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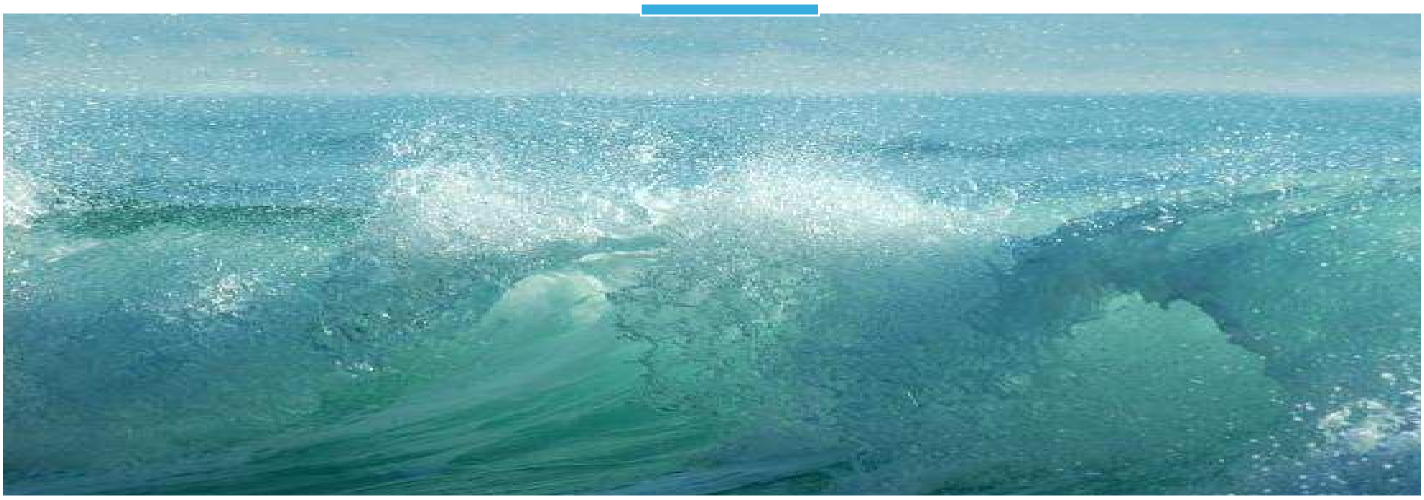

Identifying key stakeholders and developing a roadmap for the risk assessment

Strategy document in the frame of Work Package 11 “Risk assessment and management recommendations” of the FP7 project AquaTrace

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Introduction

Aquaculture could be key to meet the escalating demand for fish worldwide and also contribute to a thriving EU fisheries and aquaculture industry under the remit of the Common Fisheries Policy (CFP)[1]. However, at the same time, EU aquaculture has to be economically viable, environmentally friendly and perceived as socially acceptable[2,3].

Indeed, fostering sustainable aquaculture is one of the pillars of the CFP Concerning the environmental aspects, Ecosystem-Based Management (EBM) has, since 2003[4,5], been an integral part of the CFP. An important corollary of the approach is the fundamental requirement to conserve the integrity of exploited fish stocks and their natural environment. Any fishing or aquaculture activity that threatens to disrupt such integrity needs to be identified, and measures for mitigation implemented. In addition to overexploitation of capture fisheries, threats to the integrity of wild stocks derive from aquaculture practices, including the potential genetic impact of escapees. The basic principles of EBM have further become entrenched within the Marine Strategy Framework Directive (MSFD)[6] descriptors for monitoring of progress towards Good Environment Status (GES).

For marine aquaculture a precautionary approach towards the environment was proposed by GESAMP Working Group 31 on Environmental Impacts of Coastal Aquaculture which proposed to extend the application of the risk assessment process developed by WHO to environmental risks[7].

Escapes or releases of domesticated aquaculture fish pose a potential risk of adverse effects on native fish gene pools. The FP7 project *AquaTrace* applies molecular genetic tools, which will improve the ability for tracing farmed fish in the wild and for documentation of their potential effects on wild conspecifics. Based on the scientific insights the project provides a risk assessment and management recommendations concerning the genetic impact of aquaculture fish on wild fish gene pools.

