AQUAEXCEL

Aquaculture Infrastructures for Excellence in European Fish Research

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Capacities

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Dissemination Level	
PU Public	**X**
PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

Table of contents

Glossary

AQUAEXCEL: Aquaculture Infrastructures for Excellence in European Fish Research

Definitions

e-infrastructure: An electronic infrastructure to facilitate interchange of data and remote operation between research facilities over the internet.

Summary

Objectives

The main objective of AQUAEXCEL WP6 was to develop, implement and evaluate an e-Infrastructure for aquaculture research facilities. The specific objectives of Task 6.4, which resulted in the present deliverable, are to evaluate how the e-Infrastructure will contribute to future aquaculture research, focusing on the experimental design, the logistics of the experimentation, the cost, the potential outcome and the “new” collaboration scheme.

Rationale:

Although an experimental investigation of the impact of the e-Infrastructure would require comparative studies this was not considered feasible within the scope of this workpackage. Instead, a three steps approach was applied. (a) The already performed trials within AQUAEXCEL were re-designed applying both the standard approach and using the (or a potential) e-infrastructure. (b) The partners proceeded with a “virtual” implementation of the experiments following both approaches, concluding with a description of the procedures, logistics and the costs. (c) The last step was the analysis performed considering the potential results and the differences between the two approaches.

For this, a questionnaire on the use of e-infrastructure was designed and the WP6 partners participated in a survey. The collected information was used also for a SWOT analysis. The main results showed that e-infrastructure results in the collection of more and better quality data, facilitate the data access between partners and make easier the sampling procedure reducing the possibility of experimental failure in a more economic manner. On the other hand e-infrastructure increases the cost of the investment and may increase the cost of data analysis while the requirement for skilled personnel is increased. The lack of direct communication between partners, as a result of the reduced travelling to the experimental sites, may require the development of new schemes of collaboration.

Teams involved:

HCMR
SINTEF
NTNU
NOFIMA
WU
IMARES

Geographical areas covered:

AQUAEXCEL implementation area (particularly Greece, Norway, The Netherlands)

1. Introduction

Main aims

AQUAEXCEL WP6 aims to develop, implement and evaluate technical solutions (e-Infrastructure) for providing remote access to highly specialized aquaculture research facilities, and facilitate cooperation within the consortium.

In Task 6.4 the objective is to evaluate how the e-Infrastructure will contribute to future aquaculture research. In particular the evaluation is focusing on

(i) the experimental design,

(ii) the logistics of the experimentation,

(iii) the cost

(iv) the potential outcome and

(v) the “new” collaboration scheme.

For the purpose of the present analysis an “electronic infrastructure” is considered to facilitate interchange of data and remote operation between research facilities over the internet. In particular it is expected to allow the online access to information regarding monitoring of various sensors (e.g. T, DO, pH, etc), videos, alarms, the proper operation of pumps, engines etc. It is also expected to allow control on equipment such as valves, feeders, etc…, and finally the access to data sets.

2. Methodology

The e-Infrastructure is expected to be an enabling technology for cooperation within the consortium. An experimental investigation of the impact of the e-Infrastructure would require comparative studies and detailed analysis of the implementation procedures and the results obtained. This, however, is not considered feasible (due to the required time and money) within the scope of this workpackage. Instead, a three steps approach was proposed and has been applied as described below.

(a) The partners considered the facilities involved in the implementation of WP8. The already performed trials were re-designed applying both the standard approach and using the (or a potential) e-infrastructure.

(b) The partners then proceeded with a “virtual” implementation of the experiments following both approaches. This was concluded with a description, at maximum possible detail, of the procedures, logistics and the costs.

(c) The last step of the evaluation was the analysis that was performed considering also the potential results and the differences between the two approaches.

In order to facilitate the work a questionnaire on the use of e-infrastructure was designed and the partners involved in WP6 participated in a survey.

Furthermore, the possibility of experiments that couldn't be easily realized without the e-infrastructure were also considered. Finally, an analysis based on benefits and costs of the use of the e-infrastructure was also considered.

2.1 Questionnaire

For the development of the questionnaire, a template was used describing the procedures for the implementation of an aquaculture experiment. A three steps approach was adopted and subsequently analyzed: (a) the design of the experiment, (b) the implementation and (c) the analysis of results. In the following the template is presented.

A. Design				
	Definition of objectives			
		Experimental organism		Requirements analysis, decision on species, size and number.
	Decision on infrastructures			
		Replicates		Type of infrastructure (tank, cages) and scale of trial
		Analysis of existing instrumentation		Check available instruments and resources
		Duration		Period to meet the objective
	Sampling			
		Type of data		Environment, biological performance, behavioral
		Frequency		Continues, daily, weekly, etc depending on type of data
	Analysis			
		Analysis of existing data sets		Check available information and existing datasets

B. Implementation				
	Experimental organism			
		Availability		Transfer of organisms in place
		Husbandry (rearing - culture)		Start the trial (following adaptation if required)
	Monitoring			
		Start up phase		Ensure proper performance
		Environment		
			Frequency	Continues, daily collection of data
			Corrections	Actions to correct deviations from the protocol (e.g. adapt T, DO,)
		Animals		
			Behavior	Collection of data (video, direct observation)
			Survival	Estimates (direct or indirect measurements)
				Actions in case of crisis (mortalities, pathologies etc)
	Sampling			
		During the experiment		Samples collection / perform measurements
		Final		Samples collection / perform measurements

C. Analysis				
	Data processing			
		- data collection		
		- data analysis		
	Bibliography review			
	Reporting			

The **design** part includes information on the experimental organism, the type of infrastructure to be used, the replicates required, the duration of the trial, the type of data to be collected, instruments to be used, the sampling frequency and also considerations on the analysis requirements.

