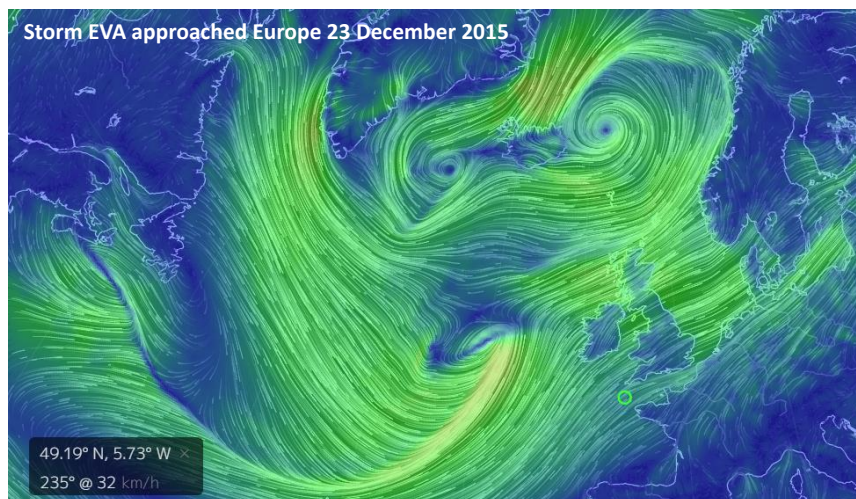# START PAGE

MARIE SKŁODOWSKA-CURIE ACTIONS

Innovative Training Networks (ITN)
Call: H2020-MSCA-ITN-2016

PART B

MANTEL

Management of Climatic Extreme Events in Lakes & Reservoirs
for the Protection of Ecosystem Services

Storm EVA approached Europe 23 December 2015

49.19° N, 5.73° W
235° @ 32 km/h

This proposal is to be evaluated as:

EJD

LIST OF PARTICIPANTS

Consortium Member		Legal Entity Short Name	Academic (tick)	Non-academic (tick)	Awards Doctoral Degrees (tick)	Country	Dept./ Division / Laboratory	Scientist-in-Charge	Role of Partner Organisation
Beneficiaries									
Dundalk Institute of Technology	1	DkIT	√			IE	Centre for Freshwater & Environmental Studies	Dr Eleanor Jennings	
Catalan Institute for Water Research	2	ICRA	√			ES	Resources and Ecosystems Area	Dr Rafa Marce	
Estonian University of Life Sciences	3	EMÜ	√		√	EE	The Institute of Agricultural and Environmental Sciences	Dr Alo Laas/Prof Peeter Nõges	
Leibnitz Institute of Freshwater Ecology and Inland Fisheries	4	IGB	√			DE	Experimental Limnology/ Ecosystem Research	Prof. Hans Peter Grossart/ Prof. Rita Adrian	
Netherlands Institute of Ecology	5	NIOO	√			NL	Department of Aquatic Ecology	Dr Lisette de Senerpont Domis	
University of Barcelona	6	UB	√		√	ES	Department of Ecology	Dr Biel Obrador	
University of Geneva	7	UG	√		√	CH	Institute F.A. Forel	Prof. Bastian Ibelings	
Uppsala University	8	UU	√		√	SE	Erken Laboratory	Dr Don Pierson	
Partner Organisations									
Centre for Ecology and Hydrology		CEH	√			UK	Lancaster Centre	Dr Ian Jones	Hosting and modelling training
Marine Institute		MI	√			IE	Fisheries Ecosystems Advisory Services	Dr Elvira de Eyto	Hosting and data provision
NIVA		NI	√			NO	Ecohydrology research group	Dr Raoul Couture	Hosting & training in modelling
Aigües Ter-Llobregat		ATLL		√		ES	NA	Juan Carlos Garcia	Industry Host for ESR during secondment
Catalan Water Authority		ACA		√			NA	Dr Antoni Munné	Industry participant in Training activities
Waterboard BrabantseDelta		WBD		√		NL	NA	Jaap Oosthoek	Industry Host for ESR and training
Witteveen + Bos		WB		√		NL	Environmental Economy	Dr Elisabeth Ruijgrok	Industry Host for ESR and

						(team) in the cluster Ecology		training
Barcelona Supercomputing Centre	BSC	√			ES	Earth Science Services	Dr Albert Soret	Training and data for ESR
ETH Zurich	ETH	√				Centre for adapting to Changing Environments	Dr Vasilis Dakos	Training for ESR 7 and 12
Dublin City University	DCU	√		√	IE	Graduate Studies Office (Dean)	Prof. Lisa Looney	Awarding doctoral degree for DkIT
Potsdam University	PO	√		√	DE	International Research Cooperation (LEAR)	Teresa Rodríguez Acebes	Awarding doctoral degree for IGB
Free University Berlin	FU	√		√	DE	Dean Graduate Studies	Prof. Dr Roland Bodmeier	Awarding doctoral degree for IGB
Wageningen University	WU	√		√	NL	Managing Director School of Env. Sciences	Dr J.A. de Vos/ Dr Miquel Lürling	Awarding degree NIOO /ESR training, hosting
University of Girona	UdG	√		√	ES	School of Doctoral Studies	Dr Elizabeth Pinart/Dr Helena Gausch	Awarding doctoral degree for ICRA

Data for non-academic beneficiaries:

Name	Location of research premises (city / country)	Type of R&D activities	No. of full-time employees	No. of employees in R&D	Web site	Annual turnover (in Euro)	Enterprise status (Yes/No)	SME status (Yes/No)
Not applicable.								

Declarations:

Name (institution / individual)	Nature of inter-relationship
UdG and ACA are in the ICRA Board of Trustees (ICRA is a non-profit foundation). We confirm that there are no other inter-relationships (e.g. family ties, shared premises or facilities, joint ownership, financial interest, overlapping staff or directors, etc.) between any of the organisations included in the consortium.	

1. Excellence

1.1 Quality, innovative aspects and credibility of the research programme (including inter/multidisciplinary, intersectoral and, where appropriate, gender aspects)

Introduction, objectives and overview of the research programme.

Climatic extremes, in particular storms and heat waves, are now becoming more frequent, a trend that has been linked to directional climate change and is projected to continue[1]. The overarching aim of the MANTEL (Management of Climatic Extreme Events in Lakes & Reservoirs for the Protection of Ecosystem Services) European Joint Doctoral (EJD) Training Network is to train a cohort of Early Stage Researchers (ESRs) to investigate the effects of the most extreme events, and more subtle lower magnitude episodic events, on lake and reservoir water quality. Understanding the impact of these events is important because of the negative effects they can have on the ecosystem services that lakes provide, in particular provision of safe water for drinking and irrigation, recreational use, and economic benefits such as fisheries and tourism. Storms with high rainfall, for example, are typically associated with in-flow of large loads of dissolved organic matter (DOM), while toxic cyanobacterial blooms can form during heat waves. Both high levels of DOM, and the occurrence of cyanobacterial blooms, can lead to substantial costs for water managers and mitigation of their effects will be a pressing need into the future. For example, an extreme event in the US in 2011 (Hurricane Irene) not only had huge effects on water column mixing in a New York drinking water reservoir[2], but was also responsible for 43% of the total annual DOM loading. High DOM levels in water result in formation of disinfection by-products (DBPs) such as trihalomethanes (THMs) when water supplies are chlorinated, compounds associated with diseases of the liver, central nervous system, and an increased risk of cancers[3]. Heatwaves, through indirect and direct temperature effects, and pulses in nutrient loading during storms, boost the development of cyanobacterial blooms [4] which can produce toxins that affect use for human consumption and for recreation. Other ecosystem services affected include general habitat quality. In Lough Feeagh (IE), managed by partner MI, a once in 250-year rainfall event lasting two hours resulted in an unprecedented influx of sediment into the lake in 2009 affecting plankton populations for up to eight months[5]. The increase in such extremes is now projected to continue as a result of global warming. The research and transferable skills that the MANTEL ESRs gain will equip them to help society adapt to climate change, not only as researchers, but also as water resources managers, industry innovators, water resource consultants, and policy makers.

Exploring the occurrence and the effects of these events requires monitoring that captures the event itself (which may occur over hours) as well as the ensuing impact (which can be months or years). As a product of EU funding initiatives over recent decades (e.g. FP4 REFLECT and FP6 CLIME projects) there is now a well-established community of multidisciplinary scientific researchers and water resource managers using the automated lake high frequency monitoring (HFM) systems needed to track these events. They have been meeting biannually through the Networking Lake Observatories in Europe (NETLAKE) COST Action (2012-2016: www.netlake.org), providing opportunities for fruitful collaborations and for ESRs to take leadership roles and establish networks. The MANTEL EJD provides the next obvious step to build on this with HFM infrastructure supporting next generation science to protect our lakes, reservoirs and ecosystems services. The lake HFM systems use instrumented platforms that simultaneously monitor a suite of parameters using state-of-the-art sensors at time steps of, for example, every two to five minutes, and relay data to researchers and managers using wireless technology. A typical station will have a chain of temperature sensors for information on thermal properties of a lake, along its full depth, and sensors at the surface to measure dissolved oxygen, pH, turbidity and chlorophyll fluorescence (for information on cyanobacterial blooms) (Fig. 1a). Lake HFM systems typically also have a weather station, either on the buoy itself or on the lakeshore. HFM is in contrast to conventional sampling which takes place typically at weekly/monthly intervals. Some HFM systems now also have sensors on a profiling winch, so that all parameters can be measured at high frequency along the full depth of the lake. Such investment is costly in time and money, a fact that is reflected in the high number of research institutes involved in the sector, and in this consortium.

It may seem paradoxical to suggest that HFM is needed to monitor events that are so large that they could hardly be missed. However, while their occurrence can be obvious, the relationships between events and their consequences have not yet been well documented [6] [7], principally due to difficulties in targeting monitoring on the

---

[1] IPCC 2014. Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Cambridge University Press.
[2] Klug, J, Pierson D, et al. 2012. Env Sc & Tech 46, 11693-11701.
[3] WHO 2011. Guidelines for Drinking Water Quality, 4th edition. WHO, Geneva.
[4] Wagner & Adrian 2009. Limnol. Oceanogr., 54, 2460–2468
[5] De Eyto, Jennings et al. In press. Inland Waters.
[6] Jennings, E. et al. 2012. Freshwater Biology 57, 589-601.

events themselves. Now, with long-term HFM data becomes more available, the true importance of episodic climatic events is becoming clear. In addition, it can often be the sum of multiple smaller events that will result in a biological or chemical response. Each of these smaller events could reduce the inherent 'resilience' of the lake system to cope with change[8]. As HFM provides new insights into changes in lakes during episodic events, tomorrow's researchers and managers also require new metrics to describe them, new modelling approaches to simulate them and new theoretical frameworks, before they can design management approaches. A very small number of sites were at the forefront of research into HFM in lakes in Europe and now have extensive data archives. A survey in NETLAKE identified only 7 sites in Europe with archives > 10 years. Five of these (Lough Feeagh (IE), Windermere, Bassenthwaite Lake (UK), Lake Erken (SE), and Muggelsee (DE)) are included in MANTEL. High frequency data are also available from another 7 sites from the consortium: Lakes Võrtsjärv, Saadjärv and Verevi (EE), Lake Geneva (CH), Sau Reservoir (ES), Lake Stechlin (DE), Lough Furnace(IE), and Mark-Vliet-Dintel catchment, and Volkerak-Binnenschelde catchment (NL). A truly unique aspect is the availability of LakeLab to the consortium - 24 individual lake mesocosms in Lake Stechlin (Fig.1b & c) which recently received a "Germany – Land of Ideas" award in a nationwide competition. In addition, large indoor mesocosms (Limnotrons, 1000L) at NIOO, offer a unique level of temperature and gas control, allowing for near-realistic simulation of mixing events.
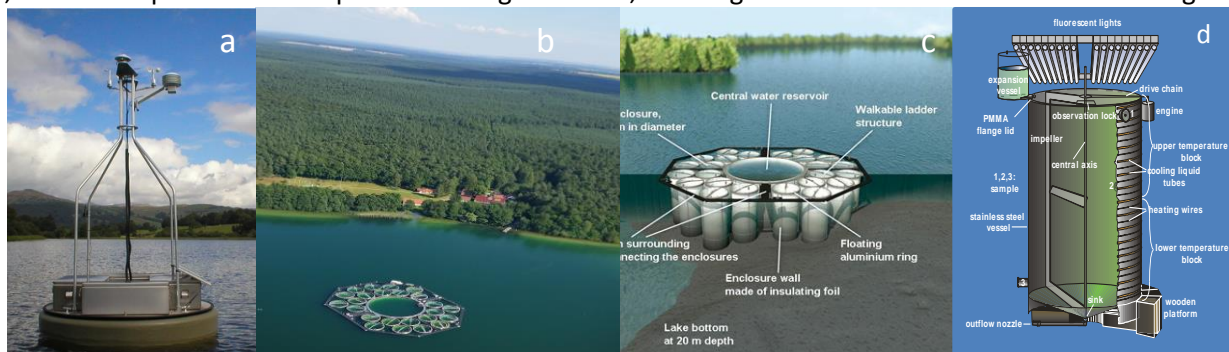

Fig. 1: a. typical lake monitoring buoy (Blelham Tarn, UK); b. LakeLab facility with 24 mesocosms in Lake Stechlin, DE; c. diagram of LakeLab mesocosms; d. Limnotrons in NIOO.

This network brings together eight beneficiary organisations including four universities and four research institutes (Fig.2), together with nine partner organisations, to train twelve Early Stage Researchers (ESRs). Supporting partners include three research institutes that manage long-term HFM sites (MI (IE) and CEH (UK)); and one institute that will also contribute modelling training (NIVA, NO), two companies (ATLL (ES) and W+B (NL)), one Dutch water board (BD) and a Spanish water authority (ACA). BSC (ES) host Mare Nostrum, the biggest supercomputer in Spain and will contribute to future climate modelling. The awarding universities for the four beneficiary research institutes (DCU for DkIT (IE), FU and PU for IGB (DE), UG for ICRA (ES) and WU for NIOO (NL)) are also included in the consortium as partners.
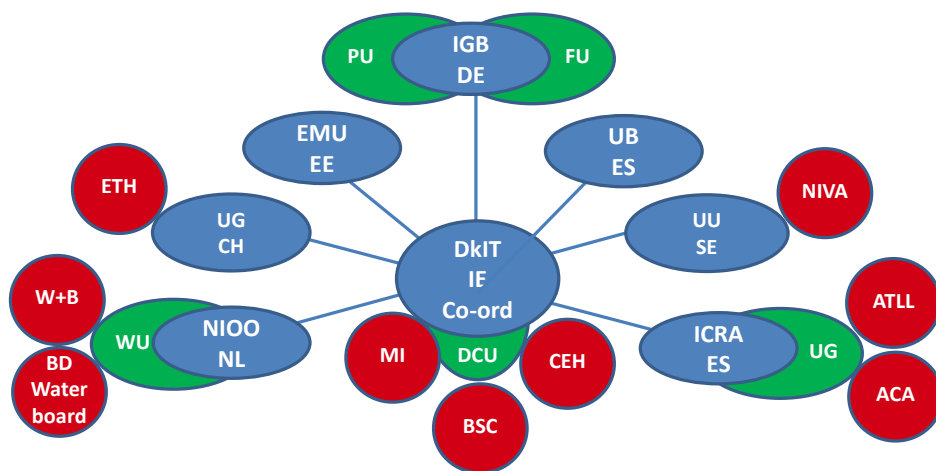
8 beneficiaries (blue) 5 degree awarding partners (green) 9 partners (red)

Fig. 2: the MANTEL consortium of beneficiaries and countries

[7] Meinson, P. Nõges P. Nõges T. & Laas A. 2015. Env. Rev. 24, 1-11.
[8] Wang R, Dearing JA, Langdon P, Zhang E, Yang X, Dakos V, Scheffer M 2012. Nature, 492, 419-422. doi:10.1038/nature11655

We will provide training in state-of-the art technology, data analysis and modelling, and sustainable provision of ecosystem services by water management or benefit-oriented protection of ecosystems services. The aim is to ensure that this cohort of next generation scientists gains expertise in the effects of and management of episodic and extreme events in lakes, so that future management strategies can be explicitly account for their occurrence. The decision to award **Joint/Double Doctoral Degrees** is based on the multi-disciplinary and inter-sectoral expertise of the consortium and also provides ESRs with:

- International (bilateral/multilateral) collaboration, exchange, promoting international networking
- Access to other expertise, analytical equipment and research infrastructure by being member of a network with the combined curricular strength of the partners.
- Stimulation to collaborate, disseminate and valorise research.
- Provide other locally-funded PhD students access to MANTEL training and dissemination activities.
- Synergy between doctoral training and international cooperative research teams
- International experience, enhanced by the exceptionally strong international networks of the supervisory teams within NETLAKE and with the Global Lake Ecological Observatory Network (GLEON).