In general, risk assessment is a step in a risk management procedure that determines the quantitative or qualitative value of risk from a recognised hazard. If

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[1] *European Commission (2011) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Reform of the Common Fisheries Policy. COM(2011) 417 final*

[2] *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Strategic Guidelines for the sustainable development of EU aquaculture. COM(2013) 229 final*

[3] *Communication from the Commission to the European Parliament and the Council, Building a sustainable future for aquaculture, A new impetus for the Strategy for the Sustainable Development of European Aquaculture. COM(2009) 162 final*

[4] *Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy*

[5] *Communication from the Commission to the Council and the European Parliament: Thematic Strategy on the Protection and Conservation of the Marine Environment. COM(2005)504 final*

[6] *Directive 2008/56/EC*

[7] *GESAMP (IMO/FAO/UNESCO - IOC/UNIDO/WMO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Environmental Protection) 2008. Assessment and communication of environmental risks in coastal aquaculture. Rome, FAO. Reports and Studies GESAMP no. 76: 198 pp. ISBN 978-92-5-105947-0.*

in the assessment the estimated risks have been found unacceptably high, risk mitigation and management measures can be proposed.

The following definitions are commonly used in the risk analysis and risk assessment:

Harm: a negative impact or adverse effect.

Hazard: inherent property of an agent or process capable of having the potential to produce harm.

Risk: the probability (likelihood) and severity of a harm resulting from exposure to a hazard.

Risk management or risk mitigation: steps to be taken to reduce or eliminate risks by reducing probability and/or severity of a harm or totally eliminate the hazard.

Quantitative risk assessment calculates the magnitude of the potential adverse effect and the probability that the adverse effect occurs as follows[8]:

$$R = P(E) \times P(H/E)$$

where

R = *risk,*

P(E) = *probability of exposure,*

P(H/E) = *conditional probability of harm given that exposure has occurred* (Hallerman, 2008)

This document aims to identify key stakeholders and to draw a roadmap for the risk assessment to be carried out in the frame of AquaTrace (see Annex).

Key stakeholders

Stakeholders (individuals or organisations) have either an interest or a gain upon a successful completion of a project or may have a positive or negative influence in the project completion. Key stakeholders are a subset of stakeholders, indispensable for the project to achieve its full set of objectives. Their absence/non-contribution may potentially cause the project to fail.

As elaborated in the project work plan during the initial stages of the project, stakeholders are involved in compiling existing knowledge, identifying the challenges, potential harms, risk pathways and assessment methods emerging from aquaculture activities..

In the frame of the project, key stakeholders are the persons from the scientific and commercial entities involved in the project planning, execution and analysis and the persons supporting the project in the collection of fish samples.

[8] E. Hallerman (2008) *Application of risk analysis to genetic issues in aquaculture*. In Bondad-Reantaso, M.G.; Arthur, J.R.; Subasinghe, R.P. (eds). Understanding and applying risk analysis in aquaculture. FAO Fisheries and Aquaculture Technical Paper. No. 519. Rome, FAO. 2008. 304p. ISBN 978-92-5-106152-7.

Stakeholder	**Project interest** (areas of interest & participation)	**Impact on project** (positive, negative, influencer, supporter)	**Role** (e.g. decision maker, collaborator, consultant, recipient)
DTU	Research/Dissemination/Implementation	Positive	Project leader
JRC	Research/Dissemination/Implementation	Positive, influencer	WP leader
IRM	Research/Dissemination/Implementation	Positive, influencer	Project team member
UniPD	Research/Dissemination/Implementation	Positive, influencer	Project team member
USC	Research/Dissemination/Implementation	Positive, influencer	Project team member
KU Leuven	Research/Dissemination/Implementation	Positive, influencer	Project team member
AUTH	Research/Dissemination/Implementation	Positive, influencer	Project team member
ISPRA	Research/Dissemination/Implementation	Positive, influencer	Project team member
CETGA	Implementation	Supporter	Project team member
Ardag Ltd.	Implementation	Supporter	Project team member
Ferme marine du Douhet	Implementation	Supporter	Project team member
Plagton S.A.	Implementation	Supporter	Project team member
DG RTD	Dissemination/Implementation	Supporter	Recipient, Customer
		Positive, supporter	Resource manager

Road map for the risk assessment (phases of the risk assessment process)