The part of the **implementation** includes the availability of the required organisms and the potential requirement for adaptation, the monitoring of the implementation and in particular the starting phase of the trial that usually requires more attention in order to ensure proper subsequent performance, the data collection and also actions of adaptation in case of deviations or in case of critical periods such as when mortalities or pathologies appear. It is also important to ensure that technical equipment is functioning properly, and that the instrumentation is delivering data as expected.

For the **analysis** the data processing and the bibliographical review together with the reporting are considered.

2.2 Assumptions

For the proper completion of the survey the following assumptions were made.

The experiment is organized and performed by researchers not affiliated with the facility, while local personnel assist as necessary following a standard approach similar to a Trans National Access project.

Furthermore, when the experiment is implemented using the standard approach, the responsible scientists is visiting the facility for planning, monitoring and collecting data. When however, the experiment is implemented using e-Infrastructure solutions, then scientists can monitor and collect data remotely and ideally with remote control. For the remote data collection, not specific technical solutions but generic ones are considered.

Also, any instrumentation for local monitoring and electronic storage of data is not necessarily part of the e-Infrastructure. The e-Infrastructure will only make these instruments/data available online for external users. In this sense, the amount of data and the analysis work would be the same in both cases. On the other hand, if a facility only has stand-alone instruments, the implementation of e-Infrastructure solutions will require that these instruments are connected to local networks first. This will increase in principle the initial installation cost of infrastructure, but it will also make data more accessible and reduce the amount of work for subsequent analysis.

Based on the previous work in WP6, generic technical solutions are described as a basis for evaluating the effects of using e-Infrastructure solutions (see for details AQUAEXCEL Deliverable 6.1 and 6.2):

- A generic facility without e-Infrastructure
- A generic facility with e-Infrastructure

a. Generic technical solutions for comparisons

The main difference between the alternatives is the possibility for remote access.

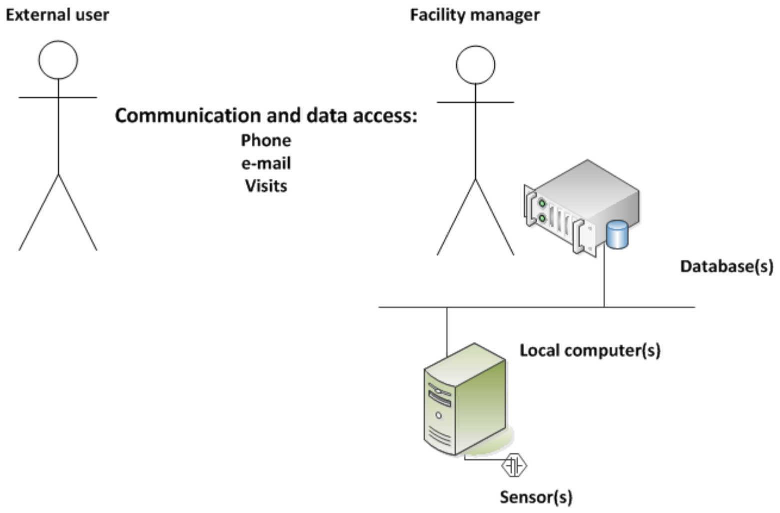

Figure 2.2.1: No e-Infrastructure solution

Figure 2.2.1 shows the alternative without e-Infrastructure, where an external user has no online access to the facility. This means that all planning, monitoring and data acquisition must be done through contact with facility personnel or by visits to the facility. Data from experiments must be assembled by facility personnel and sent by e-mail.

