March 2008	Actions required/planned for next period
Goal: *To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but constrained in resources to achieve The conservation of biological diversity,The sustainable use of its components, and The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources*		*See also www.biodiversity.cl*	*(do not fill not applicable)*
Purpose To build, in collaboration with government, industry and other stakeholders, the capacity for assessing, monitoring, and reducing the impact of the accidental or deliberate introduction of exotic fish species on Chilean aquatic biodiversity	1. New knowledge on the distribution and abundance of exotic fish species and their impact upon native aquatic biodiversity 2. Endorsement of a Management Action Plan (MAP) and Code of Best Practice (CBP) in relation to exotic species, introductions and protection of native aquatic biodiversity 3. Increased understanding and public awareness of threats to native bio-diversity resulting from foreign fish introductions	Training of volunteers, students an personnel and continuing interest in our project. Three peer-review papers published and two other under review. Presentation of results at international conferences and seminars	1. Ongoing development of online fish distribution Atlas and databases 2. Application of molecular and isotopic toolkits for GSI 3. Submission of further MS for publication : 1 popular science, 2 scientific papers
Output 1. Abundance, distribution, and impact of exotic and naturalized salmonids assessed	1. Findings endorsed by the scientific community and stakeholders	Good progress was made; Assessment of abundance and distribution of exotic and naturalized salmonids was helped by development of online Atlas and database, in addition to endorsement by scientific community and stakeholders	
Activity 1. Research & monitoring of exotic and naturalized fish species		Sampling field protocols by combination of angling and electro-fishing were developed, as well as protocols for carrying out genetic and isotopic analysis. Over 12,000 fish were sampled from 300+ sites, and the toolkits were fully tested and validated in the field (two papers under review)	
Output 2. A monitoring and impact assessment programme with trained personnel established	2. GIS database & molecular and isotopic toolkits for identification of exotic and farmed fish species developed, tested, and at least 2 staff trained	Network of sampling stations and development of molecular and isotopic protocols completed. Staff were fully trained. Testing of toolkit for molecular and isotopic stock identification completed. Development of Fish distribution database completed, and beta version now available online.	
Activity 2. Capacity building and training in assessing impact of exotic invasions		As per activity 1, involving 2 hired staff (RA's), 2 technicians and three volunteers..	
Output 3. MAP, CBP, and possible exclusion zones for protecting aquatic biodiversity from exotic invasions	3. MAP and CBP peer reviewed and presented at international conference	Drafts of CBP and MAP discussed among stakeholders at final project workshop, and now available online. Further developments of CBP and MAP are expected to take place with help of international players after the end of project, possibly through the *Salmon Dialogue*.	
Activity 3. Research & monitoring of exotic and naturalized fish species		As per activity 1.	
Output 4. Educational events and media coverage for local people, fish farmers, and rest of stakeholders	4. Participation of fish farmers and rest of stakeholders in educational events, Darwin project featured in media	Key stakeholders participated in all workshops. Darwin project was also publicized at conferences and seminars and featured in the media.	
Activity 4. Education programme and dissemination of results		MSc/MRes curriculum on Sustainable Aquaculture was developed and negotiations took place between institutions. Three peer-reviewed manuscripts were published, and two others are under review. Project results and achievements were presented at three international conferences, and will be presented at a fourth conference during spring 2010	

