Synthesis template for new/upgraded Research Infrastructure (RI) of pan-European relevance to be sent by the ESFRI delegations to the Executive Board for consideration

1. Descriptive title, and information on the ESFRI delegation submitting the proposal (or one of the member of EIROForum)
Advanced Sustainable Sea-based Aquaculture (ASSA): Integrating aquaculture knowledge and technology through the new large-scale Research Infrastructure ACE   *Submitted by the Norwegian Delegation in collaboration with the Norwegian University of Science and Technology, SINTEF Fisheries and Aquaculture and the Norwegian Research Council.*

2. Synthesis description of the new RI (or major upgrade) and S&T fields involved at Pan EU level in its use. Add links to relevant data/web pages (half page max)

By 2030 an additional 37 million tonnes of fish per year will be needed. Fish farming represents the only way to fill this gap (FAO, 19/11/07 Top ministers' debate). The development of a pan-European Aquaculture distributed Research Infrastructure, comprising the establishment of the new AquaCulture Engineering facility (ACE) (www.aceaquaculture.com), is essential to pave the way for cutting-edge marine aquaculture research. The fusion of unique experimental facilities, state-of-the-art expertise and a large-scale infrastructure to combine and apply acquired research results will lead to progress in methodologies, technologies and management practices for aquaculture. Growth, up-scaling and automation of large-scale marine biomass production in a natural environment leads to complex challenges, which can only be met by expertise in a growing number of disciplines. The final objective of the integrated Research Infrastructure is to enable Advanced Sustainable Sea-based Aquaculture (ASSA) through a holistic approach, securing:

- low conflict of interest in marine areas used for aquaculture production
- safe, healthy, affordable, high quality food, which meets the specific dietary needs of consumers
- competitive production and management
- responsible use and production of renewable bio-resources
- eco-efficient production (related to bio-diversity, energy use, eutrophication, effluents)
- ethical production including animal welfare
- fighting and preventing diseases and food related disorders
- fighting risks relating to personnel, farmed organisms and the marine environment
- adding value to coastal communities through attractive jobs and esthetic qualities

Sustainable production which accounts for these issues requires optimization of each individual production step. Therefore, advances are required in many scientific and technological fields, such as ecology, biology, genetics, fish health, material technology, cybernetics, energy, coastal planning and ICT. The scientific progress then needs to be applied to the field of seafood aquaculture.

The proposed new distributed research infrastructure will provide specialised laboratories and small-scale facilities for focused scientific research in combination with dedicated large-scale facilities for testing and validating research results in an engineering and operational context. The facilities will be offered along with services and methods for technical development and innovation, marine operations, aquaculture management, education and training. The fusion of existing partial solutions and expertise into a coordinated comprehensive system through access to flexible infrastructure solutions will reinforce Europe's leading position in knowledge-based aquaculture. The full-scale facility will stimulate direct transfer of scientific results to industrial production processes, enabling Europe to retain its dominant position in the supply of sustainable knowledge and technology.