The specific **research objectives** of MANTEL are:

- To interrogate HFM data archives for the occurrence and intensity of climate-driven episodic events and understand which conditions produce physical, chemical and biological responses in lakes [WP 2]
- To inform adaptation to climate change by simulating the effects of episodic events in lakes [WP 3]
- To assess to what extent climate-driven events affect the biological functioning of lake ecosystems, and to quantify if ecosystems approach critical transitions (tipping points) [WP 4]
- To quantify the management implications of episodic events and explore mitigation for two key challenges for the water sector: increases in DOM loading, and toxic algal blooms [WP 5]

Research methodology and approach

The MANTEL **research programme** is divided into **four scientific work packages** (WP 2-WP 5), supported by WPs on Management (WP 1), Training (WP 6), Dissemination (WP 7) and Communication and Outreach (WP 8) (Table 1.1). **Twelve projects** are either nested within WPs or cut across more than one. Each can be independently completed, thus safe-guarding ESR progress (Fig. 3). The details of each can be found in Tables 3.1d.

Table 1.1:   Work Package (WP) List

WP No	WP Title	Lead Ben. No.	Start Month	End Month	Activity Type	Short Name	ESR
1	Management	1	1	48	Management	DkIT	NA
2	Analysis of past and current HFM data for in-lake effects of episodic events	3	7	42	Research	EMÜ	1,2,3,4
3	Anticipating the impact of extreme events in current and future conditions	2	7	42	Research	ICRA	3,5,6,8,9
4	Lake ecosystem resilience	7	7	42	Research	UG	7,8,9,12
5	Informing stakeholders to ensure ecosystem services protection in face of extreme events	5	7	42	Research	NIOO	9,10,11,12
6	Training and doctoral student support	6	7	42	Training	UB	All
7	Dissemination	4	1	48	Dissemination	IGB	All
8	Communication & outreach	8	1	48	Communication	DkIT	All

WP 2 (Analysis of past and current HFM data for in-lake effects of episodic events) includes analysis of past and current HFM data to identify the frequency, duration, and intensity of episodic events. It draws on the unique set of instrumented lake monitoring stations and data archives available to the MANTEL ESRs. We will also use LakeLab (Fig. 1) to produce artificial episodic or extreme events and to better understand how episodic events affect lakes. In **WP 3 (Anticipating the impact of extreme events in current and future conditions),** potential future changes in the occurrence, duration, intensity and impact of episodic and extreme events will be undertaken using both an experimental approach and dynamic modelling. These experiments and model simulations will be informed by both past trends in observed data from the MANTEL HFM sites, future projected changes (e.g. CORDEX: coordinated regional downscaling experiment: www.euro-cordex.net/) and seasonal forecasting (partner BSC). **WP 4 (Lake Ecosystem Resilience)** will seek insight into how these events affect the

way lakes function, and assess if and how they reduce ecosystem resilience. Loss of resilience can bring the lake closer to a 'tipping point', where a critical transition may occur. Once this is past, the biological community may change with, for example, nuisance algae becoming more common. Ultimately, WP 4 aims to develop new metrics for resilience, which will also be useful for water managers. **WP 5 (Informing stakeholders to ensure ecosystem services protection in the face of extreme events)** will focus on management implications of two key challenges: large and more frequent pulses of DOM into lakes, and higher incidence of cyanobacteria blooms associated both with heatwaves, and with nutrient pulses following storms. In this WP, ecologists, decision makers and socio-economists will also work on a unique socio-economic output - 'the Benefit Game' (Fig. 4).
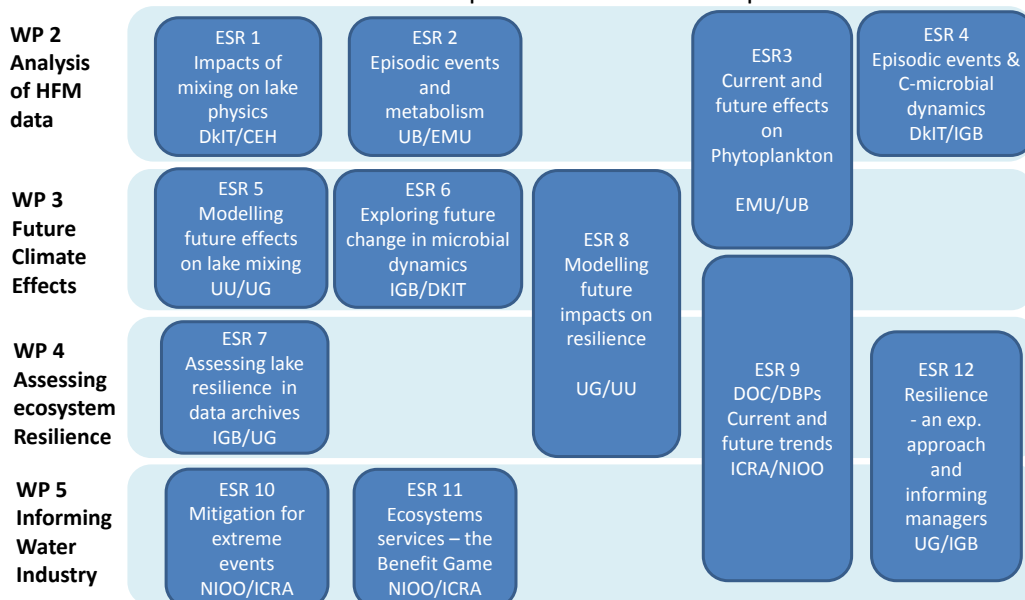
WP 2 Analysis of HFM data	ESR 1 Impacts of mixing on lake physics DkIT/CEH	ESR 2 Episodic events and metabolism UB/EMU		ESR3 Current and future effects on Phytoplankton EMU/UB	ESR 4 Episodic events & C-microbial dynamics DkIT/IGB
WP 3 Future Climate Effects	ESR 5 Modelling future effects on lake mixing UU/UG	ESR 6 Exploring future change in microbial dynamics IGB/DKIT	ESR 8 Modelling future impacts on resilience UG/UU		
WP 4 Assessing ecosystem Resilience	ESR 7 Assessing lake resilience in data archives IGB/UG			ESR 9 DOC/DBPs Current and future trends ICRA/NIOO	ESR 12 Resilience - an exp. approach and informing managers UG/IGB
WP 5 Informing Water Industry	ESR 10 Mitigation for extreme events NIOO/ICRA	ESR 11 Ecosystems services – the Benefit Game NIOO/ICRA			

Fig. 3: relationship of individual ESR doctoral projects to the overall WP structure (short WP titles)

This interactive card game, developed by W+B, is an innovative training tool to entice creative solutions from stakeholders. Building on the consortium expertise and outputs, ESR 11, NIOO and W+B will further develop this to include lakes. Players learn from each other measures that can to be taken to improve living qualities and which benefits that will generate. It covers a wide range of measures and qualities, varying from water quality, cultural heritage, nature quality and social participation. Players are forced to leave their own discipline and step outside their comfort zone. It will also be used as a training tool for ESRs in a MANTEL training event.

Fig. 4 the Benefit Game

Originality and innovative aspects of the research programme (in light of the current state-of-the-art and existing programmes / networks / doctoral research trainings)

An Innovative Training Network such as MANTEL which is using HFM to address possible climate change impacts on lakes **has not previously been carried out**. The consortium will use its **globally unique set of monitoring stations and their data archives** to train a cohort of ESRs in state-of the-art (all monitoring sites) and **beyond state-of-the art (LakeLab, Limnotrons and a new system on Lake Geneva)** technology for monitoring lakes and reservoirs. The new station on Geneva which will be commissioned in summer 2016 includes not only a profiling system but also a number of sensor-equipped Autonomous Underwater Vehicles. The ESRs will use these combined technical and data resources to produces **a new suite of indices** that can be used to describe the effects of episodic climatic events, including extreme storms, on water quality: **such descriptive indices do not currently exist**. These indices will have immediate application in both the research and water resource management sectors, thus benefitting the future careers of the MANTEL ESRs. In the modelling work undertaken in MANTEL, University of Geneva will use a **unique atmosphere-lake coupled model** that they have developed to explore future changes in duration, intensity and occurrence of extreme and episodic climate events at sub-daily time steps. Each ESR will also receive training in state-of-the-art modelling and data analysis tools including those such as **Lake Metabolizer** developed within the GLEON network, **Lake Heat Flux Analyser** developed and published by partner CEH[9] and the **MyLake model** (partner NIVA). Our partner W+B, a Dutch engineering

---

[9] Woolway, R. I., Jones, I. et al. 2015. Environmental Modelling & Software, 70, 191-198.

company, will further develop their **Benefit Game** which helps professionals and stakeholders plan for mitigating measures (WP 5). Partner ATLL, the water company that supplies Girona, also now **monitor for THMs at high frequency** within their water treatment plant.

Gender: The European Commission has prioritised gender in Horizon 2020 with 3 objectives aimed at 1. integration of gender/sex analysis in research and innovation, 2. fostering gender balance, and 3. ensuring gender balance in decision-making (European Commission, 2014)[10]. The MANTEL EJD will integrate gender balance in leadership, ESR recruitment, and research methodologies where appropriate. MANTEL is led by a female coordinator. The balance of the consortium beneficiaries is 30% female /70% male, and three of the eight work packages are led by females. A gender balance plan will be part of the project and gender will be an item on Supervisory Board agendas ensuring gender is considered in, for example, training, research, dissemination including interaction with the public and social media. Training on considering gender in science also will be integrated into the first MANTEL training school (see 1.2).

1.2 *Quality and innovative aspects of the training programme* (including transferable skills, inter/multi-disciplinary, intersectoral and, where appropriate, gender aspects)

The objective of the Training Programme is to provide the ESRs (Table 1.2a) with skillsets that ensure excellence in their doctoral work and are transferable within a range of workplaces in the water sector. The programme is managed by the UB lead. An early stage researcher was specifically selected to provide an approachable mentor and role model for ESRs who had recent experience of the transition to the role of independent researcher. The Training Plan has been designed to accomplish the League of European Research Universities (LERU) recommendations regarding good practices and target skills pursued in modern doctoral training. The achievement of the **scientific, technical and transferable skills** is based on combining direct training with training obtained from their work experience. Transferable skills that the ESRs will obtain include dissemination and communication skills, including scientific writing, networking, teamwork and leadership skills, training on gender in the research landscape, time and project management, event organisation, R programming (now an asset for a range of employers) , and high level statistical analysis. All students will be required to undertake the online course on Research Integrity[11] prior to the first Training School. *The Training Plan includes three components:* i) Expert training through individual research projects; ii) Local structured training; iii) Network-wide training schools and workshops. As an initial step personal **Career Development Plans (CDPs)** will be developed for each ESR jointly with their supervisors. The CDPs will be reviewed and revised centrally to allow feedback. To facilitate this, during the first Training School, there will be a one-day seminar for both ESRs and supervisors to guide them through this. The plans will use the VITAE Research Career Framework as a template with sections on Personal Effectiveness, Knowledge, Engagement and Governance[12]

Table 1.2 a Recruitment Deliverables per Beneficiary, awarding organisations and supervisor teams

ESR No.	Recruiting Participant	Joint Doctorate Awarding Organisations	Planned Start M	Duration months	Cosupervisor team *(MANTEL team member)*
1.	DkIT	DCU	7	36	E. Jennings (DkIT); I. Jones (CEH); *(D. Pierson UU)*
2.	UB	UB & EMÜ	7	36	B. Obrador (UB); Alo Laas (EMÜ) *(E. de Eyto MI)*
3.	EMÜ	EMÜ & UB	7	36	P. Nõges (EMÜ); B. Obrador (UB); *(I. Jones CEH)*
4.	DkIT	DCU & PU	7	36	E. Jennings (DkIT); HP Grossart (IGB); *(E. de Eyto MI)*
5.	UU	UU & UG	7	36	D. Pierson (UU); M. Beniston (UG); *(I Jones CEH)*
6.	IGB	PU & DCU	7	36	HP Grossart (IGB); E. Jennings (DkIT); *(E. de Eyto MI)*
7.	IGB	UG & FUB	7	36	R. Adrian (IGB); B. Ibelings (UG); *(V. Dakos ETH)*
8.	UG	UU & UG	7	36	M. Beniston (UG); D. Pierson (UU); *(R. Couture NIVA)*
9.	ICRA	WU & UdG	7	36	R. Marce (ICRA); L. deSenorpont Domis (NIOO);
10.	NIOO	WU & UdG	7	36	L. deSenorpont Domis (NIOO); R. Marce (ICRA) *(M. Lürling WU)*
11.	NIOO	WU & UdG	7	36	L.deSenorpont Domis (NIOO); V.Acuña (ICRA) *(E. RuijgrokW+B)*
12.	UG	UG & FUB	7	36	B. Ibelings (UG); R. Adrian (IGB); *(V. Dakos ETH)*
Total	12				

i) Expert training through individual research projects

The 'on-the-job' training will be acquired by the ESRs through their research and from supervisors and technical staff within the relevant research institutes, universities, and partner organisations. This component of the training will be carried out and overseen locally by the academic supervisors. There will also be on-going network-wide review of this training through **WP 6** (Training) including feedback from an ESR Committee, and collation and review of key performance indicators to ensure that the local training occurs in a timely and appropriate manner.

ii) Local structured training This is structured training in network institutes. All local training provided will be made available to all MANTEL ESRs *via* either online delivery or physical attendance at courses, or blended learning. Compulsory credits are required in only **two institutes**: UU have a compulsory ethics course and EMÜ require 18 ECTS in coursework. To allow full access to research ethics and integrity training all ERSs will undertake the online course by Epigeum as described above. ESR 2 (recruited by UB) will attend required courses on technical and transferable skills (e.g. Philosophy of Science, Academic Writing, Protection of Intellectual Property) during their secondment at EMÜ that are part of EMÜ doctoral training.

iii) Network-wide training schools and workshops The network-wide training activities consist of **two centralised training schools** of one working week duration each, and three **advanced statistical and data analysis workshops**, of three days' duration. There will also be a **final MANTEL conference**, which the ESRs will organize, to give them experience and training in dissemination. All will coincide with project meetings (see GANTT) to minimise ESR travel. These events are designed to complement local structured training.