Problem formulation

Foremost among the concerns in relation to "environmentally friendly" is the issue of aquaculture fish escaping from their production enclosures (‘escapees’), which pose a threat to the integrity and levels of biodiversity both through direct competition for resources and through genetic ‘pollution’ of local populations of conspecifics. These escapees are a feature of aquaculture that can occur both chronically and acutely. In consequence of the rising concerns about aquaculture impact on the environment, there is an urgent need to identify methods that allow us to assess and monitor any genetic effects of aquaculture escapees on wild populations. Nevertheless, discriminating between marine fish populations is often challenging, primarily owing to standard genetic markers exhibiting relatively low levels of population differentiation. Accordingly, there are yet few coordinated databases that allow collation of information on population boundaries and dynamics of populations beyond local scales, although exceptions exists for a database on European-wide population genetic signatures of four marine species, Atlantic cod, herring, sole and hake[9]. Discrimination between wild and farmed strains of marine fishes is further complicated by the fact that each farmed strain may have its own history of selection and domestication, sometimes including recurrent backcrosses to wild-origin brood-stock. These breeding processes have

[9] https://fishpoptrace.jrc.ec.europa.eu/

typically not been documented, and may mask the frequency and direction of interactions.

While genetic changes in wild populations over time have been demonstrated, it was more difficult to prove that such changes have been the consequences of interbreeding with escaped farmed fish. The recent technological advances in development and application of genome-wide SNP markers in fishes offer a highly promising approach that can be specifically aimed at tracing the genetic origin and potential hybrid status of individual fish in a wild/farm context. New genetically-based tools are applied to provide unambiguous proof of current and past interactions, including introgression and the incidence of hybrids.

Identification of potential harms of introgression, which might result in fitness reduction.

From the general definitions the farmed stocks has to be considered as the hazard in the genetic risk analysis as it poses harm through restocking activities or escapees.

AquaTrace both reviews knowledge and resources from previous research relevant for the assessment of risks emerging from aquaculture (Work Package 2), and also performs a risk assessment based on the insight produced by the project, including the formulation of management strategy advice (Work Package 11).

Scope, focus, sources to be considered

Species, geography, time

The rationale behind AquaTrace is to develop reliable and cost-effective molecular tools for the identification of the genetic origin of both wild and farmed fish (assignment and genetic traceability), as well as for the detection of interbreeding and assessment of genetic introgression between farmed and wild stocks. This work will be carried out on three marine fishes of economic significance, European sea bass (*Dicentrarchus labrax*), gilthead sea bream (*Sparus aurata*) and turbot (*Scophthalmus maximus*). To address quantitative effects of farm introgression, the rationale is to examine links between key fitness and life-history traits and specific functional genetic variation between wild and farmed fish, using Atlantic salmon (*Salmo* salar) and brown trout (*Salmo trutta*) as model species.

The risk will be assessed based on proxies for genetic impact on wild stocks in a similar manner as in a recently conducted risk assessment of Norwegian fish farming[10].

The outputs will include a list of suitable indicators for assessing and monitoring introgression and its associated effects, potential mitigation strategies under current practices, a cost-benefit analysis, as well as general management recommendations, setting *AquaTrace* in the context of the Marine Strategy Framework Directive.

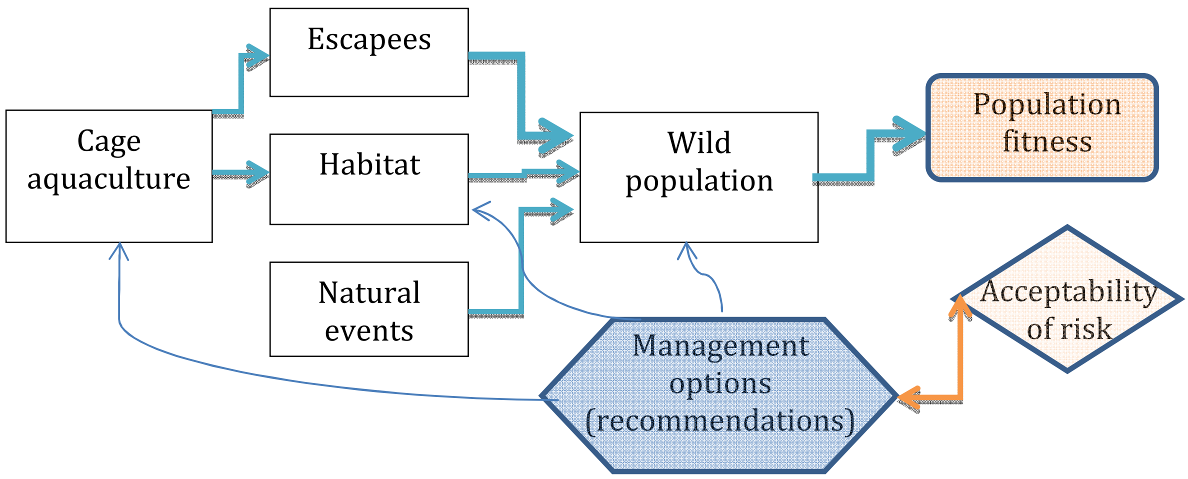
[10] *G.L.Taranger, K. K. Boxaspren, A.S. Madhum. T. Svåsand (editors); Risk assessment – environmental impacts of Norwegian aquaculture; Institute for Marine Research / Norway – Extract from "Fisken og havet, særnummer 3-2010, printed August 2001, www.imr.no*