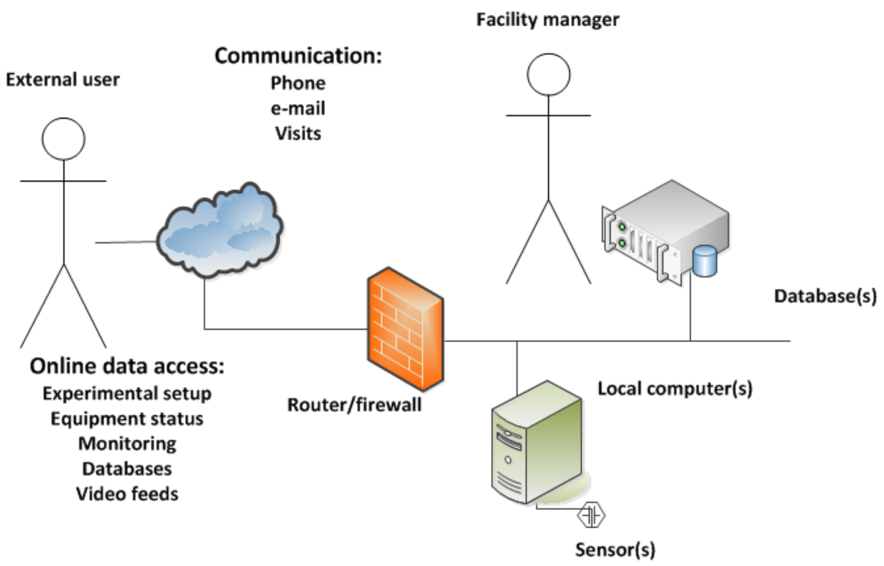

Figure 2.2.2: e-Infrastructure in place

Figure 2.2.2 shows the alternative with e-Infrastructure solutions in place. The external user can log on to the facility network and access local computers and databases. Occasional contact with facility personnel and visits to the facility might still be necessary, but there is no need for assistance in monitoring the experiment and retrieving data from the experiment (both during the experiment and after the experiment is finished). Depending on the type of

equipment and experimental setup, the external user might also be allowed to change experimental parameters (for example fish feeding rates) by remote access.

2.3 Testing “sites”

As “testing sites” the following facilities were considered for a specific trial.

i. NOFIMA, trial: “Determine the performance of Atlantic salmon in three different tank sizes”

ii. SINTEF/ACE, trial: “Growth, survival and feed utilisation of Atlantic salmon in cages”

iii. HCMR, trial: “Performance of sea bass larvae and juveniles in exp. units of varying scale”

iv. HCMR, trial: “Performance of sea bass in cages of three different volumes”

v. IMARES, trial: “Effects of scaling on kinetics in moving bed bioreactors / TNA project”

vi. IMARES, trial: “Performance of *Seriola rivoliana* at different temperatures in pilot scale RAS”

vii. WU, trial: “Impact of dietary cation anion difference and water oxygen level on voluntary feed intake, energy partitioning and stress responsiveness in rainbow trout (*Oncorhynchus mykiss*)”

For the analysis of the results, issues related to network requirements and the accessibility security, the user interface and the level of automation, the data format and the type of data – control (video – documents, access to data – control) were also considered. Also the easy expansion or replication of the required infrastructure to a new facility together with the cost of implementation were part of the analysis.

3 Results

The experiments serving in the analysis were diverse covering different experimental animals (fish species and bacteria), different infrastructures (hatchery, cages, on-growing tanks, biofilter reactors) and duration (from 4 weeks to 1 year). The completed questionnaires per research infrastructure are presented in Annex 1.

3.1 Effects on the design

For the design phase of the experiments the e-infrastructure will have either no or positive effect on the definition of objectives as it will give the opportunity to analyze available data and to share information regarding the experimental protocol using a common data base.

Regarding the decision on the required infrastructures in most of the cases the e-infrastructure will have no effect but there are cases in which the existence of e-infrastructure will allow the proper set up of parameters without requiring site visits. The availability of e-infrastructure is expected to increase flexibility in some cases on the sampling procedures and will substantially increase the amount of available data. It is not expected to have any considerable effect on the analysis of data.

3.2 Effects on the outcome

During the implementation of the experiment, e-infrastructure is expected to have a positive role on the data collection and the transfer of data to the users, reducing possible errors. It is also expected to reduce the requirements for on-site presence of the PI while allowing the improvement of the sampling procedures due to on-site monitoring. Improved data quality can be expected, as faulty instruments and needs for re-calibration can be detected earlier when data are available online. Furthermore in case of need for specialized equipment for data collection during a trial the PI could install the equipment on site and then manage (the PI or technicians) the operation remotely. Finally during the analysis of the results, as already mentioned, e-infrastructure will increase the available data and also the security. The direct collection and sharing of data may also allow a better analysis, even on-line, either on site or remotely reducing thus the required time. Standardized data formats may also decrease the labor cost for data processing and improve the quality of the derived conclusions.

A case of particular interest represent the experiment carried out by NOFIMA, “Determine the performance of Atlantic salmon in three different tank sizes”. In this particular study the performance of salmon in tanks of different size was compared having also as reference a group of fish reared in cages. A major issue of the trial was to maintain the temperature in the tanks at exactly similar levels as in cages. This was achieved by an on-line data sharing tool between the facilities that allowed the immediate adaptation of the actual sea temperature at the cages also in the tanks.

This potential of on line data sharing represents the core of the e-infrastructure concept. Although potential implementation schemes of the trial with the absence of this tool could be considered (e.g. implementation with a time lag), it is obvious that the realization of such studies is very difficult, if not impossible, without an e-infrastructure approach.