Annex 2 Project's final logframe, including criteria and indicators

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Purpose To build, in collaboration with government, industry and other stakeholders, the capacity for assessing, monitoring, and reducing the impact of the accidental or deliberate introduction of exotic fish species on Chilean aquatic biodiversity	1. New knowledge on the distribution and abundance of exotic fish species and their impact upon native aquatic biodiversity 2. Endorsement of a Management Action Plan (MAP) and Code of Best Practice (CBP) in relation to exotic species, introductions and protection of native aquatic biodiversity 3. Increased understanding and public awareness of threats to native bio-diversity resulting from foreign fish introductions	1. Project reports, workshop proceedings and publications in peer-reviewed journals 2. Documentation and correspondence for MAP and CBP 3. Records of educational programme and training workshops. Development of professional curricula on sustainable aquaculture. Students trained under programme pass their courses	1. Project findings are understood and accepted by the salmon industry, regulatory agencies and all stakeholders. Policy makers use findings to help reduce the impact of exotic species on local biodiversity 2. Market forces and increased recognition on the impact of exotics facilitate the shift towards more sustainable fish farming 3. Curriculum development is implemented by ULL with the launch of a MSc in Sustainable Aquaculture
Outputs 1. Abundance, distribution, and impact of exotic and naturalized salmonids assessed 2. A monitoring and impact assessment programme with trained personnel established 3. MAP, CBP, and possible exclusion zones for protecting aquatic biodiversity from exotic invasions 4. Educational events and media coverage for local people, fish farmers, and rest of stakeholders	1. Findings endorsed by the scientific community and stakeholders 2. GIS database & molecular and isotopic toolkits for identification of exotic and farmed fish species developed, tested, and at least 2 staff trained 3. MAP and CBP peer reviewed and presented at international conference 4. Participation of fish farmers and rest of stakeholders in educational events, Darwin project featured in media	1. Publication of results in peer reviewed, national and international scientific journals 2. Project reports, scientific papers, abundance and distribution maps, species database, fish escape assessment protocol, project website 3. Workshop proceedings, MAP and CBP published and distributed, copies sent to Darwin Initiative 4. Educational leaflets, press releases, media coverage, reports	1. Sampling strategy and logistic support are appropriate for project objectives and facilitate the collection of data 2. Adequate performance of molecular and isotopic diagnostic toolkits to produce desired results 3. Successful liaison with industry, government agencies and rest of stakeholders for project support 4. Links to educational media and NGO's are established (already in place via ULL)

Activities	Activity Milestones	Assumptions
1. Capacity building and training in assessing impact of exotic invasions 2. Research & monitoring of exotic and naturalized fish species 3. Education programme and dissemination of results	**Yr1.** Initial meetings with stakeholders. Develop GIS database, molecular and isotopic diagnostic toolkits and run training workshops, establish sampling strategy and field protocols. Follow-up training workshops in **Yr2 & Yr3.** **Yr1**.Field test diagnostic methods for species identification, stock assignment and trophic niche overlap, begin screening. **Yr2 & Yr 3**. Continue screening, workshops to discuss results. **Yr 3**. Writing of scientific publications, MAP and CBP. **Yr1.** Develop education programme, establish website, and attract media interest. **Yr2-Yr3**. Develop MSc curriculum, presentation of results at international conferences. All years: annual reports, workshops proceedings, update webpage. At least 2 scientific peer-reviewed papers submitted by end of Yr 3	1. Program receives required support from University (in place). 2. Research methods and tools are adequate. Required baseline information is provided by industry and regulatory bodies 3. Successful liaison with stakeholders and media interest. Support from University

Annex 3 Project contribution to Articles under the CBD

Project Contribution to Articles under the Convention on Biological Diversity

Article No./Title	Project %	Article Description
7. Identification and Monitoring	30	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities that have adverse effects; maintain and organise relevant data.
10. Sustainable Use of Components of Biological Diversity	20	Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
12. Research and Training	25	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness	20	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.
Other Contribution	5	Smaller contributions (eg of 5%) or less should be summed and included here.
Total %	100%	Check % = total 100

Annex 4 Standard Measures

Code	Description	Totals (plus additional detail as required)
Training Measures		
1a	Number of people to submit PhD thesis	3
2	Number of Masters qualifications obtained	5
3	Number of other qualifications obtained	4 (UG, final year projects)
4a	Number of undergraduate students receiving training	42
4b	Number of training weeks provided to undergraduate students	77
4d	Number of training weeks for postgraduate students	54
5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification(ie not categories 1-4 above)	3
6a	Number of people receiving other forms of short-term education/training (ie not categories 1-5 above)	c. 250
7	Number of types of training materials produced for use by host country(s)	7
Research Measures		
8	Number of weeks spent by UK project staff on project work in host country(s)	UK staff : 12.1 weeks UK PG students: 17.1 weeks. US/Canada partners: 8.2 weeks
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)	1
10	Number of formal documents produced to assist work related to species identification, classification and recording.	1
11a	Number of papers published or accepted for publication in peer reviewed journals	3
11b	Number of papers published or accepted for publication elsewhere	4
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	1
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	1
13b	Number of species reference collections enhanced and handed over to host country(s)	1