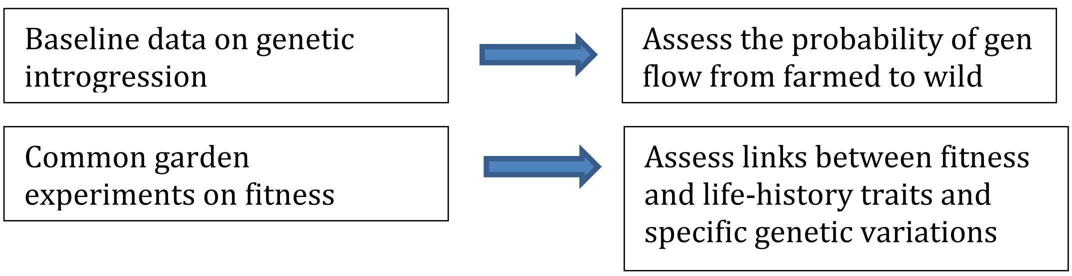
Assessment of end-points

At the onset of a Risk Assessment, the definition of ‘end-points’ is crucial. End points describe values, conditions or parameters that should be preserved. In the context of AquaTrace the aim is to describe and prseve the existing gene pools of wild fish populations. The definition of end points in the contecxt of the AquaTrace Risk Assessment will be carried out together with the Work Package partners at the initial phase.

Conceptual model

Below a generic description of the conceptual model of the planed Risk Assessment is depicted. This will be further elaborated during the project lifetime.





Plan for risk assessment

Risk analysis

Risk factors have to be identified and analysed before working on a more detailed risk analysis. Depending on the species, the factors governing the effects of interbreeding in individual populations can be different. Common factors could be e.g. extent of releases of farmed fish or escapees in a region, presence and density of wild conspecifics, genetic differences between escapees and wild conspecifics, environmental conditions, state of production of wild population, proportion of escapees in spawning population, rate of escapees spawning successfully.

The risk analysis tries to quantifying both the probability of introgression and its consequences. In biological systems it is normally very difficult to quantify these factors precisely and us as an alternative broad qualitative categories, by scoring the probability and consequences from low to high. This can in turn either, be based on some semi-quantitative assessment or on expert opinion. There are suggestions for how such environmental alterations can be scored scientifically, e.g. related to their scale of impact in the ecosystem, and whether the impact is reversible or not (e.g. GESAMP categories[11], ICES(2006)[12]).

Recently, the Institute of Marine Research, Norway, conducted risk assessments on the environmental impact of fish farming in Norway (Taranger et al. 2011[13], Glover et al. 2013[14]). The assessments were based on the likelihood of exceeding certain thresholds of environmental impact based on selected proxies such as the number and proportion of escaped salmon observed on the spawning grounds of wild salmon stocks and on the level of actual introgression into the wild stocks as quantified by SNP markers.

1. Challenges identified from the review of existing knowledge, and new knowledge generated in AquaTrace and partners involved in tackling the challenges:

- Assess available data on the impact of introgression of farmed fish into wild populations, degree of introgression as monitored with new molecular tools, its potential impact on the genetic structure of the wild populations, and ecological consequences with focus on potential changes in life-history traits and fitness based on existing data and new data generated in the project.
- Identify methods that allow assessing and monitoring any genetic effects of aquaculture escapees on wild populations (assignment and genetic traceability).
- Identify suitable effect indicators (or proxies) for assessment of the degree of introgression across spatial and temporal scales ("to which extent have their genetic integrity been altered?").