3.3 Effects on the cost

Of particular interest is the effect of the e-infrastructure on the cost of the experiments. There is an increase in cost because of the additional infrastructure required. This cost is highly dependent on the complexity of the selected infrastructure to be installed and the mode of data transfer that will apply. As the presence of the e-infrastructure will give the possibility for collecting a considerably higher amount of data there will be changes in the cost for the analysis of these datasets. On the one hand the on-line collection of data will reduce part of the analysis cost, but on the other hand there may be an additional costs either as person power or for additional tools (e.g. software to analyze video captures) that may be needed to purchase or develop.

The presence of the e-infrastructure may also result in cost reduction mostly due to the decrease of required on-site visits during the implementation of an experiment. Also as data collection is expected to be automatic, significantly reduced personnel time may be required,

thus reducing the corresponding labor cost. Unexpected technical and/ or other problems during the implementation can be detected earlier. The implementation of corrective actions will be then possible. In some cases this actions (e.g. shortage in dissolved oxygen in a tank failure of a pump, etc.) are vital for the implementation of any trial thus reducing the need for costly re-implementation of experiments, and in worst cases cancelled experiments.

3.4 Effects on collaboration

In all cases analysed the presence of e-infrastructure was considered to increase the availability of data and protocols between partners through the shared points introduced. Also in all cases a major outcome was a significant reduction of visit/travel to the implementation site. These procedures have a negative effect on the direct face to face communication between the partners, both the PI's and the technicians and between PI's. This reduced communication may have also effects on the level of collaboration as experience accumulated by the technicians may not be communicated most effectively to researchers and vice versa.

3.5 SWOT analysis

For a better understanding of the potential effect of the e-Infrastructure on the design, the outcome and the cost on the implementation of experiments and also the potential of the new scheme of collaboration, the results of a SWOT (Strengths, Weakness, Opportunities and Threats) analysis are presented below. The method applied was to compare the use or not of an e-infrastructure in the implementation of aquaculture experiments.

STRENGTHS

- Large amount of data
- Better quality of data
- Easy access to the data among partners
- Increased flexibility of sampling procedures
- Reduced cost due to the automatic procedures
- Reduced cost for data analysis due to electronic transfer and the possibility to standardize data formats
- Reduced number of visits

WEAKNESS

- Increased cost for infrastructure investments

- Increased need for skilled personnel for managing the e-Infrastructure
- Possible increased costs for data analysis

OPPORTUNITIES

- Access to higher amounts of data
- Increase the accuracy and the quality of the experimental results
- Reduced possibilities of experiment-failure due to alarm systems
- New collaborations among partners
- New types of multi-site experiment

THREATS

- Reduce communication between partners
- Reduced quality of data in “regular” monitoring procedures if roles are not properly defined

4 Conclusions

An analysis was performed using re-interpretation of specific trials for evaluating possible effects of an e-infrastructure on the design, the implementation and the logistics of the experiments. The trials used cover a wide range of parameters, infrastructures and organisms so that conclusions may be considered to have a wider applicability. The major conclusions can be summarized as follows:

- E-infrastructures are expected to have a positive role in the quantity and quality of the collected data. They will increase the flexibility of the experimental procedures and also reduce the possible failures. They provide a safer environment of data storage and data sharing.
- E-infrastructures will increase the experimental cost, at least initially, due to the required equipment. The large amounts of data collected may require additional labor for the analysis and in some case specific tools.
- E-infrastructure will reduce the required travelling and the relevant cost of the investigators to the experimental sites. This lack of direct communication between partners may require the development of new schemes of collaboration.

References

Deliverable 6.1 of AQUAEXCEL

Deliverable 6.2 of AQUAEXCEL

Annex 1

Completed Questionnaires

A. Trial: Performance of sea bass larvae and juveniles in exp. units of varying scale (HCMR)

				(*) Procedures	Logistics	Cost
A. Design						
Definition of objectives						
	Experimental organism	Requirements analysis, decision on species, size and number.	Pilot scale trial of seabass larval rearing in intensive conditions.	None	None	None
Decision on infrastructures						
	Replicates	Scale of trial. Type of infrastructure (tank, cages)	Triplicate tanks of variable volume (40, 500, 2000). Close water system, similar environmental conditions.	None	None	None
	Analysis of existing instrumentation	Check available instruments and resources	Type of tanks, monitoring instruments		Proper implementation	
	Duration	Period to meet the objective	60 days trial + the period required to assess the quality of the fry. Total 120 days.	None	None	None
Sampling						
	Type of data	Environment, biological performance, behavioral	All	None	None	None
	Frequency	Continues, daily, weekly, etc depending on data type	Daily, T, DO, pH, TL, food concentration; Twice per week WW; Specific stages Cortisol; water currents	Continuous T, DO, pH	More data	None
Analysis						
	Analysis of existing data sets	Look available information and existing datasets	Standard biological performance + Modelling (DEB) Previous trials, period of implementation	None	None Parameters properly set	None

(*) considering: e-access to the feeding system and also to a data base with continues environmental monitoring, with additional notes regarding the rearing