Table 1.2 b Network-Wide Training Events, Conferences & Contribution of Beneficiaries.

Event	Main Training Events & Conferences	ECTS	Lead	Other Ben.	M	Duration
1	Introductory Training School	2	DkIT/UU	EMÜ, ICRA, NIOO, UB	8	5 days
2	Training School on HFM data analysis tools	3	IGB	EMÜ, UB, UU	12	5 days
3	Workshop on advanced statistical analysis	3	DkIT/UU	ICRA	19	4 days
4	Workshop on ecosystem services	1	ICRA/NIOO	UG, IGB	24	3 days
5	Workshop on dynamic modelling	1	ICRA/ EMÜ	UG, UU, DkIT	30	3 days
6	Final MANTEL Symposium	-	DkIT	All	36	3 days

The **training schools (TS)** will include training on dissemination of outputs, including publication for the research and policy and management sectors, and organisation of workshops and symposia. The **two TS** will take place at **Erken Laboratory and Field Station** (Sweden) (www.ieg.uu.se/erken-laboratory). This facility includes laboratory space and accommodation. The final symposium will take place in DkIT, Ireland, and will be organised by the ESRs themselves. The final MANTEL symposium (Month 36) will be a 3-day activity hosted by **DkIT (IE).** It will focus on dissemination of outputs, with keynote addresses from MANTEL members and invited speakers. The ESRs will take the lead role in organising this, with a programme committee starting work in month 24, providing them with transferable skills in conference management. It will include a Thesis-in-3 competition (see below) as an outreach activity, where ESRs will have the opportunity to communicate their final results to the general public. All MANTEL Training Events will also be open to other local researchers.

1 Introductory Training School Lead: DkIT/UU	*Venue: Erken Lab & Field Station (SE)*	*Month: 8*

This will provide ESRs with skills needed beyond those received at home institutes and ensure a good foundation for their studies. They will get an introduction and hands-on experience to HFD monitoring using the **Lake Erken system**. They will also receive an introduction to **ecosystem services provided by lakes and reservoirs (ICRA, W+B)**, with an emphasis on those related to potable water and recreational uses. Additional components will be a half day **seminar by ATLL and ACA** on communications between researchers and the water sector, training on communicating science to the general public (UU), and training on gender in research **(DkIT).** The latter will use the yellow window tool kit, Field 5 (Environment)[13]. Students will be provided with this link before the TS and will be challenged to relate it to their research in a group exercise. On the final day, ESRs will be joined by supervisors and they will work together on their CDPs (total equates to 2ECTS).

Topic	Contributor(s)
Introduction to HFM systems	EMÜ, UU, MI
Introduction to ecosystem services	ICRA, NIOO
Communication and outreach	ATLL, ACA, UU
Gender in the research landscape	DkIT
Thesis-in-3 competition	ALL

---

[13] http://www.yellowwindow.be/genderinresearch/index_downloads.html

2 Training School on HFM data analysis tools Lead: IGB Venue: IGB/LakeLab (DE)	**Month: 12**

This 5 day TS will focus on "state-of-the-art**" techniques and tools** to manage, explore and analyse high-frequency data from automatic monitoring stations on lakes will also allow the ESRs to become familiar with LakeLab facility. It will build on the Introductory TS and ensure a full understanding of the data processing required for these unique datasets and analysis tools currently used. The ESRs will also get training in the use of the R programming language, now the language of choice for most data analysis tools in the HFM community. The TS will make use of the tools described in the NETLAKE toolbox and available through the GLEON GitHub site https://github.com/GLEON. It will also include the first of 2 **Thesis-in-3** competitions open to the local community (final night). Thesis-in-3 fosters dissemination skills through a competition based on 3 slides and 3 minutes to explain a PhD thesis (see WP 7). Those students who will be using the LakeLab facility will remain on for further training. It will equate to **3 ECTS including independent learning**.

Topic	Contributor(s)
Principles of lake physics	CEH
Principles of lake metabolism	EMÜ, UB
Existing tools for data analysis (NETLAKE toolbox)	CEH, UU, EMÜ

3 Workshop on advanced statistical analysis Lead: IGB _Venue: Erken Lab & Field Station (SE)_	**Month: 19**

The workshop will be provided by Highland Statistics, world renowned experts in analysis of time series (www.highstat.com), thus contributing to the professional portfolio, together with expertise from consortium members. It will also be open to scientists from outside of the MANTEL project. The students will use datasets that they became familiar, together with data from the LakeLab facility. This course is 3 ECTS including an assignment.

Topic	Contributor(s)
Advanced statistical analysis	Highland Statistics Ltd, ICRA

4 Workshop on ecosystem services Lead: ICRA/NIOO Venue: ICRA(ES)	**Month: 24**

This three-day course will address methodologies for valuation of lake and reservoir Ecosystem Services (ES) in terms of provisioning, regulation, cultural or supporting services. There will also be a session for the ESRs using the outputs of WP 4 on resilience in lake systems, and using the Benefit Game. This course will challenge ESRs to think outside of their academic box, by giving them both an overview and insight into the true value of water. It will equate to 1 ECTS (21 hours).

Topic	Contributor(s)
Principles of ES and ES valuation	ICRA, UG, WU,NIOO,
Techniques for ES valuation	WU, NIOO
What does HFM tell us about lake resilience?	UG, IGB, ETH
Benefit Game Training	W+B

5 Workshop on dynamic modelling Lead: ICRA/ EMÜ Venue: EMÜ (EE)	**Month: 30**

This 3 day workshop will ensure that all ERS have **skills in applying catchment and lake models,** essential for working in the water sector. Models will include MyLake and GLM. Those students who have already developed modelling skills through training for their individual PhD projects will act as teaching assistants for this workshop, thus developing their own teaching portfolios. It will equate to 1 ECTS (21 hours).

Topic	Contributor(s)
Catchment models	UU, DkIT
Introduction to lake models (GLM, MyLake)	NIVA, UG, ICRA, EMÜ
Hands-on modelling sessions	All

Role of non-academic sector in the training programme

There are three non-academic partners that will contribute to the consortium training. **W+B** with ESR 11 will give training in the Benefit Game at the Workshop on Ecosystem Services. **ACA and ATLL** will participate also in Events 1 and 4, contributing their experience in the management and policy related to water. **Highland Statistics**, world leaders in time series analysis, will contribute to statistical training as invited speakers.

1.3   Quality of the supervision

Our supervisory team are based in four awarding universities, together with four research institutes (Table 1.2). The latter have well-established links to the awarding universities that are included as partner organisations. The cosupervisors have strong records in research and in successfully supervising doctoral candidates (Tables 1.3). All are committed to implementing the European Charter & Code for Researchers and will perform their supervisory tasks to the highest professional standards (Table 1.3). Each supervisor team of 3 will also include one member from a partner organisation who has academic or industry links to their work (Table 1.2).

Qualifications and supervision experience of supervisors

Table 1.3 Qualifications and supervision experience of supervisors and the ESRs that they co-supervise.

Name		Experience	ESR
Dr Eleanor Jennings *Coordinator* (DkIT)		PhD; has supervised 4 PhDs; currently supervising 5 PhDs, 2 post-docs; supervised 3 MScs;directtor Centre for Freshwater and Environmental Studies (8 researchers; 10 students); Chair NETLAKE COST Action; GLEON steering committee member 2010-2014; 43 journal publications; H-index 15.	1,
Prof. Dr Hans-Peter Grossart (IGB)		PhD; has supervised >25 PhDs and currently supervising 8 PhDs; Has supervised >10 MScs; has managed teams of 30 scientists; >170 Publications; H-index of 42.	4,6
Prof. Bas Ibelings (UG)		PhD; has supervised 17 PhDs; currently supervising 5 PhDs, 1 post-doc; supervised 7 MScs; managed teams 7-40 people; President of interdisciplinary Master in Environmental Sciences; Vice-chair of NETLAKE; GLEON steering committee member; 90 Publications; H-index of 37.	
Prof. Dr. Rita Adrian (IGB)		PhD; has supervised 20 PhDs; currently supervising 4 PhDs, 2 post-doc; supervised 15 MScs; Led PhD-program at IGB, which included leading seminars and being mentor; manages teams of >80 people (Head of Department of Ecosystem Research at IGB); has 127 publications; H-index of 31.	7,12
Dr Don Pierson (UU)		PhD; has supervised 3 PhDs and 9 post-docs; managed a team of 13 as modelling section chief New York City Department of Environmental Protection (to 2013); a remote sensing research team of 5 at Uppsala University; 71 publications; 1926 citations; H-index 24.	
Prof. Martin Beniston (UG)		PhD; has supervised >20 PhDs; currently supervising 4 PhDs; has supervised 50 MScs; managed teams of 18 scientists; Chair for Climate Research, Director Institute for Environmental Sciences (staff of + 80); c. 180 publications, > 13,000 citations; H-index 48.	1,8
Dr Biel Obrador (UB)		PhD; has supervised 1 PhD; currently co-supervising 2 PhDs; has supervised 12 MSc projects; active in research on innovative teaching methodologies; involved in coordination of academic plans (UB has received a quality award for Excellence in PhD Programmes by the Spanish Ministry of Education); 22 journal publications; H-index 8.	
Dr Alo Laas (EMÜ) Prof. Peeter Nõges (EMÜ)		**AL:** PhD; currently supervising 2 PhDs; supervised 1 MSc; specialist for water management in Estonia Ministry of Environment; project leader of Estonian Observatory of Aquatic Environments (VeeOBS) (2012-2015) 35 persons involved; GLEON Steering Committee member; 12 publications; 323 citations; H-index of 9. **PN:** PhD; previously supervised 3 PhDs; currently supervising 3 PhDs; supervised 5 MScs; 2014-present, working group leader under Estonian institutional research funding grant with 6 people. 76 publications; 1677 citations; H-index of 20.	2, 3
Dr Lisette de Senerpont Domis (NIOO) Dr Michael Lürling (WU)		**LdS:** PhD; has supervised 2 PhDs; currently supervising 2 PhDs, 2 post-docs; supervised 9 MScs; manages a team of 5/6; Chair of Plankton Ecology Group of International Limnological Society; GLEON Steering Committee member; Steering Committee member of Platform for Ecological Restoration of Lakes; 28 publications; H-index of 15. **ML:** PhD; previously co-supervised 10 PhDs, currently supervising 5 PhDs, co-supervising 4 PhDs; supervised 42 MSc projects; 102 publications; H-index of 30	9,10 11
Dr Rafael Marcé (ICRA) Dr Vicenç Acuña (ICRA)		**RM:** PhD; previously supervised 3 PhDs, currently supervising 2 PhDs; supervised 3 MSc projects; manages a team of 2 PhDs and 3 post-docs; Teacher Assistant in the UB from 2005 to 2015. Invited trainer with VA in EU projects (e.g. GLOBAQUA), doctoral courses (UB, University of Málaga) and COST Actions (e.g. NETLAKE); 47 publications; H-index of 11. **VA:** PhD; previously supervised 2 PhDs, and currently supervising 3 PhDs; manages a team of 3 PhDs and 2 post-docs; 59 publications; H-index of 15.	
Dr Ian Jones (CEH, PO)		PhD; has supervised 4 PhD and 6 MSc students; currently supervising 1 PhD; 1 MSc student; member of the GLEON Collaborative Climate Committee; teaches physical limnology on an MSc course; 33 publications; H-index 13.	1 with DkIT

Quality of the joint supervision arrangements (mandatory for EJD)

Each ESR will have a main supervisor and a co-supervisor (**Fig. 5**). Supervisor teams include two university pairings, one for ESR 2+ESR 3 (UB (ES) and EMÜ (EE)) and one for ESR 5+ESR 8 (UG (CH) and UU (SE)): each will award double degrees. The four other teams all include research institutes. These are a university-research institute pairing: UG (CH) and IGB (DE) (IGB award by FUB) for ESR 7+ESR 12 (joint degree), a research institute-research institute team: NIOO (NL) (awarded by WU) and ICRA (ES) (awarded by UdG) for ESRs 9, 10 & 11 (double degree) and a research institute-institute of technology team of IGB, DE (awarded by PU) and DkIT, IE (awarded by DCU) (ESRs 4 and 6, joint degree). There is also one single PhD award, ESR 1, supervised in DkIT (award by DCU) but using a Collaborative PhD Agreement to include Dr Ian Jones (CEH, UK) as supervisor, thus giving the ESR full access to a supervisor with expertise in lakes physics. The coordinator has had similar agreements previously: these formally allow PhDs to be supervised for extended periods off campus by approved collaborators. Within MANTEL all other supervisory arrangements will be identical for all 12 ESRs. Following registration, each will be set up on a secure, online MANTEL Progress Monitoring System using SmartSimple (www.smartsimple.com) held by the Coordinator. This will allow the Supervisory Board and teams access to the ESRs training profile, to formally monitor progress and ensure career development. Supervisors will have daily contact with ESRs, hold weekly meetings that other team members can attend via videoconference and feedback meetings to chart progress every 3 months. The information gained will be used to conduct annual appraisals of performance. This process, initiated by the primary supervisor, occurs online and involves the ESR providing a written update on their training, career planning and outreach. Once submitted, the supervisory team will assess it and provide a written update on the system. This will be reviewed, discussed and agreed with the ESR. The online form is forwarded to the Chair of the Supervisory Board for discussion and approval by the board.
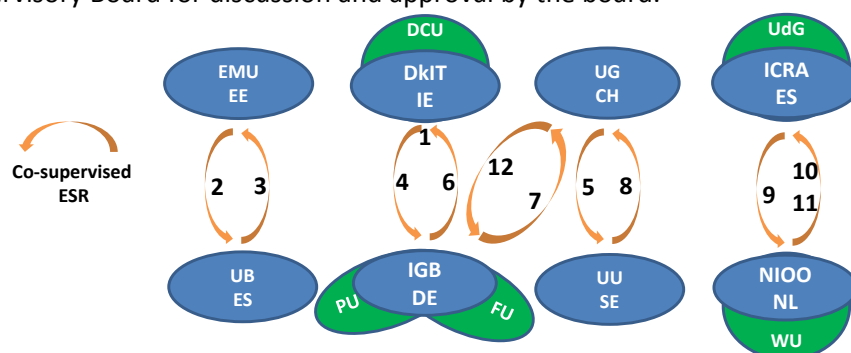

Fig. 5: Co-supervision arrangements: beneficiaries in blue; awarding partners in green.

1.4   Quality of the proposed interaction between the participating organisations

Contribution of all participants to the research and training programme

Synergies between participants:

At the core of the consortium are long-term collaborations between six beneficiaries which have continued and been sustained since the very first projects (FP4 REFLECT 1989-2000; FP5 CLIME 2000-2003) in which HFM was deployed on European lakes (DkIT, CEH, MI, UU, EMÜ, IGB). This group, with UG and NIOO, is also active in the GLEON network since the mid-2000s, and together proposed the successful NETLAKE COST Action in 2012. They are therefore at the forefront of the deployment of cutting edge autonomous systems both in Europe and globally. The consortium also includes expertise in all scientific disciplines required for this project including phytoplankton and zooplankton dynamics, the microbial loop, biogeochemistry and lake metabolism, modelling and HFM data analysis (Table 1.4). This strong and already established consortium bring to the MANTEL doctoral training programme partner organisations with expertise in climate change and modelling (NIVA, BSC), use of HFM in water treatment (ATLL), water policy (BD and ACA), and ecosystem services (W+B) (Table 1.5). DkIT coordinator has over 15 years working on European and national projects using HFM data, including on-going collaborations with MI, CEH, UU, EMÜ and IGB since 1999. She is currently Chair of the NETLAKE in which all beneficiaries and many partners are involved.