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[11] *GESAMP (IMO/FAO/UNESCO - IOC/UNIDO/WMO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Environmental Protection) 2008. Assessment and communication of environmental risks in coastal aquaculture. Rome, FAO. Reports and Studies GESAMP no. 76: 198 pp. ISBN 978-92-5-105947-0*

[12] *ICES CM 2006/RMC:04 Ref. LRC ACFM ACE ACME*

[13] *G.L.Taranger, K. K. Boxaspren, A.S. Madhum. T. Svåsand (editors); Risk assessment – environmental impacts of Norwegian aquaculture; Institute for Marine Research – Extract from "Fisken og havet, særnummer 3-2010, printed August 2001, www.imr.no*

[14] *K.A. Glover, C. Pertoldi, F. Besnier, V. Wennevik, M. Kent, Ø. Skaala; Atlantic salmon populations invaded by farmed escapees: quantifying genetic introgression with a Bayesian approach and SNPs; BMC Genetics 2013, 14:74*

2. Analysis of the potential impact

a) Analysis of exposure (predict or measure spatial and temporal distribution of a stressor of concern)
    - historic and current literature information
    - complete baseline survey

   Quantifying the degree of genetic change as a result of farming activity.

b) Interpret the life history trait consequences for different species and populations from different introgression scenarios by analysing the exposure response (effects - estimate possible impacts from common garden experiments). Links between key fitness and life-history traits and specific functional genetic variation between wild and farmed fish should emerge (e.g. survival, growth, habitat use).
    - near-field effects
    - far field effects

c) Evaluate level of uncertainty.

3. Measure or estimate the severity of the impacts
- Assess effects of introgression on the fitness of local wild populations ("How severely does introgression affect the fitness of wild populations?").

4. Quantify the probability of occurrence of the impacts
- Assess potential changes in genetic structure and life history traits of selected wild populations based on the tasks above.

Risk characterisation

Scale the possible importance if different risk factors in terms of ecological impact on the wild populations, and form basis for advice on relevant proxies to use in future assessments.

The characterisation of risks should allow comparing the identified risks in their importance to take mitigating actions.

- brings together analysis of exposure and analysis of effects
- most effects of aquaculture are interactive (complexity dealt with by modelling)

Risk assessment

The risk assessment will include an assessment of the analysed risks against acceptable risk levels. The assessment will indicate the uncertainties, the assumptions made and identify possible steps or options for the mitigation of magnitude and/or probability of undesired impacts as well as further research needs to fill existing gaps. Questions and issues that might have to be addressed include:

- What would be an acceptable level of risk?
- Options for risk mitigation both for magnitude and/or probability.
- Recommendation Provision to the EU commission for policy development and further research and monitoring activities.

With regards to an acceptable risk it might be worth considering the proposed regulation for the reformed Common Fisheries Policy (Art. 2 – general Objectives), according to which "*The Common Fisheries Policy shall ensure that fishing and aquaculture activities provide long-term sustainable environmental, economic and social conditions and contribute to the availability of food supplies*."[15]

Moreover the Communication from the Commission to the European Parliament and the Council (COM(2009) 162 final) Building a sustainable future for aquaculture - A new impetus for the Strategy for the Sustainable Development of European Aquaculture states under 4.1.1. "*An environmentally-friendly aquaculture: The EU is committed to a high level of environmental protection and Community legislation is based on the precautionary principle. The Commission will*

- Continue to emphasise the importance of environmentally sustainable development of aquaculture in its policies and actions;

- Continue to monitor developments in terms of escapees and if necessary, assess the added value of possible action at the EU level."

Deliverable of the risk assessment report

The risk assessment will result in a White Paper which should comprise:

- Description of preliminary objectives and plans
- Description of environmental setting (aquaculture production, number of farms, type of production, density of farms, clusters, breeding programmes, estimated escapees)
- Proposed practice and species (base line set up, common garden set up)
- Review of conceptual model and assessment end-points
- Major data sources and analytical procedures used
- Review of stressor response and exposure profiles
- Description of risk to assessment end-points
- Review and summary of major areas of uncertainty, their direction, and approaches to address them
- Recommendations for management and for further research will provide advice on research needs to cover the most important gaps in knowledge and to improve precision for a full risk assessment of the importance of genetic introgression of European farmed fish into wild populations.