					Procedures	Logistics	Cost
B. Implementation							
Experimental organism							
	Availability		Transfer of organisms …	Transfer of eggs	None	None	None
	Husbandry (rearing - culture)		Start the trial …	Start rearing for 60 days; transfer groups at pre-growing tanks	None	None	None
Monitoring							
	Start up phase		Ensure proper performance	As planned (intense monitoring at the beginning – presence of PI)		Not needed on Site presence	
	Environment			As planned			
		Frequency	Continues, daily collection.	Manually	Automatic	Reduced labor	Labor VS investment
		Corrections	Actions to correct deviations from the protocol	Temperature adaptations at 40 lt tanks	Automatic	Accurate implementation	No repetition/ save of money and time
	Animals						
		Behavior	Collection of data …	Direct observation	Automatic video	Better / more data	Labor intensive - high cost SW
		Survival	Estimates ….	Direct measurements of biomass at the end of each step	None	None	None
			Actions in case of crisis	None	None	None	None
Sampling							
	During the experiment		Samples collection / perform measurements	As planned by local technicians	Direct on site monitoring	Improved sampling	No presence of PI
	Final		Samples collection / perform measurements	As planned by local technicians / travel of PI	-"-	-"-	-"-
C. Analysis							
Data processing							
	- data collection		XL sheet; automatic feeding system				
	- data analysis		XL, SigmaPlot, MatLab		None	Availability of all data	None
Bibliography review							
			Standard		None	None	None
Reporting							
			Standard		None	None	None

B. Performance of sea bass in cages of three different volumes (HCMR)

A. Design				(*) Procedures	Logistics	Cost
Definition of objectives						
	Experimental organism	Requirements analysis, decision on species, size and number.	Pilot scale trial of seabass larval rearing in intensive conditions.	None	None	None
Decision on infrastructures						
	Replicates	Scale of trial. Type of infrastructure (tank, cages)	Triplicate tanks of variable volume (40, 500, 2,000). Close water system, similar environmental conditions.	None	None	None
	Analysis of existing instrumentation	Check available instruments and resources	Type of cages, monitoring instruments		Proper implementation	
	Duration	Period to meet the objective	60 days trial + the period required to assess the quality of the fry. Total 120 days.	None	None	None
Sampling						
	Type of data	Environment, biological performance, behavioral	All	None	None	None
	Frequency	Continues, daily, weekly, etc depending on data type	Daily, T, DO, pH, TL, food concentration; Twice per week WW; Specific stages Cortisol; water currents	Continuous T, DO, pH	More data	None
Analysis						
		Analysis of existing data sets	Standard biological performance + Modelling (DEB) Check available information and existing datasets	None	None Parameters properly set	None

(*) considering: e-access to an automatic feeding system and also to a data base with continues environmental monitoring, with additional notes regarding the rearing and an on-line monitoring system of the behavior with cameras

B. Implementation

					Procedures	Logistics	Cost
Experimental organism							
	Availability		Transfer of organisms …	Transfer of eggs	None	None	None
	Husbandry (rearing - culture)		Start the trial …	Start rearing for 60 days; transfer groups at pre-growing tanks	None	None	None
Monitoring							
	Start up phase		Ensure proper performance			Not needed on site presence	
	Environment			As planned			
		Frequency	Continues, daily collection.	Manually	Automatic	Reduced labor	Labor VS investment
		Corrections	Actions to correct deviations from the protocol …	Temperature adaptations at 40 lt tanks	Automatic	Accurate implementation	No repetition/ save of money and time
	Animals						
		Behavior	Collection of data …	Direct observation	Automatic video	Better / more data	Labor intensive - high cost SW
		Survival	Estimates ….	Direct measurements of biomass at the end of each step	None	None	None
			Actions in case of crisis	None	None	None	None
Sampling							
	During the experiment		Samples collection / perform measurements	As planned by local technicians	Direct on site monitoring	Improved sampling	No presence of PI
	Final		Samples collection / perform measurements	As planned by local technicians / travel of PI	-”-	-”-	-”-

C. Analysis

			Procedures	Logistics	Cost
Data processing					
	- data collection	XL sheet; automatic feeding system			
	- data analysis	XL, SigmaPlot, MatLab	None	Availability of all data	None
Bibliography review					
		Standard	None	None	None
Reporting					
		Standard	None	None	None

C. Growth, survival and feed utilisation of Atlantic salmon in cages (SINTEF)

A. Design				(*) Procedures	Logistics	Cost
Definition of objectives						
	Experimental organism	Requirements analysis, decision on smolt delivery coordination	Industry scale trial of salmon rearing	None	Video feeds and sensor data available from site during planning	Reduced number of visits/travel
Decision on infrastructures						
	Replicates	Type of infrastructure (tank, cages) and scale of trial	Triplicate cages of 120 meter circumference, 200 000 fish in each cage from same stock. Comparative experiments in tanks with similar environmental conditions	None	None	None
	Analysis of existing instrumentation	Check available instruments and resources		None	Ensure all parameters are properly set without being onsite	Reduced number of visits/travel
	Duration	Period to meet the objective	6 months trial (until 0,75 kg/ind.)	None	None	None
Sampling						
	Type of data	Environment, feeding, growth, survival	All	None	None	None
	Frequency	Depending on type of data	Near continuous: O2, temp, salinity current speed/direction Daily: Feed, feed type, growth estimates, dead count Monthly: Weight sampling	Increased flexibility, possible to change frequency during the experiment based on online access	Automated transfer of data	Reduced need for discussions with local personnel, and reduced work for local personnel
Analysis						
			standard biological performance	None	None	None
	Analysis of existing data sets	Check available information and existing datasets	Analysis of weight samples to determine end of trial (0.75 kg/ ind.)	Existing datasets available online as support for experimental design	Ensure all parameters are properly set without being onsite	Reduced need for discussions with local personnel