Exposure of recruited researchers to different (research) environments, and the complementarity thereof

The strengths of the MANTEL consortium and the carefully selected complementary supervisory arrangements for the EJD doctoral programme will ensure that each ESR will be exposed to a tailored set of research environments (Table 1.4). Each will spend at least one research period with their co-supervisor, a training secondment

Table 1.4: secondments for MANTEL ESRs. GREEN = co-supervisor; orange = other secondment.

M ESR	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	31-32	33-34	35-36	37-38	39-40	41-42
1				CEH			UU			CEH								
2				EMU					MI			EMU						
3				UB					CEH			UB						
4				IGB			UB			IGB								
5		NIVA		CEH		UG				NIVA	UG			UG				
6				DkIT	MI			DkIT										
7				UG		ETH		UG										
8		UU							UU			ICRA						
9		ATLL		NIOO			BSC			NIOO								
10	WU		BD	ICRA		WU			BD	ICRA			WU					
11		WB		ICRA			WB			ICRA	WB							
12				IGB		ETH		NIOO										

from at least one other partner, and also benefit from interacting with MANTEL consortium senior researchers and industry partners at network wide training events. In addition, MANTEL ESRs will benefit from other research on-going in the network. UU for example is leading a Water JPI project Predicting In-Lake Responses to Change Using Near Real Time Models (PROGNOS) (2016-2020). This includes the Coordinator, partners MI and NIVA, and has two PhDs. It will couple HFM data to near real-time modelling to forecast short-term changes in lakes. We expect that there can be collaboration between PROGNOS and MANTEL, particularly for ESR 5, and ESR 9. Secondments at UU, MI, DkIT and NIVA will include interaction with PROGNOS members. Where appropriate, MANTEL ESRs will be included in PROGNOS meetings and workshops. ESRs will also attend GLEON meetings in each year and become part of the GLEON Graduate Student Association (GSA), adding to their exposure to global science on HFM. At each meeting there is a workshop organised by and for the GSA. Leadership skills for GSA members are promoted and encouraged.

Table 1.5 Contribution of partners to the consortium.

	DKIT	EMÜ	ICRA	NIOO	IGB	UB	UG	UU	CEH	MI	ETH	WU	ATLL	ACA	NIVA	BSC	W+B	BD
Data archives		✓	✓		✓			✓	✓									
HFM stations	✓	✓	✓		✓		✓	✓	✓	✓			✓		✓			
Mesocosms		✓		✓	✓		✓					✓						
Lake physics					✓			✓	✓									
Carbon cycling	✓	✓	✓		✓	✓		✓		✓					✓			
Lake biology dynamics		✓		✓	✓	✓	✓					✓						
Modelling	✓		✓				✓	✓	✓							✓		
Lake resilience					✓			✓				✓			✓			
Ecosystem services			✓	✓								✓	✓				✓	
Future impacts	✓	✓					✓	✓	✓	✓		✓			✓			
Early warning systems								✓	✓		✓							
Communications	✓	✓	✓	✓	✓								✓					
Water services sector													✓	✓				✓
Cost-benefit analysis			✓										✓	✓	✓		✓	✓
NETLAKE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓			
GLEON	✓	✓		✓	✓		✓	✓	✓	✓								

2. Impact

2.1 *Enhancing the career perspectives and employability of researchers and contribution to their skills development*

MANTEL will create a cohort of highly qualified, motivated professionals with a unique expertise in cutting edge science and technology, essential if we are to understand and manage lakes under changing climatic conditions. It is a given that they will have strong specialist research competencies: they will also have multi-sectoral insight, an interdisciplinary perspective on water science and resource management, and an entrepreneurial attitude that draws on a range of transferable skills. MANTEL mobilises the academic sector, industry representatives, stakeholders, diverse technical and scientific experts, and policy-makers to train a generation of professionals to change the way in which water quality monitoring is carried out so the effects of episodic events can be more clearly understood, predicted, prevented, and mitigated against. MANTEL will provide innovative training coupled to a scientifically ambitious research projects to generate professionals who:

- have an understanding of and **international training** in the **interdisciplinary science, technological solutions and social science** associated with impacts of climatic events on lake ecosystem services at an **global scale**;
- have **inter-sectoral experience** of working on and delivering a research project that includes meeting the real needs of the non-academic sector;

- be trained in business relevant skills (including project management and teamwork), delivered by practitioners who are **working in the industry and the policy sector.**

MANTEL will have long-term benefits for their career perspectives through its unique and specific training program that emphasises internationality (European perspective), inter-sectorality (academic and non-academic sector including industry) and inter-disciplinary (from climate dynamics to ecosystems services and society), in line with the EU Principles for Innovative Doctoral Training. The trainees will raise their profile by presenting achievements to a broad audience at network workshops, conferences and other occasions. Given the strong track record of high-impact publications and presentations of the MANTEL scientists, the MANTEL ESRs' work will be disseminated widely benefiting their future job and fellowship applications. Mentoring and supervision provided by the senior researchers and experts from industry and policy sectors will provide trainees with a wide range of role models, helping them identify a future career structure. The geographical and sectoral mobility will additionally increase the competitiveness of trainees and give them confidence to start an independent career. Table 2.1 summarizes the links between MANTEL's programme elements and the enhanced employability and career development of the trainees in the context of EU policies and innovation.

Table 2.1 skills provided by MANTEL and contribution to innovation related to water challenges in Europe.

MANTEL programme elements	Impact on EU policies & innovation capacity	Enhanced employability & career development
. Research Excellence Attractive Institutional Environment	Contribution to European Innovation Partnership (EIP) on Water & Blueprint to Safeguard Europe's Water Resources	Expertise gained will cover two of five thematic EIP priorities & support two of three cross-cutting priorities, placing ESRs as the reference for jobs related to protection of freshwater resources against extreme events, particularly institutions interfacing science & policy e.g. EU Joint Research Centre.
Interdisciplinary Research Options	Achieving the objectives for improved water related policy	Training objectives in line with EU policies such as the WFD. ESRs will have skills required to modify such policies for the effects of extreme events, and to propose monitoring & mitigation; of interest to institutions implementing policies.
Exposure to industry International networking	Research and Earth Observation	One of the most active and innovative research areas in Europe. MANTEL ESRs will be the reference for projects like Copernicus and GEOSS. The inclusion of lakes in these observation systems is the next step in their development.
Transferable skills training	Creation of market opportunities in industry	Exposure to industry is a key component in MANTEL & will ensure that ESRs become a reference for companies facing challenges of climate extremes (water supply, sensor tech developers, etc.).

2.2 Contribution to structuring doctoral/early-stage research training at the European level and to strengthening European innovation capacity, including the potential for:

Contributing to aims of the EIP on Water and the Blueprint to Safeguard Europe's Water Resources: Defining best management solutions for extreme events is an important contribution to the goal of preserving freshwater and making sustainable use of its ecosystem services, as set forth by the European Innovation Partnership on Water. Furthermore, MANTEL addresses two of five EIP thematic priorities (Flood and drought risk management and Ecosystem services) and supports two of the three cross-cutting priorities (Water governance and Decision support systems and monitoring). It also addresses smart technology, identified to be of key relevance.

Achieving the objectives for improved water related policy: the MANTEL training programme will contribute to the successful implementation of several EU directives and policies e.g. Water Framework Directive (2000/60/EC, updated in 2008/105/EU), Floods Directive (2007/60/EC), Drinking Water Directive (98/83/EC), and Bathing Directive (2006/7/EC). Extreme episodic events can have large impacts of water quality that are largely disproportional to the length of the events. Understanding the impacts will contribute to a healthier status of water bodies and a safer environment for recreational activities and water supply: researchers trained in MANTEL will have the necessary skills to become the reference professionals in this area.

Research and Earth Observation: our training program is aligned with the EC research areas in: **1.** Earth observation: our training will establish links with the Group on Earth Observations (GEO), providing cross-cutting activities relevant to GEO understanding, modelling, and predicting environmental phenomena. MANTEL will also support activities needed for GEOSS (The Global Earth Observation System of Systems). The new Lake Geneva HFM platform will be linked to Earth Observation for example by a ULM equipped with spectral sensors. **2.** Climate change: at the core of several projects is the impact of extreme events on ecosystem services, contributing to prediction of climate change effects and definition of mitigation and adaptation strategies.

MANTEL researchers and collaborating organisations will therefore be well positioned for strategic actions developed by the European Environmental Agency (EEA), GEOSS, the Integrated Carbon Observation System infrastructure (ICOS), and the European Earth Observation Programme (Copernicus).

Creating market opportunities in the industry: by contributing to the strengthening of the link between the water management and innovation for sustainable use of resources, MANTEL will be a showcase for professionals with a view to the global water sector market.

Meaningful contribution of the non-academic sector to doctora/ research training.

All of the four ESRs associated with WP 5 are strongly linked to non-academic partners, including secondments. The remaining ESRs will have meaningful interaction with non-academic partners at the project meetings and through training events. The non-academic partners contributing to the consortium training include **W+B** for the Benefit Game at the Workshop on Ecosystem Services. **ACA and ATLL** will participate also in Events 1 and 4 contributing their experience in the management and policy related to water. **Highland Statistics**, world leaders in time series analysis, will contribute to statistical training as invited speakers.

b) Developing sustainable joint doctoral degree structures (for EJD mode only)

MANTEL decided on jointly or double awarded doctorates because the consortium is founded on a strong existing collaborative research base which will benefit students, institutions and national/regional education systems. These strong international collaborations inform the design of the research programme and ensure that mobility will be more than just a period of study abroad. The joint supervision and collaborative research provided to ESRs will build and reinforce academic cooperation between partner universities.

From the student perspective, a jointly or double awarded doctorate will encourage both international mobility and research as a career for high calibre students. MANTEL joint doctoral degrees will provide the ESRs with a widened research experience and enhanced generic skills. The benefits of a MANTEL Joint PhD programme include: 1. Access to complementary facilities and resources; 2. Exposure to at least two cultural approaches to research; 3. International student mobility; 4. Enhanced acquisition of research and transferable skills, such as negotiation skills, use of videoconferencing, adaptability to different work environments; 5. Better networking opportunities for future job prospects; 6. Comparative research projects; 7. Access to techniques, equipment or resources available in two institutes; 8. Facilitates local industrial/public sector involvement; 9. Dual supervision allowing complementary approaches to research questions;. 10 Enhanced knowledge exchange and sharing of research, learning and resources and mutual recognition of all partner university qualifications.

From the institutional perspective, participating in a jointly/double awarded doctorate will enhance the institutions' attractiveness as a place to study thus attracting excellent students. Jointly or double awarded doctorates also promote academic and research collaboration. An additional added value could be increased capacity to leverage research funding, fulfilling European principles on mobility and enhancing future EU applications. The MANTEL joint PhD will also **stimulate and formalise cooperation** between Universities, research institutions on a national or an international level, leading to a greater exchange of knowledge. Moreover, a joint PhD formally underscores the student's (inter)national mobility. The PhD degree certificate makes official mention of co-operation with another partner institution. This will be an enormous asset in terms of career, both within the academic community and in the outside world.

MANTEL identifies the need to have recognised and approved procedures for jointly or double awarded doctorates in place thus minimising administrative burden for all. MANTEL partners will agree to a mutually satisfactory generic overarching Memorandum of Understanding (MOU). This will allow for flexibility between institutions and nations with regard to rules and regulations. Each collaborative student programme established under the terms of this MOU will be the subject of a separate bilateral Memorandum of Agreement (MOA) entered into between the two MANTEL institutions concerned. MOU and MOA templates will be customised for a MANTEL joint doctoral programme. The following documentation is proposed:

1. An overarching, generic, multilateral non-legally binding MOU for a jointly/double awarded doctorate.

2. A student-specific bilateral MOA template detailing, as a minimum, arrangements for: admission; registration; payment of fees (tuition, examination, research costs); social security and insurance; duration of study at each location; coursework; intellectual property; supervision; language of thesis; thesis examination and graduation. The MOU provides a multilateral, over-arching framework for universities to create tailor-made programmes of study for each student, taking individual research needs into account and enabling research collaboration with other MANTEL partners. This will detail student-specific supervision, coursework, thesis, examination and graduation arrangements. The template MOA lists the areas to be agreed between academic supervisors and

between the two universities while allowing room for customisation, modification and flexibility. The participation of individual students in a jointly/double awarded doctorate between partner universities will be agreed on a case-by-case basis. We plan to sustain MANTEL long beyond the period of the MCSA-ITN funding since the community of researchers within the MANTEL network is enhanced by a clearly defined mission, vision and values; a proven culture of collaboration; and strong relationships with host organisations, in addition to the international network in GLEON. This framework for sustainability will enhance strategic planning within the network and guide relationships with stakeholders. Unlike other joint degree programmes, under MANTEL two partner universities will create a tailor-made study programme for the student, taking individual research needs into account and enabling collaboration with network partners. Each ESR will benefit from the expertise of two research groups – either working in complementary areas or through an interdisciplinary element to the individual ESRs research area. MANTEL considers that sustainability is not limited to funding but includes 1. Sustaining the impact of the network on the ESRs career; 2. Maintaining the quality aspects of the project; and 3. Starting new activities and forms of cooperation among partners. MANTEL will ensure a long term network sustainability as the partnership is built upon strong network fundamentals that efficiently aligns resources with network operational and strategic aims as proven with PRONOS Water JPI project involving four partners.

2.3 Quality of the proposed measures to exploit and disseminate the project results
Dissemination of the research results
Dissemination is a task that will run throughout the project. A central hub will be a Plan for Exploitation and Dissemination of Results (PEDR), with both internal and external communication, and dissemination to stakeholders. The working document will identify the main outputs from each ESR and potential for dissemination as in Table 3.1c, including target journals and conferences, and for communication to other end-users. This plan will be finalised in the initial meeting. It will map each project deliverable to tailored outputs using a 'what, why, who, how and when' framework. It will be an agenda item on each consortium meeting, and will be reviewed and revised at six monthly intervals. This task will be managed through WP 7. There will be a target minimum of three peer-reviewed publications per ESR for the thesis. The first papers for each ESR, however, will be formal WP deliverables (Tables 3.1a). The ESRs will be guided in the production of these for their targeted journals (Table 3.1b) in the MANTEL Writers Groups, led by IGB through WP 7. These will meet at each biannual project meeting, with an informal approach, allowing ESRs to present and discuss their progression in a collegiate atmosphere. Each ESR will also present as a poster of presentation at least once in each year to the project, with all ESRs presenting posters at the annual GLEON meetings in years 1 and 2. Dissemination to the water management sector will also be targeted to ensure that relevant outputs become embedded in that community. NIOO who have expertise in this area will contribute to this, including liaising with ERSs attending World Water Week in Stockholm in year 2, one of the premier events in the European water sector calendar. Training on the production of policy briefs will be included in WP 6, enabling appropriate dissemination by MANTEL ESRs. These will be evaluated by a panel of non-academic partner organisations pre-distribution. Close collaboration with non-academic partners will include promotion of the economic value of outputs at in-house presentations and at local dissemination events.