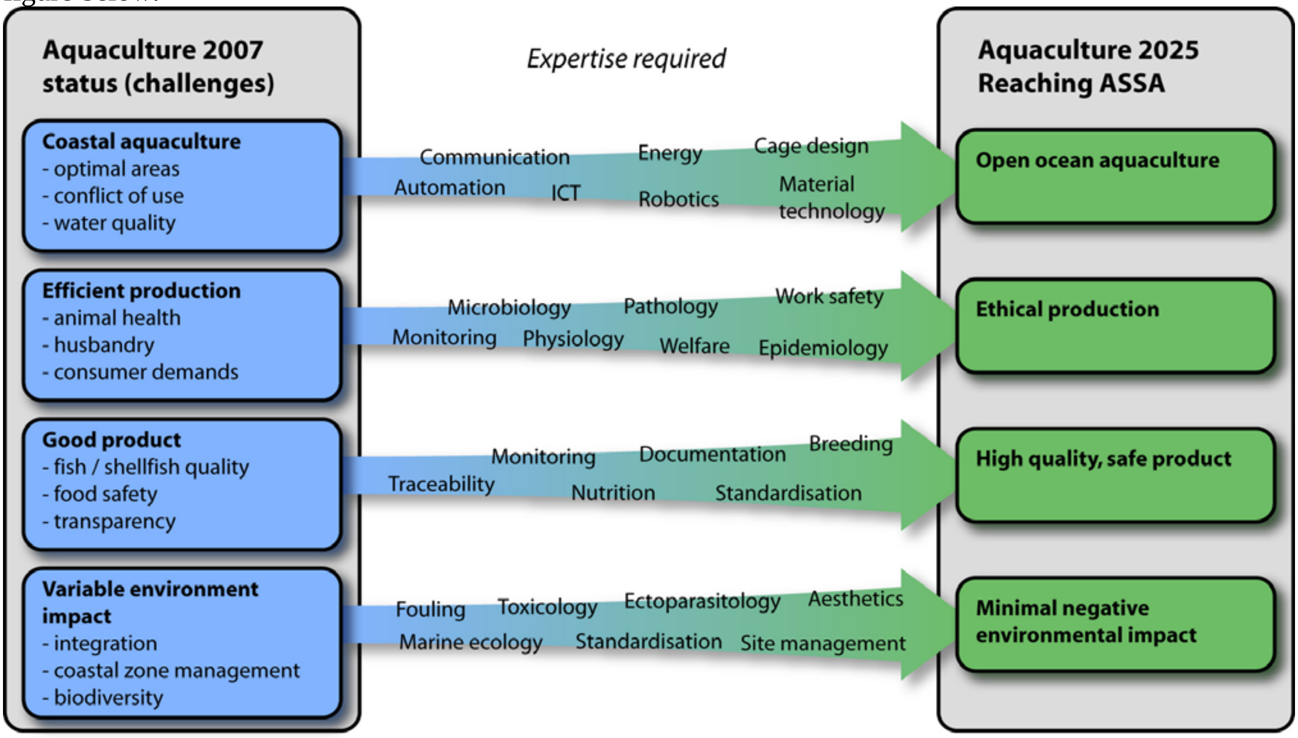
3. Science case: scientific area(s) and potential and/or explicit users, how the new RI will fit into the existing and future landscape of Research and of existing RI's, at EU and World level (one page max, links to relevant documents, references).

For European aquaculture to remain competitive and to develop in a sustainable manner, research efforts must be concerted, requiring cross-cutting interdisciplinary research and commitment (EATP - European Aquaculture Technology Platform, www.eatpnet.eu).

The establishment of a pan-European distributed research infrastructure will open new ways of doing aquaculture research and training by combining access to specialised and large-scale facilities, consolidation of expertise in a multidisciplinary way and international networking. The infrastructure and its research philosophy will provide scientific-based solutions for the main anticipated challenges the sector is facing during the next 20 years – enabling cultivation of the sea.

The interaction of aquaculture with the coastal zone will become increasingly important, involving competition for physical space with other users, waterborne transport, nutrient loading, disease spreading, interactions with wild fish and biodiversity protection (Beveridge et al. 1997; Black 2001; Hill 2005; Karakassis et al. 2005; IUCN 2004; NOAA 2007; Read and Fernandez 2003; Ryan 2004; Subasinghe 2003; Weir and Grant 2005) (www.iucn.org/themes/marine/). Better control of environmental conditions, animal behaviour and an efficient technology transfer will greatly improve the success of production operations at sea (CSN-INTRAN 2004). Consumer needs for top quality, safe, fresh, healthy and responsibly produced seafood at an affordable price is another important challenge for the future (Van Ooijen 2007, CWA 14659 2003). The precautionary principle, the ecosystem approach and rules for good governance all require scientific knowledge as the foundation for sustainable sea-based aquaculture (Simard 2007).

The process towards the realization of an ASSA over a 20 years time scale calls for a holistic approach where expertise in a range of fields meets the main challenges in sea-based aquaculture. This is presented in the figure below.