(*)Considering: e-access to automatic feeding system with recording to database, continuous environmental monitoring with storage in database and live video with the possibility for online data analysis

B. Implementation					Procedures	Logistics	Cost
Experimental organism							
	Availability	Transfer of organisms in place		Transfer of smolt	None	None	None
	Husbandry (rearing - culture)	Start the trial (following adaptation if required)		According to regulations and industry standard by local operators	None	None	None
Monitoring							
-	Start up phase		Ensure proper performance			Not needed on-site presence	
	environment			Semi-automatic, local storage			
		Frequency	Daily collection of data		Automated data transfer	Reduced delays in data transfer, reduced labor	Reduced manual labor for data transfer
		Corrections	Actions to adjust parallel tank experiments according to temperature and feeding	Coordination with tank experiments with same smolt stock, temperature and feed type	Automated data transfer	Reduced risk of errors	Reduced manual labor for data transfer
	Animals	Behavior	Collection of data (video, direct observation)	Direct observation	Live video	Remote observation possible	Reduced number of visits/travel
		Survival	estimates (direct or indirect measurements)	Manual count (daily)	None	None	None
			Actions in case of crisis (mortalities, pathologies etc)	None	None	None	None
Sampling							
	During the experiment		Samples collection / perform measurements	As planned by local technicians	None	Direct on site monitoring can improve sampling without presence of PI	Reduced number of visits/travel
	Final		Samples collection / perform measurements	As planned by local technicians / travel of PI	None	Direct on site monitoring can improve sampling without presence of PI	Reduced number of visits/travel

C. Analysis			Procedures	Logistics	Cost
Data processing					
-	data collection data analysis	Database queries XL, MatLab	None	Availability and security, redundancy of data	None
Bibliography review					
-		standard	None	None	None
Reporting					
		standard	None	None	None

D. *Seriola rivoliana* experiment in 5 RAS (IMARES)

A. Design				Procedures	Logistics	Cost
Definition of objectives						
	Experimental organism	Requirements analysis, decision on species, size and number.	Performance of *Seriola rivoliana* at different temperatures in pilot scale RAS	One protocol with all information, as well as databases where all information can be uploaded and shared	Commercial software	Time of IT service to create share point, safety of IT environment because of the ability to share digital information between institutes
Decision on infrastructures						
	Pseudo-replicates	Scale of trial. Type of infrastructure (tank, cages) and scale of trial	5 independent RAS, with three tanks each, testing 5 temperatures	see above	see above	see above
	Analysis of existing instrumentation	Check available instruments and resources	Preparation of the systems (biofilter, stability)	see above	see above	see above
	Duration	Period to meet the objective	4 weeks trial, plus two weeks to prepare the systems, plus two weeks to acclimatize the fish	see above	see above	see above
Sampling						
	Type of data	Growth performance and some physiological parameters of the fish, behavior, system performance	Water quality, BW, SGR, FCR, feed intake, mortality, physiology	see above	see above	see above
	Frequency	Continues, daily, weekly, etc depending on data type of data	daily monitoring for fish performance, final measurement of SGR, FCR, BW, physiology	see above	see above	see above
Analysis						
	Analysis of existing data sets	Look available information and existing datasets	Comparison with previous similar trials with other (related) species	see above	see above	see above

B. Implementation

				Procedures	Logistics	Cost
Experimental organism						
Availability		transfer of fish	Acclimatization of fish to the conditions	Transfer of fish	Automatic registration of water quality during acclimatization	Installation of sensors, maintenance and calibration of sensors and equipment, IT costs, uploading and checking of data
husbandry (rearing - culture)		start the trial	Start growth experiment for four weeks	Start of trial	see above	see above
Monitoring						
Environment	Frequency	Continues, daily collection of data of water quality and feed intake	As planned Manually (feed intake, water quality)	Automatic and according to protocol	Reduced labor, more data	see above
	Corrections	Actions to correct deviations from the protocol (e.g. T, NO2)	Water flows, temperature adjustment	see above	Alarm system	see above
Animals (fish)		Daily measurement of feed intake, monitoring behavior	Manually, as planned	see above	Performance data on SP and visible	see above
Sampling						
During the experiment		Behaviour monitoring, feed intake, water quality	Manually as planned	see above	Data on DB	Uploading data on DB, such as growth performance, this does not go automatically
Final		Samples collection / perform measurements	Manually as planned, blood, growth performance, feed intake	see above	Data on DB	see above