Exploitation of results and intellectual property
The scientific results from each of the 12 ESR projects will be disseminated using peer reviewed papers as described above, policy briefs and through presentations at limnological and aquatic science conferences, including the annual GLEON meeting, Symposium for European Freshwater Sciences (SEFS), Association for the Sciences of Limnology and Oceanography (ASLO) and SIL (International Society of Limnology). Intellectual property rights will be included in the MANTEL Consortium Agreement. Where outputs are based on HFM data from MANTEL sites, Background IP for data will remain with the data owners, with foreground IP residing with the MANTEL ESR and their collaborators. Where circumstances permit, the processed data on which ESR publications are based will be published on a data archieve site e.g. the DataOne (Data Observation Network for Earth) site, with an agreed authorship that will include the data owners and relevant ESRs. All background IP rights for the Benefit Game will be retained by W+B; in addition any new foreground IP associated with its adaptation will be retained by W+B. Any licencing will be the decision of W+B who retain all IP rights. If Background IP includes all or part of a commercially available product of a Party or of a third party, the terms and provisions governing the access to and use of such product shall be the prevailing terms. For the avoidance of doubt, the exclusions and limitations of liability of the Consortium Agreement shall not apply to a breach of such terms and conditions.

2.4 Quality of the proposed measures to communicate the project activities to different target audiences
Communication and public engagement strategy of the project

Communication and Outreach (WP 8) will be managed by UU, facilitated by staff at Erken Field Station who have long experience in liaising with the community and schools, with input from the MANTEL project manager. The aim of the communications strategy is to ensure that MANTEL ESRs can engage in a dialogue and communicate with the general public in a jargon-free manner. There will be three components to this communication:

1. Communication with the public will be a primary consideration in the MANTEL website. The project will also use Facebook, Twitter, and a regular project newsletter/blog. ESRs will contribute articles and document their field activities. **2.** ESRs will have an initial **Thesis in 3** competition with an invited audience at the first Training School. Thesis in 3 is an initiative started in Ireland to encourage ESRs to disseminate their work. Participants are allowed 3 slides and 3 minutes to explain an entire thesis to a general audience (http://thesisin3.com/). The first MANTEL Thesis in 3 will include a survey with audience feedback to ESRs, and a meet and greet session. This will prepare the ESRs for a consortium wide **Thesis in 3** competition at the final symposium that will also be open to the general public. **3.** Each ESR will also have at least one **promotional activity at their local institute for the general public**, either at school level or more generally, for example this could be linked to a 'Storm watch', where communities will be encouraged to provide ESRs with images using their smartphones of the effects of extreme events. This outreach will build on the extensive activities already undertaken by the consortium, including in NETLAKE which has had a Working Group focused on citizen science. Activities in NETLAKE have included school water days and two citizens Training Schools (Fig. 6). Other activities of consortium members a specifically designed school curriculum for 10-12 year olds (DkIT, IE), community outreach days, Lake District, and nature days for schools at Erken Laboratory (SE) (Fig. 7). There is a set of outreach tools now available from NETLAKE, including four school lessons, an 'All About Water' book translated into 8 languages, and protocols for local communities. MANTEL ESRs will plan their first activity at the first Training School. The events will be promoted through MANTEL social media and the website and ESRs will assess their success using a mini survey.

Fig. 6: a. press report on NETLAKE event; b. NETLAKE citizen science, Serbia; c. Polish children learn about HFM.

Fig. 7: a. children learn All About Water; b. citizens meet CEH scientists (UK); c. schools Nature Day, Lake Erken.

3. Quality and Efficiency of the Implementation

3.1 Coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources (including awarding of the doctoral degrees for EID and EJD projects)

The Scientific WPs focus on identifying drivers of episodic and extreme events (WP 2), investigating future impacts (WP 3), examining resilience of lakes (WP 4) and protecting Ecosystem Services (WP 5). The four supporting WPs are Management (WP 1), Training (WP 6), Dissemination (WP 7) and Communication & Outreach (WP 8). Workshop meetings for each scientific WP will take place at each of the nine project meetings.

WP Number	1	Start Month 1 – End Month 48
WP Title	Management of the MANTEL consortium and doctoral programme *(Management WP)*	
Lead Beneficiary	DkIT	

Objectives
To ensure that the consortium agreement and EJD supervisory agreements are in place [D1.1]
To oversee MANTEL ESR recruitment and monitor progress of the joint doctoral programme[D1.2]
To ensure that finances are managed in accordance with EC rules [D1.3]
To oversee project Milestones and Deliverables and manage associated risks.
To ensure effective communication between all beneficiaries and partners including for the MANTEL Supervisory Board.
To maintain contact with the EC project officer, draft, review and submit reports as required [D1.4, D1.5]

Description of Work and Role of Specific Beneficiaries/Partner Organisations
This work package will ensure that all MANTEL project objectives are achieved in a timely manner according to the overall project work plan as defined by WP 2-8 below and the Gantt chart. A dedicated project manager will be employed to assist the consortium coordinator in overall management for the lifetime of the project, funded from a pooled consortium budget. There will be six work package tasks (WT):
WT 1.1 establish and coordinate the MANTEL supervisory board (DkIT).
WT 1.2 manage any consortium financial operations in an appropriate and transparent manner, including management of consortium pooled budget (DkIT)
WT 1.3 Monitor and coordinate WP reporting to ensure that all beneficiaries meet their reporting and other obligations; manage and attempt to resolve any issues; risk management; maintain contact with the EU desk officer; draft & submit all reports including Researcher Declarations with assistance of WP leaders and ESR supervisors (DkIT lead; all).

Description of Deliverables
D1.1 Agreed and signed Consortium Agreement including IPR rules (M1)
D1.2 Plan for recruitment including advertising (M2)
D1.3 Agreed and signed EJD supervisory agreements (M6)
D1.4 Financial reporting (M24 & M48)
D1.5 Reporting of project activities and impacts (M12, M24, M36 & M48)

WP Number	2	Start month 7 – End month 42
WP Title	**_Analysis of past and current HFM data for in-lake effects of episodic events_** _(Research WP)_	
Lead Beneficiary	EMÜ	

Objectives: to analyse HFM data archives and undertake new monitoring programmes as outlined in the PhD projects (Tables 3.1d) in order to 1) define episodic events, 2) understand which environmental conditions produce episodic events in lakes and 3) quantify short-term and long-term effects of those events on physical structure of the lake and subsequent impacts on carbon cycling through assessment of changes in lake metabolism (i.e. the balance between bacterial dominated and phytoplankton dominated) and changes in biological communities.

Description of Work and Role of Specific Beneficiaries / Partner Organisations
Four specific tasks will contribute to the objective:
WT 2.1 Defining episodic events: define how an event is considered as "episodic" for both climatic and response variable data for a range of variables, including lake physical, biogeochemical (carbon (C) cycling, and biological data. For example, the depth of the metalimnion (a physical response) can be defined by changes in water temperature and density. An index/set of indices for quantifying this disturbance will be devised (_EMÜ, UB, DkIT, CEH, UU_)
WT 2.2 Assess long-term trends in events: the consortium has a set of HFM systems which have been collecting data for more than 10 years. This database will facilitate the tracing of episodic and extreme events on a longer time scale by ESRs 1 to 4 (_EMÜ, UB, DkIT, MI, CEH, UU_)
WT 2.3 Exploring impacts using new field data and an experimental approach: gather new sampling data on events during the project lifetime, and use LakeLab, to produce artificial episodic and extreme events and understand how these affect microbial and phytoplankton communities, and physical and chemical conditions _(UB, EMÜ, DkIT, MI)._
WT 2.3 Depth variable or multiple depth systems: several consortium lake systems have now the ability to measure parameters other than temperature on multiple depths (that is on profiling winch systems). This is a recent development and was not previously available to inform research and theory. WP 2 studies linked to these data will help to widen knowledge about the effect of episodic events on along the full depth gradient _(WU, ICRA, UU, UB, EMÜ)_

Description of Deliverables
D2.1 Morphological controls on in-lake physical responses to atmospheric episodic event. (M28)
D2.2 Contribution of aquatic metabolism to lake C emissions in response to weather events of differing severity. (M30)
D2.3 A disturbance index for lake phytoplankton based on anthropogenic factors and changes in meteorological forcing. (M27)
D2.4 How do episodic events control microbial communities on the Atlantic fringe of Europe? (M32)

WP Number	3	Start month 7 – End month 42
Title	**Anticipating the impact of extreme events in current and future conditions** (_Research WP_)	

Lead	ICRA

Objectives to quantify and understand how extreme events impact ecosystem processes in current and future climate conditions using both dynamical modelling and experimental studies.

Description of Work and Role of Specific Beneficiaries / Partner Organisations
WP 3 will be the umbrella for all ESR activities related to exploring lake responses to extreme events combining both an experimental and numerical modelling approach. It will identify appropriate water quality models and adjust these to optimally simulate extreme events. It will also link seasonal climate prediction to models in order to anticipate and mitigate the impacts of extreme events on Ecosystem Services of lakes and reservoirs, and will also include exploratory seasonal and decadal scale predictions of the impacts of extreme events. WP 3 will develop the modelling tools and procedures most suited to climate predictions that consider the short duration and lasting impacts of extreme events.

WT3.1 This will focus on how to simulate short term variations in lake water quality with models that typically have a daily time step. The time scale of episodic events may be of hours, particularly wind driven mixing events, or diel changes in the upper mixed layer. The time step of lake models will need to be reduced, which could in turn require evaluation of algorithms originally parameterised with daily data. This will identify models that can be used to deal with extreme events, with a focus on how episodic changes in atmospheric variables affect the thermal response which typically characterise an episodic event. Similar issues will be addressed by the EU PROGNOS project, which is focusing on short term forecasting. We expect that ESR5 will collaborate with PROGNOS. *(UU, UG, NIVA, CEH)*.

WT3.2 This task will use an experimental approach to assess future changes in both phytoplankton (ESR 3) and microbial (ESR 6) dynamics in response to storms. This work will be informed by assessment of the trends in extremes at lake types across Europe *(EMÜ, UB, IGB, DkIT, MI)*.

WT3.3 In the context of WP4, ESR8 will develop universal metrics which quantify critical thresholds for the magnitude, frequency and duration of episodic events beyond which lake ecosystem functioning is at risk. ESR8 will apply these metrics to future climate scenarios to explore more fully the role of non-linear behaviour in particular on the advent of extreme events that could have an impact on the response of lake waters into the future *(UG, UU, ICRA)*.

WT3.4 Understanding how future changes in the duration and intensity of extreme events will change the challenges that water resource managers must face will be critical if they are to plan and adapt in the face of our changing climate. ESR 9 will offer a modelling framework for the assessment of long term threats for water supply from disinfection-by-products and investigation of mitigation measures during extreme events at both operational and strategic levels, including seasonal forecasting *(ICRA, NIOO, BSC)*. ESR9 will work in close cooperation with the EU PROGNOS project modelling team which is developing short term water quality forecasting methodologies.

Description of Deliverables
D3.1 The ability of lake hydrothermal & water quality models to capture the effects of episodic events (M30).
D3.2 The implications of changes in the microbial community for lake C cycling and metabolism following storms (M30).

WP Number	**4**	**Start month 7 – End month 42**
WP Title	*Lake Ecosystem Resilience (Research WP)*	
Lead Beneficiary	**UG**	

Objectives: to assess the extent to which climate-driven episodic events affect the biological functioning of lake ecosystems, in particular if and how they reduce **ecosystem resilience**, bringing the system closer to a point where a critical transition may occur, defined here as a discontinuous ecosystem response that is not easily reversible.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

WT 4.1 Episodic events in terms of ecosystem resilience: (i) nature of the disturbance (e.g. climate driven, hydrologically, physically determined); (ii) frequency and amplitude of the event; (iii) lake ecosystem properties affected, e.g. cyanobacterial blooms (iv) resilience of lake properties to the episodic disturbance and likelihood of critical transitions. Develop quantifiable indices and threshold values for (i)–(iv) *(lead UG, with IGB, ETH)*.

WT 4.2 Detect effects of episodic events on resilience: the MANTEL HFM database will be used to trace episodic events over longer time scales and will be mined for response variables of ecosystem functioning and loss of resilience. The latter will involve studying evidence of critical slowing down (increased response times), and increases in auto-correlation or variance of ecosystem variables[14]n(*lead UG, IGB, ETH)*.

WT 4.3 Experiments to induce episodic events and study responding resilience in LakeLab: Study how artificial episodic, extreme storm events affect physical and chemical conditions and how properties like cyanobacterial blooms or aquatic metabolism respond. Resilience to disturbance will be scaled to the magnitude of the event, which will be varied experimentally. The experimental setup will be based upon criteria from "optimal design", which reduces the number of experimental units and allows parameters to be estimated with reduced bias and variance *(UG, IGB, ETH)*.

WT 4.4 Whole lake manipulation and ecosystem resilience

The simplest way to measure the approach to a potential tipping point would be to measure the recovery time of the system back to its initial equilibrium state following perturbation. This has rarely been studied at whole ecosystem level.

---

[14] Dakos V, Scheffer M, van Nes EH, Brovkin V, Petoukhov V, Held H 2008. Proceedings of the National Academy of Science USA, 105, 14308-14312

We will closely work with lake and reservoir managers in Europe when restoration measures are being implemented and study response and resilience of the ecosystem. (*lead UG, IGB, ETH*).

WT 4.5 Quantifying resilience and application in lake management: develop universal metrics which quantify critical thresholds for the magnitude, frequency and duration of episodic events beyond which lake ecosystem functioning is at risk. The question will be addressed in the context of climate change, particularly episodic events and anthropogenic-induced habitat transformations. "Night Time Light" will be used as a control variable to reflect global anthropogenic impacts on ecosystems. This can be substituted by robust and easy to apply light meters like Sky Quality Meter (SQM), which allow HFM of night time light pollution at local scales[15]. *(lead UG, IGB, ETH).*

Deliverables

D4.1. Effects of episodic events on critical thresholds and resilience (M28)

D4.2 Assessment of thresholds in lake bio-geophysical characteristics (M30)

D4.3 Investigating lakes for resilience: do return times increases when systems approach critical transitions? (M28)

WP Number	5	Start month 7 – End month 42
WP Title	*Informing stakeholders to ensure protection of key ecosystem services in the face of extreme events (Research WP)*	
Lead	**NIOO**	

Objectives: To quantify the management implications of episodic and extreme events and explore mitigation for **two key challenges** for the water sector: increases in DOM loading, and occurrence of toxic algal blooms.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Climatic extremes such as storms, or prolonged heat waves or droughts, can be particularly costly for water managers, while mitigation of their effects will be a pressing need for the sector into the future. Work Package 5**,** therefore, will be **focused on the management implications of episodic and extreme events for two key ecosystem services**: large and more frequent pulses in the export of DOM into lakes during storms, material that can result in formation of DBPs when water is disinfected with chlorine, potentially toxic cyanobacterial blooms related to higher nutrient runoff as well as heat waves. These impacts will compromise sustainable provision of ecosystem services, including healthy water for drinking and irrigation, pleasant water for recreation, and a suitable habitat for wildlife.

WT 5.1 Assessment of the link between extreme events, the input of organic matter from the watershed, and the formation of disinfection-by-products during water treatment (lead ICRA)

WT 5.2 Developing a modelling framework for the assessment of long term threats for water supply from disinfection-by-products and investigation of mitigation measures during extreme events (lead ICRA)

WT 5.3 Develop different mitigation measures making lakes systems more resilient to extreme events (lead NIOO)

WT 5.4 Assess negative impacts of episodic events on degraded ecosystems, in terms of ecosystem services (lead NIOO)

WT 5.5 Identify measures for a benefit oriented rehabilitation plan to increase resilience of degraded lakes (NIOO)

WT 5.6 Increase awareness on how benefits of lake rehabilitation are generated through the development of a tailor made lake version of the Benefit game. This is an interactive card game, during which the players learn from each other, which measures can to be taken to improve certain living qualities and which benefits that will generate (NIOO, W+B).