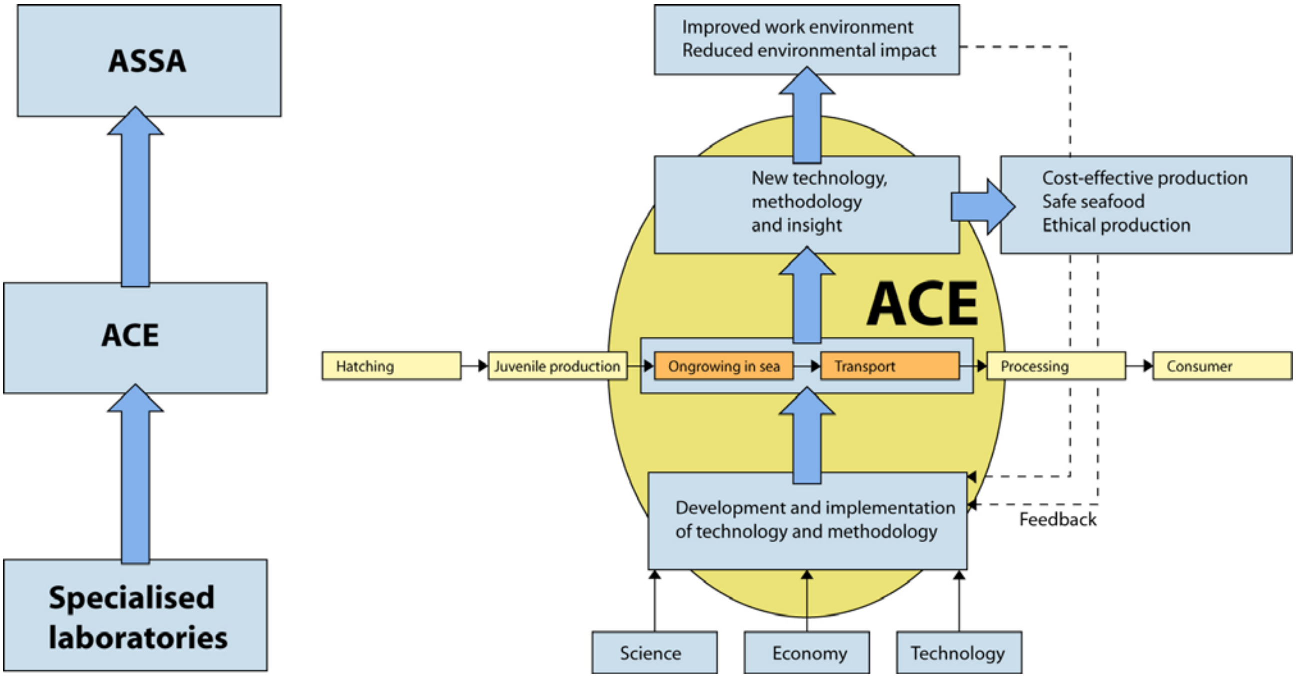


Research institutions and universities in the European Research Area have built up an important knowledge base within the fields of expertise visualized above (www.marinera.net, www.esf.org/research-areas/marine-board/). Important research progress can be obtained through synergies among the network of research institutions and universities and their existing and planned infrastructures. The new Research Infrastructure ACE will merge knowledge and technology from this wide range of disciplines into a single large-scale environment, adding the necessary operation, management and engineering aspects to put results into a realistic context that is relevant for its application, and providing feedback to the individual expert groups for new RTD activities. This cannot be achieved by finding better ways to link parts of existing laboratories together into interesting projects. It needs a new pan-European structure with the following features:

- state of the art facilities of appropriate size, scale and relevance
- equipment and laboratories to meet state of the art challenges
- research outputs coupled with bio-informatic tools and ICT systems
- database integration
- environmental parameters and interaction management / optimisation
- most efficient use of limited resource inputs
- technologies to facilitate desired outputs at all levels
- solutions fulfilling consumer preferences

4. Technical case: summary of results (technical specifications) of conceptual and/or technical design studies (half page, list references/links).

A design study financed by the European Commission's 6th Framework Programme, has prepared the establishment of ACE, a new European AquaCulture Engineering infrastructure (www.designact.org). This large-scale research facility will be the core of the distributed Research Infrastructure assimilating research expertise and knowledge from the different nodes, as shown in the figure below.



The new infrastructure will offer Dedicated Technology Test Sites (DTTS) and Dedicated Operation and Management Sites (DOMS). DTTS are research facilities for the development, testing and optimisation of new tools, materials, equipment, instruments or cage components in sea-based aquaculture. They are species independent and allow users to perform bottom-up research in an objective and reproducible way. DOMS are production test facilities for the development, testing and documentation of aquaculture operation and management aspects. This may relate to interactions between animals, environment, staff and technology, harvesting, marine operations and dealing with issues such as personnel safety, transport and logistics. New knowledge in sea-based aquaculture is linked to the 3 dimensions where the production takes place, i.e on the water surface, in the water column and related to the seabed.