C. Analysis

		Procedures	Logistics	Cost
Data processing				
- data collection		Data on DB and available for the team		
- data analysis		None		None
Bibliography review				
-	standard	None	None	None
Reporting				
	standard	None	None	None

* security of data

E. Rearing of post-smolt Atlantic salmon in different tank volumes (NOFIMA)

A. Design	Standard Approach		Effects of e-Infrastructure: Procedures	Logistics	Cost
Definition of objectives					
Experimental organism	Requirements analysis, decision on species, size and number.	Rearing of post-smolt Atlantic salmon in different tank volumes	None	Improved design/ objectives due to extensive info to tank site, from feed producer and cage site on feed lots, using e-infra	None
Decision on infrastructures					
Replicates	Scale of trial. Type of infrastructure (tank, cages) and scale of trial	Triplicate, to quadruplicate tank replicates in controlled systems, triplicate cage reference	None	None	None
Analysis of existing instrumentation	Check available instruments and resources	Manually analyses and monitoring	None	None	None
Duration	Period to meet the objective	7 months	None	None	None
Sampling					
Type of data	Environment, biological performance, behavioral	All	None	None	None
Frequency	Continues, daily, weekly, etc depending on data type of data	Daily T, O2, pH, Bi-monthly: weight, physiological variables, feed intake, behavoiur, standard biological performance, physiology, video	Much improved, continuous (5 min): T, O2, feeding	Considerably more data	Reduced labour per data set
Analysis					
Analysis of existing data sets	Look available information and existing datasets	Previous trials, period of implementation	None	None	None

B. Implementation

Experimental organism

	Availability		Transfer of organisms in place		Transfer of smolt	None	None	None
	Husbandry (rearing - culture)		Start the trial (following adaptation if required)		Phase I: Transport; phase II: scale history; phase III: scale effects	None	None	None

Monitoring

-	Start up phase		Ensure proper performance		Acclimatization 1 month (phase I)		On-site presence not needed, except in case of sensor malfunction (seldom)	
	Environment	Frequency Corrections	Continues, daily collection actions to correct deviations from the protocol (e.g T adaptation, DO, etc)		As planned, manually T, feeds, feeding as in ref cages	Automatic Automatic	Reduced labor Accurate implementation	Labor VS sensor investment Increased costs if transfer of data over telephone
	Animals	Behavior	Collection of data (video, direct observation)		Video and direct observation	Semi + automatic video	More data that may result in fast identification of problem	Expensive software vs labor costs for analyzing video
		Survival	Estimates (direct or indirect measurements)		Direct measurements of biomass at the end of each trial step; estimation of biomass	Biomass frames in cages	None	Biomass frames may have reduced costs per sampling (manual vs biomass frames)
			Actions in case of crisis (mortalities, pathologies etc)		Alarm from technician on duty	Sophisticated twice-redundant alarm systems	Sophisticated twice-redundant alarm systems	Can save experiment; impact on ethics and costs

Sampling

	During the experiment		Samples collection / perform measurements		As planned by local scientists and technicians	None	Direct on site monitoring, improved sampling without presence of PI	Biomass frames strengthen weight estimates
	Final		Samples collection / perform measurements		As planned by local scientists and technicians / travel of PI	None	Direct on site monitoring, improved sampling without presence of PI	Biomass frames strengthen weight estimates

C. Analysis

Data processing

-	data collection		XL sheet; automatic feeding system			
-	data analysis		XL, ScienceDirect, SAS	More robust data, higher amount of data/increased N	None	Increased labor cost on data processing. Quality much improved

Bibliography review

-			standard	None	None	None

Reporting

			standard	More robust data, higher amount of data/increased N	None	Increased labor cost on data visualization. Quality much improved

F. Upscaling of Biofilter (IMARES)

A. Design		Upscaling of MBBR research	Procedures	Logistics	Cost
Definition of objectives					
Biofilter type	Requirements analysis, decision on biofilter and sizing.	medium & small scale MBBR's	Experimental protocol development	On Commercial software	None
Decision on infrastructures					
Replicates	Scale of trial. Type of infrastructure (tank, cages) and scale of trial	1 Medium size MBBR, 3 small MBBR's	1 common protocol	On Commercial software	None
Analysis of existing instrumentation	Check available instruments and resources		1 common protocol	On Commercial software	
Duration	Period to meet the objective	12 months trial	1 common protocol	On Commercial software	None
Sampling					
Type of data	Environment,	T, pH, N-species	1 common protocol	On Commercial software	None
Frequency	Continues, daily, weekly, etc depending on data type of data	Weekly for monitoring	1 common protocol	On Commercial software	None
Analysis			None		None
Analysis of existing data sets	Look for available information and existing datasets	Not relevant			