Description of Deliverables

D5.1 The link between pulses in DOM from the watershed, & the formation of DBPs during water treatment (M32).

D5.2 Dose-effect relationships of rehabilitation measures in current and future climates (M30).

D5.3 Benefit oriented design framework for migrating the negative consequences of extreme (M28).

WP Number	6	Start Month 1 – End Month 48
WP Title	Training and doctoral student support (*Training WP*)	
Lead Beneficiary	**UB**	

Objectives: The overall objective **of WP 6 is to coordinate training in MANTEL.** WP 6 will centralise the definition of personal **Career Development Plans (CDPs),** organise and coordinate the network-wide training activities (training schools and advanced workshops), and monitor ESR progress together with supervisors.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 6.1. Elaboration of the Career Development Plans for each ESR *(Lead: TBD; Participants: all).*

Task 6.2. Organisation of Training Schools, data collection, management and analysis (lead as in 1.2).

Task 6.3. Organisation of three advanced workshops on statistical data analysis and modelling tools, and specific scientific and technical skills required by ESRs (leads as in 1.2).

Task 6.4. Coordination of MANTEL final conference with ESRs focusing on dissemination of research outputs (DkIT).

Task 6.5. Centralised review/monitoring of ESRs training progress, with feedback to ESRs and supervisors (DkIT)

Task 6.6 Awarding of doctoral degrees for the MANTEL ESRs (All)

---

[15] Kyba, C. C., Tong, K. P., Bennie, J., Birriel, I., Birriel, J. J., Cool, A. et al.. (2015). Scientific reports, 5.

Description of Deliverables
D6.1. Personal Career Development Plans for each ESR (M 7)
D6.2. Reports on Training schools & Advanced Workshops (M 9,13,20,25,31)
D6.3. Summary of Final Conference (M 37)
D6.4. Annual reports on ESRs training progress (M 18, 30, 43)
D6.5. Awarding of doctoral degrees (after project end)

WP Number	7	Start Month 1 – End Month 48
WP Title	**Dissemination of MANTEL outputs** *(Dissemination WP)*	
Lead Beneficiary	IGB	

Objectives To disseminate the MANTEL doctoral outputs widely to global researchers and the water industry.

Description of Work and Role of Specific Beneficiaries / Partner Organisations
WP 7 will ensure timely delivery of the Plan for Exploitation and Dissemination of Results (PEDR). This will be overseen by IGB with the help of a dedicated project manager. The two principle scientists from IGB have outstanding publishing records, thus will be role models for the ESRs and will oversee the MANTEL ESR writing group, leading to the peer-reviewed papers for WP 2-5 deliverables.
WT 7.1 Drafting and on-going review of the project PEDR. This will be a working document, and will be drafted at the first project meeting and updated to ensure relevant dissemination. A detailed audit will be undertaken at M18 and measures required to address any gaps in dissemination will be implemented (lead DkIT)
WT 7.2 Drawing on additional expertise in research dissemination at IGB from the IGB doctoral training programme, this partner will contribute to MANTEL ESR training in dissemination (WP 6), and will mentor the PhD students on dissemination within the research community. It will oversee a **writing group** for the ESRs and their supervisors to ensure successful delivery of the MANTEL set of peer-reviewed papers (lead IGB)
WT 7.3 Dissemination to the water sector will include disseminating at World Water Week in Stockholm in year 2. NIOO who have a expertise in research valorisation, will contribute to preparing the ESRs for this. This task will also ensure that a set of policy briefs for the water managers and policy makers are produced.

Description of Deliverables
D7.1 Working project PEDR (M1)
D7.2 Set of policy briefs describing outputs (M38)

WP Number	8	Start Month 1 – End Month 48
WP Title	**Communication of MANTEL outputs** *(Dissemination WP)*	
Lead Beneficiary	UU	

Objectives To foster & facilitate communications between the MANTEL doctoral cohort and the general public.

Description of Work and Role of Specific Beneficiaries / Partner Organisations
WP 8 will draw on the experience of the consortium through their own local initiatives and through the NETLAKE. The project will have an active Facebook and Twitter presence and a project e-newsletter. The ESRs will be encouraged to provide material for dissemination through social media, and will receive training in this in their first Training School, where they will also take part in an initial Thesis in 3 competition for the public, with a second one at the final symposium. Each will also undertake one outreach event at their home institute. They will use protocols developed within NETLAKE, which include use of cheap temperature sensors (ibuttons) to show how temperature can be monitored.
WT 8.1: launch of the MANTEL social media presence (Twitter and Facebook) (lead DkIT).
WT 8.2: Design and launch the website. The public side will have pages targets at the water industry, the research community and the general public (DkIT)
WT 8.3: The MANTEL Thesis in 3 competitions: ESRs will receive training in year 1 to enable them to create a dialogue with society in a jargon-free manner, while explaining often complex ideas to the general public (UU).
WT 8.4: coordination and management of the local events for the general public linked to MANTEL sites and organised by the relevant ERSs (all).

Description of Deliverables
D8.1 MANTEL Facebook and Twitter account (M1)
D8.2 Project website (M3)
D8.3 Symposium Thesis in 3 competition (M36)
D8.4 Media press releases to coincide with MANTEL outreach events (M20 and M40)

Table 3.1 b   Deliverables List

No	Deliverable Title	WP	Name	Type	Dis. Level (target journal)	Due (M)
	Scientific Deliverables					
D2.3	A disturbance index for lake phytoplankton based on anthropogenic factors and changes in meteorological forcing	2	EMÜ	PDE	PU (Limnol & Ocean)	27
D2.1	Morphological controls on in-lake physical responses to atmospheric episodic event	2	DkIT	PDE	PU (Geophys Res. Letters)	28
D4.1	Effects of episodic events on critical thresholds and resilience	4	IGB	PDE	PU (Global Change Biol.)	28
D4.3	Investigating lakes for testing resilience theory: do return times increases as systems approach critical transitions?	4	UG	PDE	PU (PNAS)	28
D5.3	Benefit oriented design framework for migrating the negative consequences of extreme	5	NIOO	PDE	PU (Ecol. Econ.)	28
D2.2	Contribution of aquatic metabolism to lake C emissions in response to weather events of differing severity	2	UB	PDE	PU (Limnol & Ocean)	30
D3.1	Ability of lake models to capture the effects of short-lived episodic events	3	UU	PDE	PU (Ecological Modeling)	30
D3.2	The implications of changes in the microbial community for lake C cycling and metabolism following storms	3	IGB	PDE	PU (Envir. Microbiology)	30
D5.2	Nutrient dose-effect relationships of rehabilitation measures in current and future climates	5	NIOO	PDE	PU (Water Research)	30
D4.2	Assessment of thresholds in lake bio-geophysical characteristics	4	UG	PDE	PU (Climatic Change)	30
D5.1	Assessment of pulses in organic matter from the watershed and the formation of DBPs during water treatment.	5	ICRA	PDE	PU (Water Research)	32
D2.4	How do episodic events control microbial communities on the Atlantic fringe of Europe?	2	DkIT	PDE	PU: (Limnol & Ocean)	32

No.	Deliverable Title	WP	Name	Type	Dis.Level	Due Date (M)
	Management, Training, Recruitment and Dissemination Deliverables					
D1.1	Consortium Agreement	1	DkIT	ADM	CO	1
D7.1	Working PEDR	7	IGB	R	PU	1
D8.1	MANTEL Facebook/Twitter live	8	DkIT	PDE	PU	1
D1.2	Plan for recruitment including advertising	1	DkIT	ADM	CO	3
D8.2	Website online	8	DkIT	PDE	PU	3
D1.3	EJD supervisory agreements	1	DkIT	ADM	CO	6
D6.1	Personal Career Development Plans	6	UB	ADM	CO	7
D6.2	Reports: Training Schools & Advanced Workshops	6	UB	R	PU	9,13,20,25,31
D1.5	Reporting on project activities and impacts	1	DkIT	ADM	PU	12,24,36, 48
D6.4	Annual reports on ESRs training progress	6	UB	R	PU	18,30,33
D8.4	Press releases for MANTEL outreach events	8	DkIT	PDE	PU	20/40
D1.4	Financial reports	1	DkIT	ADM	PU	24, 48
D6.3	Summary of Final Conference	6	UB	PDE	PU	36
D7.2	Set of policy briefs describing outputs	7	IGB	PDE	PU	38
D8.3	Symposium Thesis in 3	8		PDE	PU	36
D6.5	Awarding of doctoral degrees	6	All	Other	PU	Post ITN

Table 3.1 c   Milestones List

Number	Title	WP(s)	Lead	Due Date	Means of Verification
M1	Kick-off meeting	All	DkIT	1	Meeting minutes
M2	MOA on joint PhDs	All	DkIT	2	Signed MOAs
M3	All ESRs recruited	All	DkIT	7	All ESRs on DkIT smartsimple
M4	Completion of Network training	6	UB	30	All training reviews complete
M5	Submission of MANTEL papers	2-5, 7	All	32	All papers in review
M6	MANTEL symposium	2,3,4,5,7	IGB	36	Symposium summary report
M7	Delivery of doctoral degrees	All	DkIT	Post ITN	Successful defence for 12 ESRs

Table 3.1d for Individual Research Projects

Fellow ESR 1	Host DkIT	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D2.1

Project Title and Work Package(s) to which it is related:
Time scales of physical change in the lake environment (WP 2)

Objectives: water column stratification patterns in lakes fundamentally affect how lakes function[16]. Traditional lake monitoring typically occurs at weekly or lower frequency, and patterns of stratification and mixing when viewed through this low frequency filter appear to show gradual seasonal change. We believe that these patterns are strongly influenced by short-lived episodic events that occur over short time intervals, but have much longer lasting effects. These two types of change, gradual vs. episodic, can lead to very different levels of environmental stability while in the end accounting for similar seasonal patterns of thermal structure. **Overall aim:** to test the hypothesis that changes in lake thermal structure are strongly affected by short lived episodic events and develop indexes of environmental change and stability based on differences in water temperature (density). This PhD will also identify the time scales that must be considered in modelling episodic events (WP 3). **The specific objectives are to:**

- Analyse high frequency lake water temperature records to define the distribution of stratification events by both magnitude and duration. Thresholds derived from these distributions will be used to define periods of mixing and calm.
- Analyse return period of events of different magnitude, and the duration of relatively calm periods between mixing.
- Examine seasonal variation in lake thermal structure accounting for episodic changes and how these patterns and the role of episodic events vary between lakes with different climate and morphometry.

Expected Results:
Indices of physical change in lake thermal structure.
Morphological controls on in-lake physical responses to atmospheric episodic event (D2.1)

Planned secondment(s):
1. CEH (Dr Ian Jones); M 13-15 (3 months); training in lake physics and data analysis with co-supervisor.
2. UU (Dr Don Pierson); M 19-20 (2 months); data collation and analysis.
3. CEH (Dr Ian Jones); M 25-26 (2 months); data analysis with co-supervisor.

Fellow ESR 2	Host UB	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D2.2

Project Title and Work Package(s) to which it is related:
Effects of major weather events on relationship between carbon emissions and aquatic heterotrophy in lakes (*WP 2, WP 3*)

Objectives: the metabolism of lakes and reservoirs has received major attention in the last decade to understand net heterotrophy derived from terrestrial organic matter inputs and the role of inland waters as C sources to the atmosphere. Recently processes other than aquatic metabolism have received attention as potential drivers of C emissions, e.g. hydrological inputs of inorganic C from different sources[17]. While this is a topic under debate, most of the contributions to this have relied on low-frequency approaches. This contrasts with evidences on the fast response of aquatic ecosystem functioning or C cycling to major yet infrequent weather-related events, either in terms of community composition, metabolism, and carbon fluxes[18], or of fast organic matter transport downstream the fluvial networks (Pulse-shunt concept[19]). The **overarching aim** of this project is to understand the effect of weather-derived events on the contribution of aquatic ecosystem metabolism to lake and reservoir C fluxes at short time scales. It includes major water inputs after high rainfall events, fast changes in mixing dynamics and ice-off events. Alternating locations between UB and EMÜ will ensure the ESR gets the necessary skills on lake metabolism and gas flux calculations, modelling of catchment hydrology and management and analysis of HFM data. The analysis of in-lake high-frequency data in contrasting catchments (lithology and land uses) combined with model-derived data for organic matter transport and processing along the fluvial network and *in situ* monitoring gas fluxes is the basis for this project, which aims at discerning purely physical and hydrological effects of rainfall events from internal responses based on changing ecosystem functioning.

Expected Results:
Contribution of aquatic metabolism to lake C emissions in response to weather events of differing severity (D2.2).
Quantification of contribution of metabolic vs non-metabolic processes to lake C fluxes in contrasting catchments

Planned secondment(s):
1. EMÜ (Dr Alo Laas); M 15-20 (6 months); training and data collation with co-supervisor.
2. EMÜ (Dr Alo Laas); M 29-30 (2 months); data analysis with co-supervisor.
3. MI (Dr Elvira de Eyto); M 24 (1 month); Feeagh data analysis.

---

[16] Law, R. J., Elliott, J. A., Jones, I. D., & Page, T. (2014) Fundamental and Applied Limnology/Archiv für Hydrobiologie, 185, 139-153.
[17] Marce, R., B. Obrador, J.-A. Morgui, J. Lluis Riera, P. Lopez & J. Armengol, 2015. Nature Geosci 8: 107-111
[18] Lennon, J. T. & K. L. Cottingham, 2008. Ecology 89:1001-1014
[19] Raymond, P. A et al. 2013. Nature 503: 355-359

Fellow ESR 3	Host EMÜ	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D2.3

Project Title and Work Package(s) to which it is related:
The sensitivity of differing lake types and their phytoplankton dominants to the strength and frequency of environmental disturbance (WP 2, WP 3).

Objectives: the aims of this project are to 1. establish an index to quantify potential environmental disturbance in relation to the dominant phytoplankton species based on day-to-day changes in meteorological and hydrological forcing and mapping this index retrospectively at a regional/European scale; 2. identify how sensitive lake metabolism and the equilibrium state of phytoplankton are to potential environmental disturbance depending on lake type parameters and lake status parameters and 3. assess the influence of the dominant phytoplankton taxa on lake metabolism. To accomplish this, the student will (a) develop a conceptual framework for selecting disturbance factors and create an algorithm for combining them into an index; (b) estimate lake metabolism based on in-situ HFM dissolved oxygen data and analyse the dominance structure of phytoplankton in a number of lakes of different types; (c) run enclosure experiments measuring metabolism of phytoplankton communities dominated by different taxa (d) apply adequate statistical analysis (WP 2) and use modelling tools (WP 3) for identifying episodic events, testing relationships between disturbance levels and episodic events, and between phytoplankton community structure and metabolism.

Expected Results:
A disturbance index for lake phytoplankton based on anthropogenic factors and changes in meteorological forcing (D2.3)
A lake type specific sensitivity scale for disturbance
Assessment of the influence of phytoplankton taxa on metabolism in lakes along a latitudinal gradient.

Planned secondment(s): Host, supervisor, timing, length and purpose
1. UB (Dr Biel Obrador); M15-20 (6 months); training and experimental work with co-supervisor.
2. UB (Dr Biel Obrador); M 29-30 (2 months); data analysis with co-supervisor.
3. CEH (Dr Ian Jones); M 24 (1 month); UK lake data analysis and modelling work.