Scientific results within the fields listed above are generated in specialised laboratories for research on fish health and welfare (www.imr.no, www.aqua.stir.ac.uk, www.cefas.co.uk, www.marine.ie, www.vetinst.no, www.veths.no, www.frs-scotland.gov.uk), physiology (www.ualg.pt/ccmar/, www.ifremer.fr/toulon, www.csic.es), nutrition (www.inra.fr, www.csic.es, www.wageningenimares.wur.nl), genetics (www.ocean.org.il, www.akvaforsk.no, www.nofima.no), coastal zone management (www.imr.no), marine ecology (www.nina.no, www.nioz.nl, www.sams.ac.uk), ICT and cybernetics (www.sintef.no), materials (www.sintef.no). These are some of the main facilities that are planned to be an essential part of the distributed Research Infrastructure. Across these scientific fields, special attention will be given to training and technology transfer.

The European AquaCulture Engineering infrastructure has been proposed to be included in the national Norwegian road map, which will be presented towards the end of 2007.

5. e-infrastructure: what does the new RI require as far as e-infrastructure? How is it integrated with the existing EU e-infrastructure (e.g. Geant, grid, digital repositories).

ICT is an essential tool in the establishment and operation of the new infrastructure towards the realisation of an ASSA. ICT is necessary for integrated collaboration between specialists within different fields of science. Electronic communication systems will be used to store and distribute real-time measurements on-line within the distributed Research Infrastructure. A database of production, environmental and performance data will

be accessible for researchers through an internet-based system. This is crucial for analysing results and for making statistical analyses. With the objective to develop an integrated data management system, it will be necessary to reinforce the use of international standards. The new infrastructure will support and encourage the implementation of standards generated through ISO/TC 234 "Fisheries and Aquaculture" (isotc.iso.org).
The infrastructure is aiming to become a demonstrator for the use of ICT in complex sea-based aquaculture management operations and participate in developing best practices.
Concerning the use of e-infrastructure, the EGEE grid (Enabling Grids for E-sciEnce) is providing a production quality Grid infrastructure spanning more than 30 countries with over 150 sites to a myriad of applications from various scientific domains (www.eu-egee.org). The EGEE can be used to build a sustainable Grid for the ASSA distributed Research Infrastructure.
The Norwegian Metacenter for Computational Science (NOTUR, www.notur.no) is a national infrastructure providing computational resources. The available high-performing hardware systems can be used to handle the large amount of data generated at the distributed Research Infrastructure. NOTUR is part of the Norwegian Research Network Uninett (www.uninett.no), which is organised under the Scandinavian network NORDUNET (www.nordu.net), which again is part of the pan-European GEANT2 network (www.geant2.net).

6. Other expected socio-economic impacts: development of new technologies, effects on training, involvement of industries, local impact, other (one page, references).

Fish convert feed into proteins in a much more efficient way compared to land animals (Brown, 2006). With the world population increasing and fish stocks decreasing, aquaculture has a great potential to meet the increasing demand for food (Rana, 2007). The European Aquaculture Strategy highlights the importance of technological innovation for quality, health and welfare (COM (2002) 511 final). One of the main challenges identified in the Commission strategy is the development of new equipment and management tools to reduce environmental pollution. Other priorities put forward by the Profet policy platform were the development of innovative methods and production systems to support aquaculture diversification and the improvement of technologies for offshore cages (www.profetpolicy.info). Innovations resulting in reaching economies of scale, promoting new productions and creating new opportunities for employment are encouraged by the European Commission (Christofilogiannis P. 2005. FEAP – Aquainnovation). Long term marine and maritime strategic documents also recommend development of innovative production systems in marine aquaculture to reduce environmental impacts, reduce space conflicts, improve economies of scale, promote new productions and create new opportunities for employment (Green paper 2006, Eurocean 2007, EEA Report 2006, Blue paper 2007).
The policy priorities set out by the Financial Instrument for Fisheries Guidance (FIFG) of the European Union include decreasing environmental impacts, the development of offshore farms, and stimulating internal technological development leading to increased competitiveness (Council Regulation 1999). As the competition for seafood production is at a world level, Europe should be cooperating in this worldwide challenge. The European marine and maritime science, research, technology and innovation strategy aims to increase Europe's share of the global maritime market economy through the development of innovative technologies for sustainable seafood production (Aberdeen declaration).
The rising demand for fish protein and falling fish stocks are creating a growing gap, which sea-based aquaculture can fill (FAO 2005a, FAO 2005b). Establishment of aquaculture activities in fishing related communities, with their catching, processing and marketing infrastructures, can contribute to sustaining employment as available fish stocks and total allowable catches are continuously reduced.
The experienced transition of a young industry into a very industrialized sector is therefore likely to continue, in both Europe and the rest of the world, with an increasing share of activity taking place at sea. This creates great opportunities for enhancing Europe's competitiveness and for the creation of a large number of jobs in remote areas, which are two of the main goals of the Lisbon Strategy. The anticipated long-term growth in sea-based aquaculture calls for more focused, basic research on fundamental issues. Continuous up-scaling of production units leads to operational challenges related to handling, monitoring and engineering, while dense concentrations of fish may challenge the marine environment, fish health, welfare and ethics. If aquaculture production is to continue to increase without adaptation, water quality may also be affected at a larger scale. However, research progress on production management, integrated aquaculture systems and advanced monitoring and control tools could reduce nutrient discharges. This may be an important contribution to the Water Framework Directive of the European Commission, which sets ambitious objectives to manage pollution sources in a sustainable way. In addition, climate changes are expected to have a significant impact