B. Implementation						
Experimental organism						
		not relevant		None	None	None
				None	None	None
Monitoring						
- Start up phase		Ensure proper performance			not needed on-site presence	
Environment	Frequency	Continues, daily collection of data	As planned manually	Automatic	Reduced labor, more data	Labor VS investment
	Corrections	Actions to correct deviations from the protocol (e.g temperature adaptation, DO, etc)	tune flows	Alarm for e.g pump or heating	alarm system	Investment
Animals (bacteria)		Performance biofilter	Weekly mass-balance nitrogen species and flows	None	Performance data on shared e-location and visible	Labor intensive or high cost SW
Sampling						
During the experiment		Samples collection / perform measurements	As planned by local technicians	None	None	None
Final		Samples collection / perform measurements	As planned by local technicians / travel of PI	None	None	None

				Procedures	Logistics	Cost
C. Analysis						
Data processing						
-	data collection		XL sheet;	Data on Shared e-location and available for the team		
-	data analysis		XL, SigmaPlot	None		None
Bibliography review						
-			standard	None	None	None
Reporting						
			standard	None	None	None

G. Impact of dietary cation anion difference and water oxygen level on voluntary feed intake, energy partitioning and stress responsiveness in rainbow trout (*Oncorhynchus mykiss*)). (WU)

A. Design				Effect of e-infrastructure: Procedures	Logistics	Cost
Definition of objectives						
	Experimental organism	Requirements analysis, decision on species, size and number.	370 rainbow trout (*Oncorhynchus mykiss*) of 100 g in the experiment. Origin, INRA, France. Isogenic trout lines.	An exp. protocol (EP) approved by the experimental committee of WU and a work-protocol (WP) describing experimental procedures (who is doing what, where, when and how) available on a shared e-location	Commercial software	Time and annual costs to give access to specific software (= access host PC WU-MRU) and time to give access to the software.
Decision on infrastructures						
	Replicates	Scale of trial. Type of infrastructure (tank, cages) and scale of trial	12 metabolic chambers of 200 L each (WU-MRU) connected to one RAS. 2 x 2 factorial design with oxygen (DO) and diet as factors each factor replicated 3 times (DO ~4 and ~8mg/L).	EP & WP	None	None
	Analysis of existing instrumentation	Check available instruments and resources	Calibration of DO, pH and water flow meters. Set T, photoperiod. Check recirculation system performance WU-MRU is connected to.	EP & WP	Check without being onsite. Adjustment	Smartphone
	Duration	Period to meet the objective	9 weeks trial (2 wks adaptation, 6 wks to test the effect diet x DO, 1wk for sampling and final stress test).	EP & WP	None	None
Sampling						
	Type of data	Environmental, biological, performance, behavioral	Feed intake, growth performance, cortisol, chyme, gene expression fore brain, pituitary, interrenal, gill tissue... Daily (influent): pH, T, DO, conductivity. Online: (blocks of 4 chambers): DO, pH, conductivity, T, flow ; Autonalyzer (week 5) 2 x 6 chambers 48hrs , TAN, NO_2-N, NO_3-N, urea, CO_2, PO_4-P	EP & WP	Fast control & adjustment of DO and flow	Smartphone
	Frequency	Continues, daily, weekly, etc depending type of data		EP &WP	Freq. sensor measurements per metabolic chamber adjustable.	None
Analysis						
	Analysis of existing data sets	Look available information and existing datasets	Ref. to previous publications	Ref. of publications & posters WU-MRU on wikidot-site	None	None

				Effect of e-infrastructure:		
B. Implementation				**Procedures**	**Logistics**	**Cost**
Experimental organism						
Availability		Transfer of fish	Transport of fingerlings from France to quarantine exp. facility	None	None	None
Husbandry (rearing culture)		Start the trial	Adaptation to WU-MRU and adjustment WU-MRU to experimental conditions, random assignment of treatments and fish to metabolic chambers	Start of trial, adjustment WU-MRU exp. conditions (Work protocol (WP))	None	None
Monitoring						
Environment	Frequency	Continues, daily collection of data of water quality and feed intake	pH, T, conductivity, flow (per block of 4 chambers), max. feed intake twice/day, auto analyzer wk 5	Automatic, schedule according to WP	Reduced labor	Replacement and maintenance sensors, checking data.
	Corrections	Actions to correct deviations from the protocol	Water flows & DO adjustments FI manually	According to description WP	Direct correction for deviation from preset values WP(DO and flow)	Smartphone, saves time to correct deviations from WP.
Animals (fish)		daily measurement of feed intake (FI), monitoring behaviour	Alarm on pump and T (Camera per chamber available)	Call to network Biotechnicians	Alarm system pump, T.	Can save experiment, important ethical issue
Sampling						
During the experiment		Behavior monitoring, feed intake, water quality	Direct observation per chamber (video) According to time schedule and planning EP	Experimental protocol and work protocol on shared e-location	Shared e-location (EP, WP)	None
Final		Samples collection / perform measurements	According to EP, blood, growth performance, feed intake,……	None	Shared e-location (EP & WP)	None
C. Analysis						
Data processing						
	Data collection		XL-sheet	Diurnal variation metabolite production and DO consumption analysis	Availability of all sensor data	Higher quality collected
	Data analysis		SAS or SPSS			
Bibliography review						
			Standard	None	None	None
Reporting						
			Standard	Existing publ ref. WU-MRU online	None	Higher quality data