Code	Description	Totals (plus additional detail as required)
Dissemination Measures		
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	4
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	45 (by all partners & students)
15a	Number of national press releases or publicity articles in host country(s)	9
15c	Number of national press releases or publicity articles in UK	2
18c	Number of local TV programme/features in host country	3
19a,b	Number of national radio interviews/features in host country(s)	3
Physical Measures		
20	Estimated value (£s) of physical assets handed over to host country(s)	£XXXX (capital equipment)
21	Number of permanent educational/training/research facilities or organisation established	1
23	Value of additional resources raised for project	£XXXX (details in annual reports)
Other Measures used by the project and not currently including in DI standard measures		

Annex 5 Publications

Type * (eg journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (eg contact address, website)	Cost £
Theses				
UG Thesis	V. Schröder. 2009. Invasive salmonids in Chile - A stable isotope approach	Swansea University, UK	Summary and conclusions in project website www.biodiversity.cl	
UG Thesis	G. T. Orellana. 2009. Evaluación de hábitos alimenticios de salmónidos cultivados y asilvestrados de vida libre en ríos y lagos del sur de Chile	Universidad Austral de Chile, Chile	Summary and conclusions in project website www.biodiversity.cl	
UG Thesis	H. E. Venegas. 2009. Estudio de la variabilidad genética y diferenciación poblacional mediante análisis de microsatélites en poblaciones asilvestradas de trucha arco-iris (*Oncorhynchus mykiss*) y trucha café (*Salmo trutta*), en ríos del Sur de Chile	Universidad de los Lagos, Chile	Summary and conclusions in project website www.biodiversity.cl	
MSc thesis	A. Rees. 2007. Determinants of establishment success among non-native fish	Swansea University, UK	Summary and conclusions in project website www.biodiversity.cl	
MSc thesis	B.J. Perry. 2007. Effects of non-native salmonids on native fish fauna in Chile and the Falkland Islands	Swansea University, UK	Summary and conclusions in project website www.biodiversity.cl	
MSc thesis	P. N. Howes. 2008. Predator recognition of invasive salmonids by native galaxiids	Swansea University, UK	Summary and conclusions in project website www.biodiversity.cl	
MSc thesis	E. L. John. 2009. The Discrimination of Farmed and Free-Living Salmonids, The Isotopic Changes of Escapees With Time at Liberty, Trophic Overlap with native Galaxiids and Piscivory Utilising Scales and Stable Isotopes in Chile	Swansea University, UK	Summary and conclusions in project website www.biodiversity.cl	
MSc thesis	N. C. Phillips. 2009. The Genetics of Invasion of Rainbow Trout (*Oncorhynchus mykiss*) in the Southern Hemisphere	Aberystwyth University, UK	Summary and conclusions in project website www.biodiversity.cl	
Peer-reviewed Papers, published				
Journal	Buschmann, A. H., Cabello, F., Young, K., Carvajal, J., Varela, D. A., & Henríquez, L. 2009. Salmon aquaculture and coastal ecosystem health in Chile: Analysis of regulations, environmental impacts and bioremediation systems.	*Ocean & Coastal Management* **52**: 243-249	Downloadable from project website www.biodiversity.cl	
Journal	Young, K. A., Stephenson, J., Terreau, A., Thailly, A. F., Gajardo, G., & Garcia de Leaniz, C. 2009. The diversity of juvenile salmonids does not affect their competitive impact on a native galaxiid	*Biological Invasions* **11**: 1955-1961	Downloadable from project website www.biodiversity.cl	
Journal	Young, K. A., Dunham, J. B., Stephenson, J. F., Terreau, A., Thailly, A. F., Gajardo, G., & Garcia de Leaniz, C. 2010. A trial of two trouts: comparing the impacts of rainbow and brown trout on a native galaxiid.	*Animal Conservation* (in press),	Downloadable from project website www.biodiversity.cl	