on the marine environment, requiring more robust containment systems and mooring technology. Conflicts in use of coastal areas may force aquaculture activities into more exposed areas. The USA has made it a priority to pursue the development of large offshore aquaculture operations (NOAA, 2007). Changes in ocean currents, temperature and nutrient availability may increase the risk of occurrence of both existing and emerging diseases. New areas for research are opened, and a new and integrating infrastructure can contribute to face challenges in a proactive and multidisciplinary way. Promotion of self-sustained units using e.g. wave, wind or tidal energy can create aquaculture production centres that are independent of external power supply.

7. Commitments / maturity: which States / Organizations have demonstrated interest / commitment in supporting and/or funding the proposal?

The EATP draft vision is supported, stating that a high level of technology innovation, and research and knowledge development should be sustained in order to develop knowledge intensive products (EATP Interim working group, 2007). The Aquainnovation inquiry carried out by the Federation of Aquaculture Producers (FEAP) revealed that technical issues are of major interest (www.aquainnovation.net). The areas of highest priority for innovation were production bottlenecks, integrated aquaculture systems and cage technology. In Norway, aquaculture is one of the main economic sectors, supported by well-established groups from research institutions, authorities and feed, technology and service providers (St. meld. nr. 19, 2005; STEP 2005). A foresight study produced by the Norwegian Research Council identified the major technology research challenges in the future as being automation and process control, instrumentation, robotics, advanced IT applications, cage technology and constructions, anchoring systems, dynamic positioning, feeding systems, cages reducing the risk for escapes, use of materials and nanotechnology, alternatives to the use of chemicals (anti-fouling), water treatment and recirculation (Norwegian Research Council, 2005). In many cases, marine aquaculture may be promoted by implementing technological solutions used in other maritime sectors, and by applying technological knowledge from other fields such as information, communication and material technology.

EATP has expressed its interest in establishing a pan-European sea-based aquaculture research infrastructure. There is a growing focus on a European scale towards interdisciplinary collaboration for open-ocean aquaculture. This has been illustrated by the establishment of Offshore Aquaculture Technology Platform (OATP) and International Council for Offshore Aquaculture Development (ICOAD), both supporting the foundation of a cross-cutting research infrastructure necessary to generate solutions for mariculture of the next generation.

At present, actions concerning an expression of interest are in progress with the European Aquaculture Society (www.easonline.org) and the Federation of European Aquaculture Producers (www.feap.info). Support letters will be continuously added to the proposal through updates on the ASSA web page (www.sintef.no/ASSA/).

A study (www.designACT.org) among European aquaculture stakeholders showed that more than 90 % of the respondents were interested in using the proposed large-scale facilities. The study also published an inventory of experimental facilities for sea-based aquaculture research in Europe. This demonstrates the presence of a wide range of specialised laboratories, providing a sound basis for cross-cutting research using the new Research Infrastructure. It also reveals the lack of a large-scale facility for operational research, showing the uniqueness of the proposed infrastructure. Evaluations by the European Commission (DesignACT proposal, DesignACT mid-term review report) support the initiative to establish the infrastructure. Members of the DesignACT International Advisory Group (Marine Institute, Culmarex, Cetmar, DHI, Aquark, University of New Hampshire) have secured the Euorpean dimension of the initiative throughout the project.