[15] *European Commission (2011) Communication from the Commission to the European Parliament, the Council , the European Economic and Social Committee and the Committee of the Regions: Reform of the Common Fisheries Policy. COM(2011) 417 final.*

ANNEX

Defining the baseline for the AquaTrace target species

Traceability and introgression of

European sea bass

- Sampling map for wild sea bass populations
- In addition 17 large hatchery populations

Gilthead sea bream

- Sampling map for wild sea bass populations
- In addition 18 large hatchery populations

Turbot

- Sampling map for Turbot populations
- In addition 6 large hatchery populations


Development of SNP tools

Identifying genetically based trait differences

Quantitative effects of farmed fish introgression

Relation between endpoint and fitness e.g. for survival, growth, food consumption, displacement, habitat use, behaviour

Work plan chart

Task		2014									2015												2016					
		4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4		
11.1	**Assess available data**																											
	Problem formulation Assessment of end points Conceptual model																											
11.2	**Identify suitable effect indicators**																											
11.3	**Conduct initial isk assessment**																											
	Risk analysis Risk characterisation Risk assessment																											
11.4	**Report and recomendations**																											
	White paper																					D				♦		

D = deliverable 11.1
♦ = milestone 25

Work package description

WT3:
Work package description

Project Number [1]	311920	Project Acronym [2]	AQUATRACE

One form per Work Package

Work package number [53]	WP11	Type of activity [54]	RTD
Work package title	Risk assessment and management recommendations		
Start month	18		
End month	48		
Lead beneficiary number [55]	7		

Objectives

- Provide an initial risk assessment on the potential impact of introgression of farmed fish into wild populations
- Develop recommendations for management and further research

Description of work and role of partners

The risk will assessed based on proxies for genetic impact on wild stocks in a similar manner as in a newly conducted risk assessment of Norwegian fish farming (Taranger et al. 2011). This initial analysis will be based on a state of the art review for each species produced in part in WP3. A further development of this risk analysis approach will be based on results for studies with new molecular tools such as SNP markers to quantify the level of actual introgression into the wild stocks, and studies that link this to possible changes in life history traits with implications for the future fitness of the wild stock. Based on this we will develop management recommendations the will be prepared as a white paper at the end of the project including suggestions for mitigation and associated costs.
Specific tasks:
Task 11.1. Assess available data on the impact of introgression of farmed fish into wild populations, degree of introgression as monitored with new molecular tools, its potential impact on the genetic structure of the wild populations, and ecological consequences with focus on potential changes in life-history traits and fitness based on existing data and new data generated in the project (link to other WPs). Partners involved: P2, P3, P4, P5, P7, P11, P12, P16
Task 11.2. Identify suitable effect indicators for assessment of the degree of introgression (link to other WPs). Partners involved: P2,P7, P11
Task 11.3. Conduct an initial risk assessment of potential changes in genetic structure and life history traits of selected wild populations based on task 11.1 and 11.2. Partners involved: P2, P7
Task 11.4. Provide recommendations to the EU commission for policy development and further research and monitoring activities. Partners involved: P2, P7, P11

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
2	IMR	5.00
3	UniPD	0.50
4	USC	1.00
5	KU Leuven	1.00
7	JRC	2.00
11	AUTH	2.00
12	ISPRA	0.50
16	CETGA	2.00

Person-Months per Participant

Participant number [10]	Participant short name [11]	Person-months per participant
	Total	14.00

List of deliverables

Deliverable Number [61]	Deliverable Title	Lead beneficiary number	Estimated indicative person-months	Nature [62]	Dissemination level [63]	Delivery date [64]
D11.1	White paper with risk assessment and research and management recommendations	7	14.00	R	PU	42
		Total	14.00			

Description of deliverables

D11.1) White paper with risk assessment and research and management recommendations: White paper with risk assessment and research and management recommendations T11.1-T11.4 [month 42]

Schedule of relevant Milestones

Milestone number [59]	Milestone name	Lead beneficiary number	Delivery date from Annex I [60]	Comments
MS25	White paper on risk assessment and mitigation	7	46	

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Abstract
Escapes or releases of domesticated aquaculture fish pose a potential risk of adverse effects on native fish gene pools. The FP7 project AquaTrace applies molecular genetic tools, which will improve the ability for tracing farmed fish in the wild and for documenting their potential effects on wild conspecifics. Based on the scientific insights the project aims to provide a risk assessment and management recommendations concerning the genetic impact of aquaculture fish on wild fish gene pools.
In the frame of the AquaTrace project, this document identifies the key stakeholders, sets out the lines of a risk assessment process and draws a roadmap for the risk assessment to be carried out.

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