Peer-reviewed MS currently under review				
Journal	V. Schröder & C. Garcia de Leaniz. Discrimination between farmed and free-living invasive salmonids in Chilean Patagonia using stable isotope analysis			
Journal	C. Garcia de Leaniz & G. Gajardo. Exotics in Aquaculture, the Pollution Pays Principle and the 2010 Biodiversity target			
Journal	D. Gomez, P. Conejeros, S. Marshall, & S. Consuegra. MHC variation in three salmonid species: a comparison of class II α and β genes			
Popular Science articles, published				
Magazine Article	K.A. Young. 2007. La salmonicultura de Aysen y sus posibles impactos en los ecosistemas. *El Periódico de Acuicultura Junio* 20-22.	*El Periódico de Acuicultura / Puerto Montt*	Downloadable from project website www.biodiversity.cl	
Newspaper Article	http://cyt.elmercurio.com/archives/2007/10/ciencia_basica.asp	*El Mercurio Oct 2007*	Downloadable from project website www.biodiversity.cl	
Newspaper Article	G. Gajardo & C. Garcia de Leaniz. 2009. Hacia una acuicultura exótica más sustentable. [jn Spanish]	*La Nación*	Downloadable from project website www.biodiversity.cl	
Darwin Newsletter	www.darwin.gov.uk/downloads/newsletters/DARWIN_NEWS_9.pdf	*DEFRA*	http://darwin.defra.gov.uk	
Darwin Newsletter	C.,Garcia de Leaniz & G. Gajardo. Assessing the Impact of Exotic Salmonids on Chilean waters. 2009. *Darwin News* **16**: 8.	*DEFRA*	http://darwin.defra.gov.uk	
Databases				
Online, interactive database	Darwin Atlas of Exotic and Native Freshwater Fish Species of Chile		Beta version available at project website www.biodiversity.cl	
Database	C. Correa, B. Dyer, G. Gajardo, C. Garcia de Leaniz, C. Meier, G.H. Samaniego et al. 2009. Rumbo a un sistema nacional de información geográfica de peces dulceacuícolas de Chile. *VI Congreso de Sociedad Chilena de Limnología.* *http://www.eula.cl/limnologia/*		Poster available at http://biology.mcgill.ca/grad/cristian/PosterSCL_2009.gif	
Project Documents				
Joint Declaration	Reducción del Impacto de la Acuicultura con Especies Exóticas en la Biodiversidad Acuática de Chile. Conclusiones de la Reunión de Partes interesadas (Stakeholders). (In Spanish) Puerto Montt, Chile, January 2007		Downloadable from project website www.biodiversity.cl	
CBP & MAP Manuals (first draft)	A Code of Best Practices and Management Action Plan to Minimize the Impact of Exotic Salmonids Escaping from Chilean Fish farms [in Spanish]. January 2010		Downloadable from project website www.biodiversity.cl	
Summaries and selected presentations	First International Darwin Workshop , Puerto Montt, Chile, January 2007		Downloadable from project website www.biodiversity.cl	
Summaries and selected presentations	Second International Darwin Workshop, Viña del Mar, Chile, December 2007		Downloadable from project website www.biodiversity.cl	
Summaries and selected presentations	Third International Darwin Workshop , Puerto Varas, Chile, September 2009		Downloadable from project website www.biodiversity.cl	
Conference	B.J. Perry, K.A. Young, B. Gara,	*MALIAF*	www.dbag.unifi.it/m	

Abstract	G.Gajardo & C. Garcia de Leaniz. 2008	*Website*	aliaf/	
Conference Abstract	K.A. Young, J. Stepehnson, A. Terreau, A-F. Thailly, G. Gajardo & C. Garcia de Leaniz. 2008	*MALIAF Website*	www.dbag.unifi.it/maliaf/	
Conference Abstract	C. Garcia de Leaniz, P.N. Howes, K.E. Whitlock. 2009. Invasive sal;monids as agents of selection	*ESEB 2009 Website*	www.eseb2009.it/uk/	
Conference Proceedings	G. Gajardo, S. Consuegra, C. Garcia de Leaniz. 2009. Efecto de las actividades humanas sobre la biodiversidad genética: el caso de la Salmonicultura en Chile. [in Spanish]. *VII Simposio de Recursos Genéticos para América Latina y el Caribe* **2**: 127-128	*VII Simposio de Recursos Genéticos para América Latina y el Caribe*	Downloadable from project website www.biodiversity.cl	
Conference Presentation	P. Beristain. Reducing the impact of exotic aquaculture on Chilean aquatic biodiversity: A hot topic for the developing world. Bahia, Brazil, 2010	*DEFRA Darwin Conference*	Downloadable from project website www.biodiversity.cl	

Annex 6 Darwin Contacts

Ref No	162/15/020
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Ema	
Partner 1	
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