Fellow ESR 4	Host DKIT	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D2.4

Project Title and Work Package(s) to which it is related:
Aquatic microbial community responses to episodic events in Atlantic humic catchments (WP 2)

Objectives: peatland (humic) catchments are characteristic of the North-eastern Atlantic fringe of Europe. These aquatic ecosystems are sustained by carbon inputs from terrestrial sources[20], and therefore microbial heterotrophy plays an important role in controlling lake productivity[21, 22] and in determining emissions of CO_2 and CH_4. Many such lakes are also sources of potable water, and are key habitats for salmonid fish. In Europe, much of our current understanding of carbocentric limnology comes from humic systems in Nordic countries where year round monitoring is limited by winter ice. In contrast, little is known about more temperate systems, where warmer winter temperatures and a lack of ice may have surprising implications for biogeochemical processes such as annual greenhouse gas fluxes. Our ability to assess climate change consequences is still limited by a fundamental lack of knowledge about the diversity and abundance of microbial communities, and the role that episodic events have in controlling community dynamics. Development and testing of specific hypotheses for this ESR will be carried out at LakeLab, while they will also benefit from a focussed fieldwork program based in the Burrishoole catchment (IE) which is situated at the western extreme of Europe. Proximity to the Atlantic means that lakes here track oceanic teleconnections and are subject to frequent storms with wind mixing and heavy precipitation. The use of this site enables the real-world testing of hypotheses developed using mesocosms, and the scaling up of conclusions to a catchment and ecoregion level. The **overarching objective** of this project is to obtain new insights into the role that aquatic microbial communities play in processing autochthonous and allochthonous carbon sources in a western humic catchment. Specific objectives include 1. to explore changes in the lake microbial community following inflows od carbon and 2. how disruption of these communities following climatic episodic events.

Expected Results:
Multi-annual monitoring (abundance and diversity) of aquatic microbial community in Lough Feeagh
How do episodic events control microbial communities on the Atlantic fringe of Europe (D2.4)

Planned secondment(s):
1. IGB (Prof. Hans Peter Grossart); M 13-14 (2 months); microbial training/experimental work with co-supervisor.
2. IGB (Prof. Hans Peter Grossart); M 25-28 (4 months); microbial training and writing.
3. UB (Dr Biel Obrodor);, M19-20 (2 months); metabolism modelling.

[20] Ryder, E., de Eyto, E., Dillane, M., Poole, R. & Jennings, E. 2014. Sci. Total Environ. 490, 28–36.
[21] Sparber, K. et al. 2015. Inland Waters 5, 295–310.
[22] Solomon, C. T. et al. 2013. Limnol. Oceanogr. 58, 849–866.

Fellow ESR 5	Host UU	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D3.1

Project Title and Work Package(s) to which it is related:

Modelling the impacts of atmospheric episodic events on the thermal response of lakes (WP 3)

The **overall aim** of this project is to assess the effects of changes in the duration and intensity of episodic climatic events for physical processes in European lakes using dynamic modelling.

Specific objectives include:

- to use existing *in-situ* HFM lake and atmospheric data to calibrate and validate the effectiveness of 1-D physical lake models (e.g. MyLake, GLM) to simulate episodic events in lakes and assess limitations of model time step length.
- using one year of Lake Erken data as a control, run and automate a process for systematically perturbing different meteorological variables at different times of year to investigate the impact of episodic atmospheric events on physical lake parameters such as mixed depth, surface temperature, stability etc.
- repeat this process using annual datasets to assess sensitivity of thermal profile to the natural variability in weather.
- assess for other MANTEL lakes across Europe to explore the morphological and geographic influences on impacts.

Expected Results:

New understanding of impacts of short term changes in atmospheric drivers on the physical characteristics of lakes.

The ability of lake hydrothermal and water quality models to capture the effects of short-lived episodic events (D3.1).

Planned secondment(s):

1. CEH (Dr Ian Jones); M 13-15 (3 months); training in lake physics and data analysis
2. NIVA (Dr Raoul Couture); M9 & 26 (2 by 1 month periods); training in MyLake model
3. UG (Prof. Martin Beniston); M 17-18, 27-28, 33-34 (3 x 2 month periods) training lake modelling, co-supervisor.

Fellow ESR 6	Host IGB	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D3.2

Project Title and Work Package(s) to which it is related:

Effect of storm events on microbial dynamics and ecosystem functions in lakes. (WP 3)

Objectives: it is still unknown how extreme weather events such as storms will affect a lake's function as a carbon source or sink. Current estimates suggest that lakes globally emit between 8–48 Tg CH_4 yr^{-1} (equivalent to 6–16% of total natural methane emissions) which is greater than oceanic methane emission[23]. There are indications that storms can severely alter greenhouse gas dynamics[24] and alter phytoplankton and microbial dynamics. The LakeLab mesocosms are fully equipped with automatic profilers allowing for a high temporal and spatial monitoring of all important limnological variables including phytoplankton dynamics. A preliminary experiment, mimicking a storm event in July 2014, led to the formation of a massive cyanobacterial bloom (*Dolichospermum flos-aquae*) which resulted in alteration of microbial dynamics and hence C-cycling, and in particular changes in calcite precipitation rendering the lake from a C-sink to a C-source. The **overall objective of this project** is to study the **microbial** response to simulated mixing events in different seasons to better evaluate the effect of mixing in both the productive (summer) and less productive (winter) seasons (**contributing to WT 3.2).** Specific objectives include:

- To carry out a set of experiments informed by current/projected intensity and duration of storm events at MANTEL sites.
- To collect and collate profiler data (temperature, pH, conductivity, oxygen, PAR, pigments, turbidity etc.).
- Observe changes in the microbial community structure (next generation sequencing and microscopic counts) and activities (gross primary production, net ecosystem respiration, bacterial production, sedimentation and whole lake metabolism).

Using these data, evaluate whether future storm events have the potential to significantly alter ecosystem dynamics and function rendering lakes from C-sources to C-sinks.

Expected Results:

Assessment of the effects of future storm events on microbial populations and activities.

The implications of changes in the microbial community for lake C cycling and metabolism following storms **(D3.2)**

Planned secondment(s):

1. DkIT (Dr Eleanor Jennings); M 13-14 (2 months); data analysis with co-supervisor.
2. MI (Dr Elvira de Eyto), M 15-16 (2 months); training in lake metabolism calculations/use of Lake Metabolizer.
3. DkIT (Dr Eleanor Jennings); M 20-22 (3 months); data analysis with co-supervisor.

[23] Bastviken, D., Cole, J, Pace, M, Tranvik, L (2004) Global Biogeochem. Cycles 18, 4, DOI: 10.1029/2004GB002238.

[24] McGinnis, DF, Kirillin, G, Tang, KW, Flury, S, Bodmer, P, Engelhardt, C, Casper, C, Grossart, HP (2015) Environmental science & technology 49 , 873-880.

Fellow ESR 7	Host institution IGB	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D4.1

Project Title and Work Package(s) to which it is related:

Determination of critical thresholds for ecosystem resilience *from* long term HFM datasets (WP 4)

Objectives: long-term changes are often of a non-linear nature, surpassing critical thresholds and leaving systems in a different state[25][26] often with temperature as a main forcing for a cascade of abrupt environmental changes[27]. We know little about the temporal scales we need to consider for detecting change[28] in resilience and how extreme events contribute to long term trends and variability in ecosystem functionality. This ESR will use HFM data to study the effects of episodic events on algal mass and lake metabolism as a proxy of ecosystem functionality, using the Metabolic Theory of Ecology[29] as a universal concept. Moreover, they will test how general anthropogenic pressure, measured here as Night Time Light (NTL; data derived from nighttime satellite imagery (DMSP-OLS) acts to erode ecosystem resilience and brings the system closer to a critical transition. High taxonomic resolution records will allow them to study the role of episodic events in the context of known long-term trends (30+ years) and short term recovery- and link overlapping effects of climate and other anthropogenic induced responses to overall ecosystem functionality. The **overall objective** is to quantify critical thresholds of the amplitude and frequency of episodic events affecting algal development and test whether a very general available proxy such as NTL can be used to capture human interferences with lake ecosystem functionality and resilience. Specific objectives include:

- Empirically test recovery rate (resilience) of algal blooms and metabolic balance after episodic events.
- Empirically test if HFM of NTL can be used as universal proxy of environmental change affecting ecosystem functionality.
- Develop an index predicting ecosystem resilience to long term change and short term episodic events.

Expected Results:

Effects of episodic events on algal bloom formation & lake metabolism; quantification of critical thresholds and resilience (return time). (D4.1)

Index development based on water temperature and NTL which quantifies shifts in ecosystem functionality and resilience.

Planned secondment(s):

1. UG (Prof. B. Ibelings; Prof. M. Beniston); M13-14 (2 months) data acquisition and analysis.
2. UG (Prof. B. Ibelings; Prof. M. Beniston); M 21-22 (2 months) data analysis.
3. ETH (Dr Vasilis Dakos); M 18 (1 month); training in resilience theory.

Fellow ESR 8	Host UG	PhD enrolment Y	Start date 7	Duration 36	Deliverables 4.2

Project Title and Work Package(s) to which it is related:

Assessing future effects on lake ecosystem resilience using data analysis and dynamic modelling (WP 2, WP 3, WP 4)

Objectives: highly non-linear systems such as climate are invariably characterized by thresholds, some that may be irreversible often referred to as "tipping points". There is therefore a need to explore more fully the role of non-linear behavior in particular on the advent of extreme events that could have an impact on the response of lake waters. In mid-latitude regions, lake physical, chemical and biological characteristics can be significantly disrupted when subjected to intense/persistent heat-waves, and both extremes of precipitation (droughts and floods). However, even in the absence of extreme events, the long-term rise of atmospheric temperatures can also lead to sustained changes in lake functioning through increased stable stratification in the upper layers of a lake. This can lead to a progressive shift towards a situation where the wintertime overturning of surface waters and the oxygenation of deep waters no longer occurs. The **overall objective** of this project will be to identify thresholds in lake biogeophysical characteristics that could be induced either by progressive changes in climate or through shorter-lived extremes, assess whether these are irreversible or not, and investigate future changes in these extremes on tipping points. The following tasks will be undertaken:

- Assess HFM data for lakes and the neighbouring atmosphere to identify past climate-induced tipping points.
- Use these data to calibrate coupled atmosphere-lake models previously developed and used at the University of Geneva
- Run models in predictive mode to investigate the role of projected changes in climates on the biogeophysical response.

Expected Results:

Assessment of thresholds in lake bio-geophysical characteristics (D4.2)

Future climate simulations of in-lake responses using a coupled atmosphere-lake model

Planned secondment(s):

1. UU (Dr Don Pierson); M 11-13 & 23-25 (2 x 3 months); sensitivity analysis of coupled lake atmospheric models: comparison with Swedish sites and models with cosupervisor.
2. ICRA (Dr. Rafael Marcé); M 29-31 (3 months); uncertainty analysis on climate-lake coupled models.

[25] Dakos V, Carpenter SR, Brock WA, Ellison AM, Guttal V, Ives AR, et al. 2012. PLoS ONE 7(7): e41010. doi:10.1371/journal.pone.0041010.

[26] Scharfenberger, U., A. Mahdy, and R. Adrian. 2013. Limnol. Oceanogr 58:741-752.

[27] Reid et al. Global impacts of the 1980s regime shift. *Global change biology*. DOI: 10.1111/gcb.1310

[28] Adrian et al. (2012). Windows of change: Marine Biology: 159:2533–2542.

[29] Brown et al. 2004. Ecology 85 : 1771-1789.

Fellow ESR 9	Host ICRA	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D5.1

Project Title and Work Package(s) to which it is related:
Managing the impacts of extreme events related to inputs of organic matter on the Ecosystem Services provided by water supply reservoirs (WP 5: also WP 2, WP 3)

Objectives: the overall objective is to establish the casual link between extreme events, the input of organic matter from the watershed into water supply reservoirs, and the formation of DBPs during water treatment. To accomplish this, the PhD will apply state-of-the-art statistical analysis (WP 2) and modelling tools (WP 3), with also a focus on the future impacts on extreme events considering climate change projections. They will take advantage of the impressive long term record in Sau Reservoir (ES), with almost uninterrupted measurements since 1964, and also the high frequency records started in 2015 under the umbrella of NETLAKE. This will be fully supported by ATLL, the water supply company that manages the reservoir, who will also contribute an impressive on-line, high frequency analytical system for detecting DBPs after the treatment of reservoir water. The **final aim** is to quantify and predict the impact of extreme events on the Ecosystem Service at play (water supply) using the costs related to the avoidance of DBPs in treated water as an end-point for the analysis. The prediction of extreme events at the seasonal time scale (expertise provided by partner BSC) will be the keystone for assessment of the long term threat for water supply and the investigation of mitigation measures during extreme events both at the strategic and operational level. We want to use this case study as a flagship exemplifying how data collection and treatment from natural to engineered systems helps protect Ecosystem Services from threats posed by extreme events.

Expected Results:
Assessing link between extreme events, input of organic matter, and the formation of DBPs during water treatment (D5.1)
Modelling long term threats for water supply from DBPs and investigation of mitigation during extreme events at both operational and strategic levels

Planned secondment(s):
1. ATLL (Juan Carlos García); M9 (1 month); familiarisation with water treatment & focus from the company perspective.
2. BSC (Albert Soret) M18-20 (3 months); training on seasonal climate prediction.
3. NIOO (Dr Lisette de Senerpont Domis); M13-15 & 25-27 (2 x 3 months); training on ecosystem services.

Fellow ESR 10	Host NIOO	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D5.2

Mitigating negative impacts of extreme events on the sustained provision of lake ecosystem services (WP 5; WPs 2 and 3)

Objectives: this project will support stakeholders through development of measures that mitigate the negative consequences of extreme events, including toxic cyanobacterial blooms, and runoff induced high nutrient loads. Lowering the trophic status of surface waters is expected to increase resilience against predicted global warming and therewith to reduce problematic cyanobacterial blooms[30][31]. Cost-efficient mitigation calls for a tailor made benefit oriented restoration plan, building on an arsenal of restoration techniques, combined with innovative techniques. A very promising way of moving lakes to an oligo/mesotrophic state is by using geo-engineering techniques that reduce cyanobacterial biomass and bioavailable phosphorus[32][33]. **The overall objective of the project is** to test the hypothesis that such rehabilitated waters are not only more resilient to increased water temperatures, but also to pulsed inflows of nutrients. Experiments will be conducted in highly controlled indoor mesocosms – so called "Limnotrons" that all will start eutrophic, including nutrient rich sediments: half will be treated (rehabilitated) and exposed to four temperatures ranging from low summer (20°C), normal (23°C), warm (26°C) and extreme (29°C). Effects of heat wave events and pulsed summer rain events (dilution and nutrient enrichments) will be studied. In addition, to gain a better understanding of cost-efficient mitigation, the ESR will have access to HFM data of the catchment area Mark-Vliet-Dintel, and Volkerakzoommeer-Binnenschelde, two areas where rehabilitation projects are ongoing. To detect the negative impacts of episodic events on these degraded systems, a modelling framework will be developed. The results will give a much needed management perspective of both the Dutch water board Brabantse Delta as well as the drinking water company ATLL.

Expected Results:
Dose-effect relationships of rehabilitation measures in current and future climates systems (D5.2)
Timeseries modelling framework for the assessment of consequences of episodic events on degraded catchment areas

Planned secondment(s):
1. WU (Dr Miquel Lurling); M 7-9, 17-19, 29-31 (3x3 months); experimental work.
2. BD (Jaap Oosthoek); M11, M23 (2x1month); familiarisation with industry, data access.
3. ICRA, (Dr Rafael Marcé); M13-15, M 25-27 (2x3 months); training in modelling with co-supervisor.