A company, with aims to become pan-European, has been constituted (www.aceaquaculture.com) in order to prepare the structure and operation of the proposed infrastructure. Industrial stakeholders (producers and providers) have already shown interest in the operation of ACE.

8. Costs for construction, operation and decommissioning, indications on project financing (half page, with references/links). Give budget info in M€

Costs are shown in the table below. Operations will be funded through research and development projects financed by the EC, national research programmes and the aquaculture industry. Costs for the farming (fish, feeding etc.) in the DOMS will be high since this is large-scale production, but these costs are planned to be in balance with the sale of fish products and are therefore not included in the budget.

Preparatory cost	***M€***	***Funders***
Design ACT - inquiry, planning, surveys	0.5	EC 6th FP
Site surveys, licences, financing, services, staff	1.2	Local/regional public funding
Infrastructure network	0,6	EC
Total	**2.3**	
Total construction costs		
ACE - Land facilities (offices, workshops), pier	4.9	EIB, SIVA (Norway), EC
ACE - DTTS (Dedicated technology test sites)	3.2	Public funding, EC
ACE - DOMS (Dedicated operation / management sites)	7.6	Industry, public funding, private bank, EC
ICT and tools for operation and integration of the distributed research infrastructure	3.0	Industry, public funding, research infrastructures
Total	**18.7**	
Operation costs/year		International/national projects
Management, scientific & technical staff	1.5	
Travel, consumables	1.0	
Financial costs	2.0	
Network and e-infrastructure	0.5	
Maintenance	0.5	
Total	**5.5**	
Decommissioning cost		
Disposal of fish production	0	Sale of biomass
Disposal of sea farms	0	Sale of floating constructions
Disposal of land station and other facilities	0.7	
Total	**0.7**	

Total preparatory cost	Total construction cost	Operation cost /year	Decommissioning cost
(of which already spent or committed) **2.3 M€**	(specify contributions committed or indicated by possible funders) **18.7 M€**	(specify contributions by possible funders) **5.5 M€**	(possible funders) **0.7 M€**

9. Timetable for construction, operation and decommissioning (half page, with references/links)with duration and possible starting dates.

The total time schedule should at least be 20 years based on the time needed to establish the European network, to prepare and construct the new large-scale infrastructure and to link it with its distributed laboratories.

The preparatory phase started in 2005 through the EU-project Design ACT (www.designACT.org). The project includes the following activities: an inquiry of European needs, content specification, environmental survey, management and operation plan, financial plan and construction plan. The work will be finalized in March 2008. In May 2006, a company was founded with the aim to prepare the post-project period (www.aceaquaculture.com) prior to establishment. The AquaCulture Engineering company ACE will be the research hub for reaching a European ASSA, through planning, financing, constructing and operating the large scale engineering facilities and linking this with the European distributed network of specialised aquaculture laboratories.

The construction phase is foreseen to start in 2008/2009 and is divided into 2 steps:

Step 1 (2008 – 2011): Construction of the pan-European AquaCulture Engineering large-scale research infrastructure, including dedicated technology test sites at different degrees of exposure, dedicated operation and management sites for marine fish, salmon and shellfish, as well as land offices and workshops

Step 2 (2011 – 2013): The formation of a distributed pan-European research infrastructure for Advanced Sustainable Sea-based Aquaculture, consisting of the ACE engineering facility and a dedicated number of

specialised laboratories with specific research expertise.
Operations are planned to start soon after the first construction step and will increase as the European distributed infrastructure grows.
Decommissioning will involve reducing the production of fish, sales of fish and shellfish and sale of the structures. The infrastructure planned is based on ethical principles, with the objective to establish facilities that have a minimal environmental footprint. Fish, shellfish as well as tools and equipment present at the infrastructure can be sold on the market, whereas the facilities at sea are floating constructions that can easily be removed.

Preparatory phase 2005 - 2008	Construction phase 2008 - 2013	Operation 2008 -	Decommissioning n.a.

10. Reference: Person who has submitted the proposal, and will follow up in ESFRI

ASSA web page: www.sintef.no/ASSA/

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