---

[30] Lisette N De Senerpont Domis, et al. 2013. Freshwater Biology 58 463-482.
[31] Lisette N De Senerpont Domis, et al. 2014. Ecology 95 6 1485-1495.
[32] Lürling, Miquel, and Frank van Oosterhout. *Hydrobiologia* 710.1 (2013): 253-263
[33] Waajen, Guido, et al. *Water research* (2015).

Fellow ESR 11	Host NIOO	PhD enrolment Y	Start date Month 7	Duration 36 months	Deliverables D5.3

Project Title and Work Package(s) to which it is related:

Towards benefit oriented rehabilitation to make degraded lakes more resilient to extreme events (WP5; also WPs 2 and 3)

Objectives: How can we make our lakes more shock resistant, so that society will not have to suffer the negative consequences such as toxic algae blooms that compromise recreation or the preparation of drinking water? Building on the science in MANTEL, ESR 11 focuses on the socio-economic aspect of rehabilitation measures. They will pay special attention to the reality that an effective set of physical measures is not the only precondition for high societal benefits. Social aspects such as access to the lake, legal restrictions for entrepreneurs, and division of costs and benefits for stakeholders, play an equally important role. This ESR will make an inventory of the key determining social design factors that determine the success (in terms societal of benefits) of lake restorations. They will determine the benefits of increasing the resilience of three study systems; i.e. Mark-Vliet-Dintel catchment (NL), Volkerakzoommeer-Binnenschelde catchment (NL), and Sau reservoir catchment (ES). These systems from North-western Europe as well as Southwestern Europe, offer different constraints to how benefits can be determined. Close collaboration with ICRA (Dr Vicenç Acuña) will ensure that this is recognized. Secondly, using expertise from the consortium they will identify measures that lead to these benefits. Thirdly, to create awareness on how benefits of lake rehabilitation are generated they will update the existing **Benefit Game** developed by the consultancy firm W+B. This interactive card game covers a wide range of measures and qualities, varying from water quality, safety, mobility, cultural heritage, nature quality to social qualities such as social participation. **The main objective** is to provide a decision support framework that allows both stakeholders as well as researchers to come to a benefit-oriented rehabilitation plan to make degraded lakes more resilient to extreme events.

Expected Results:

Benefit oriented design framework for migrating the negative consequences of extreme events (D5.3)
Tailor made version of the benefit game for lakes

Planned secondment(s):

1. ICRA (Dr Vicenç Acuña); M13-15, 24-26 (2x3 months); training in ecosystem services at Spanish sites with supervisor.
2. W+B (Dr Elisabeth Ruijgrok); M 9; M20; M28 (3X1 month).

Fellow ESR 12	Host UG	PhD enrolment Y	Start date Month 7	Duration 36	Deliverables D4.3

Project Title and Work Package(s) to which it is related:

Determination of critical thresholds for ecosystem resilience from perturbation experiments: (WP 4)

Objectives: Perturbation experiments are the most straightforward way to measure critical slowing down (www.early-warning-signals.org), the most reliable empirical indication that the system approaches a critical transition. It has been shown in simple perturbation (pulse) experiments that the difference in return time varies greatly between a situation where a system is far from - vs. close to - a transition. We will start by making use of LakeLab which offers experimental control, while being large enough to approach natural levels of complexity. This ESR will manipulate the physical stability of the water column, mimicking the effect of storms. Experimental design in LakeLab will be following criteria from "optimal design", which allows parameters to be estimated with minimum variance and bias. The response in metabolism and the phytoplankton community will be studied at both low and high nutrient levels, since theory predicts that eutrophication reduces resilience and brings systems closer to a tipping point[34]. The next and final level of (natural) complexity will be studied by performing whole lake manipulations. Resilience and critical slowing down have rarely been studied at whole ecosystem level. The ESR will closely work with lake and reservoir managers and study response and resilience of the ecosystem. Preference will be given to systems where radical restoration measures are planned, for example installation of artificial mixing, or use of hydrogen peroxide to selectively remove cyanobacteria[35].

Expected Results:

Investigating lakes for testing resilience theory: do return times increases as systems approach critical transitions? (D4.2)
A set of metrics quantifying critical thresholds at which episodic events affect key ecosystem properties, and beyond which lake ecosystem functioning is at risk.

Planned secondment(s): *Host, supervisor, timing, length and purpose*

1. IGB (Prof. Rita Adrian); M 13-15 (3 months); experimental design & statistical analysis with co-supervisor.
2. ETH (Dr Vasilis Dakos); M 18 (1 month); training in resilience theory.
3. NIOO (Dr Lisette de Senerpont Domis); M 21-23 (3 months); training on restoration for whole lake manipulations.

---

[34] Scheffer, M., Carpenter, S., Foley, J. A., Folke, C., & Walker, B. 2001. Nature, 413, 591-596.
[35] Matthijs, H.C. et al. 2012. Water Research 46, 1460-1472.

3.2 Appropriateness of the management structures and procedures, including quality management and risk management (with a mandatory joint governing structure for EID and EJD projects)

3.2.1 Network organisation and management structure: The Coordinator will be responsible for overall management (financial management, administrative requirements including Contract & Consortium Agreement) and will ensure communication between partners. The Management Structure is outlined below (Fig. 8). **The Supervisory Board (SB)** will have members from all beneficiaries and partners and an ESR representative. It will undertake high-level decision making and is the ultimate decision body in the project. The SB is chaired by the Coordinator who will also act as the intermediary between the EC and the MANTEL EJD. The Coordinator will be supported by a recruited Project Manager. The SB will receive inputs from the Project Management Committee and the Training WP Leader (UB) at each SB meeting. Eight of the SB meetings will be organised during the project (see GANTT). The SB will ensure a high level of interaction between all of the partners and will be responsible for: Quality of the Research and Training Programme; Ensuring that each and every ESR receives the appropriate training and secondment; Delivery of milestones and deliverables listed in Table 3.1b; Recruitment of ESRs by month 6 consistent with the European Charter and Code for Researchers[8]; the supervision of the ESRs. It will monitor and evaluate the scientific progress of each project and ensure that the principles of research integrity are adhered to, and deal with any research misconduct in line with local and European policies.[36] [37] **The Project Management Committee (PMC)** comprising Coordinator, Project Manager and Financial Officer (DkIT) will undertake day-to-day management, support open communication, manage finance and risks, report to the EC, support administrative, personnel and legal issues for the consortium. It will manage meetings of the SB and AC and be ultimately responsible for ensuring milestones and deliverables are met on time and compliance on all financial matters. **Academic Committee (AC):** Comprised of the academic supervisors for each ESR, this will be specifically responsible for ensuring that each project is successfully launched and managed in relation to awarding university requirements. **ESR Committee (ESRC): Comprised of the ESRs, the Training WP leader and the Coordinator,** this will raise any concerns to the AC from ESRs in relation to their programme or facilities in their hosts/secondments, ensure the effective progress monitoring of the ESRs, and provide feedback and deal effectively with any issues of concern between the ESRs and their supervisory teams. The Training WP Lead will fulfil the role of the 'ombudsperson' for ESRs and will deal with complaints or appeals.
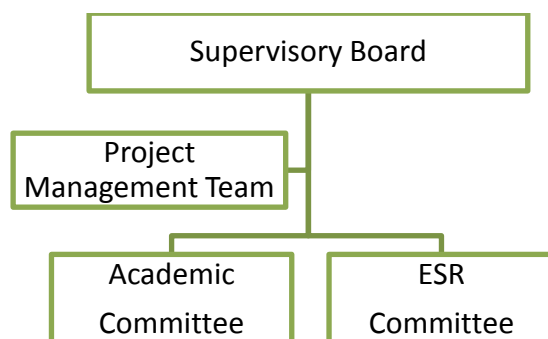

Fig. 8: PERT chart of management in the MANTEL EJD

3.2.2 Quality management of training:

The SB will bear ultimate responsibility to ensure the quality of training. Network-wide training will be reviewed and managed by the WP 6 leader. Feedback will be gathered using forms completed by ESRs after events, and by inviting comments from ESR representatives at annual meetings. Additionally, all ESRs and other participants will be invited to contact the Training leader on an *ad hoc* basis. The Training leader will act as the ombudsperson for the ESRs and will deal with all aspects of provision including quality, relevance and appropriateness.

3.2.3 Recruitment strategy:

Recruitment will begin immediately following notification of funding (May 2016). ESRs will be appointed to their host institutions in 1 block within 7 months of the beginning of the EJD. This will allow time for finalising institutional agreements, advertisement, shortlisting, recruitment and appointment. The Coordinator (DkIT) and several recruiting beneficiaries (UB, IGB, ICRA and CEH) and the degree awarding bodies (DCU, WU) have achieved the HR Excellence in Research Logo and will conduct a transparent and merit-based recruitment process in accordance with the 40 principles of the European Charter for Researchers and Code of Conduct for Recruitment

---

[36] http://www.iua.ie/wp-content/uploads/2014/06/National-Policy-Statement-on-Ensuring-Research-Integrity-in-Ireland-2014.pdf

[37] http://www.esf.org/fileadmin/Public_documents/Publications/Code_Conduct_ResearchIntegrity.pdf

of Researchers. Recruitment will be managed centrally by the Supervisory Board. Advertisements will give a broad description of knowledge and competencies required, but will not be so specialised as to discourage suitable applicants. Host Institutions will include a description of working conditions and entitlements, and career development prospects. The time allowed between call for applications and the deadline will be realistic. We recognise that the EU Research Area must draw the best researchers from all societal groups if research is to be of the highest quality, relevant to users and of benefit to the EU economy. Vacancies will be advertised widely using both printed and electronic media. Publicity will highlight the equal opportunities policy of MANTEL. We will also post announcements via various national and international channels (e.g. Euraxess Gateway, Nature.com), the MANTEL website and the GLEON and NETLAKE networks, as well as our extensive academic and industrial links.

3.2.4 Selection and appointment of trainees:
Applications will include a Motivation Letter explaining background and future career interests, a Curriculum Vitae, an official copy of degree(s) (if applicable an official English translation), course transcripts (if applicable an official English translation) and an English proficiency test result. Applications will be considered (eligibility check) only if candidates fulfil the requirements for Early Stage Researchers as defined in the People Work Programme 2016-2017. Applications will be screened using eligibility criteria based on Marie Skłodowska Curie rules for mobility and previous experience to ensure transparency and equality of selection. MANTEL will ensure that Selection Committees at each institution will harness diverse expertise and competences, have an adequate gender balance and, where appropriate and feasible, include members from different sectors (academic and non-academic), including from other countries and with relevant experience. Whenever possible, a wide range of selection practices should be used, such as external expert assessment and face- to-face interviews. MANTEL will ensure a gender balance in recruitment and harness the experience of all researchers within the partnership.

3.2.5 Progress monitoring and evaluation of individual projects:
Progress monitoring for ESRs will be standardised and will include weekly lab meetings, and monthly meetings with Supervisors with input from collaborators via videoconferencing. A quarterly progress report (completed by ESR and reviewed in conjunction with Supervisor) will be used to inform the SB of progress. Progress at a network level will be reviewed every 6 months by the SB as informed by WP leaders. Each project will be monitored by the Supervisory Team associated with that ESR. Initially there will be an assessment of each ESR's competencies in order develop a CDP for the full 36 months. This will follow the Marie Skłodowska Curie model: research results; research skills and techniques; research management; communication skills; other professional training; networking opportunities and other activities with professional relevance. Day to day research supervision, 6-months monitoring, and meetings will take place between the supervisor and the ESR to evaluate progress required to reach the objectives in the CDP. The Supervisory Board and ESRs will carry out a final evaluation at the end of the appointment to ensure that the objectives have been reached. The SB will ensure that there is support given to the ESRs after the end of their appointment to support their future career development.

3.2.6 Strategy for dealing with scientific misconduct:
Participants will adhere to their own institutional and national policies for dealing with scientific misconduct[38]. Reporting of alleged scientific misconduct to relevant institutions will be coordinated by the SB.

3.2.7 Risk management at consortium level (including table 3.2a):
Effective communication and decisive action is crucial to the successful progress and completion of MANTEL and will be ensured by; (i) having a clearly defined management structure (Fig. 8) (ii) having a Consortium Agreement, to be signed post-award, that clearly defines the roles and expectations of each member (iii) use of video conferencing, email and social media to organise regular meetings of the consortium.

3.2.8 Financial management strategy: To date, the coordinating partner (DkIT) has participated in 16 EU projects totalling in excess of €9.6 million. It has extensive experience of EU funded projects and in-depth expertise in financial management, reporting, auditing and researcher agreements. The Research Office at DkIT has a dedicated European Framework Programme administrator and two EU funding accountants, who will support the Coordinator. This will ensure prompt transfer of payments and the preparation of financial statements.

3.2.9 Gender: All participants have equal opportunities policies that are rigorously adhered to. We will take all necessary and reasonable measures to ensure that gender balance is reflected in the recruitment of ESRs. In addition, as outlined in Section 3.2.4 Selection and appointment of trainees to MANTEL will ensure the following: (i) the Selection Committee will have equal numbers of men and women; (ii) the underrepresented candidate will

---

[38]http://www.iua.ie/wp-content/uploads/2014/06/National-Policy-Statement-on-Ensuring-Research-Integrity-in-Ireland-2014.pdf;
http://www.esf.org/fileadmin/Public_documents/Publications/Code_Conduct_ResearchIntegrity.pdf

be chosen when two candidates are of equal calibre; (iii) flexible working will be offered to trainees with changing family circumstances; and (iv) training actions will include female keynote speakers.

3.2.10 Exploitation of results and intellectual property: All new datasets generated will be made available through open access data repositories.

3.2.11 Management of intellectual property: MANTEL anticipates that the Benefit Game developed by Partner W+B (adapted by the MANTEL programme) will have commercial potential. It will be the responsibility of the relevant Technology Transfer Office (or equivalent) to fully assess the IP arising. Any IP will be managed according to the Consortium Agreement (DESCA Format) of MANTEL following successful award of funding.

Table 3.2a Implementation Risks

No.	Description	Risk	WPs	Proposed mitigation measures
R1	Delay in recruitment	Low	1	6 month lead in time to recruitment. Re-advertisement if necessary.
R2	Scientific Misconduct.	Low	All	Scientific Misconduct Strategy Detailed in Consortium Agreement
R3	Recruitment Gender Imbalance	Med	All	Recruitment strategy in place to ensure Gender Balance. Engage positive discrimination to ensure gender balance
R4	ESR issues with supervisory team	Low	2-5	Dealt with first by Academic Board. If not resolved, pass to the SB for resolution
R5	Poor ESR progress	Low	2-5	Progress Monitoring System in place. Regular meetings with team
R6	Slow Scientific progress	Med	2-5	Teams meet regularly to review progress & suggest alternative strategies.
R7	Training Event Unsatisfactory	Low	6	All ESRs will provide an assessment of the success of each Training Event. Feedback will be used to address any ESR concerns and further develop
R8	Partner leaves	Low	All	Attempt to recruit another PI into the consortium with the same skillset.
R9	Dissemination Programme fails	Low	All	Continuous feedback from the Dissemination WP leader to the SC will ensure that milestones and deliverables are met.
R10	ESR leaves consortium	Low	2-5	Re-advertise and recruit new ESR.
R11	Poor Communication	Low		Roles of Partners clearly laid out in Consortium Agreement post-award. Efficient use of project management and communication software.
R12	Milestones not reached	Med	All	Progress monitored continuously and discussed in detail at SC meetings.
R13	Low data quality	Low	2-5	MANTEL will use data from long established sites with established QA/QC procedures that have substantial archives available to the project.
R14	Unavailable data	Low	2-5	All partners have archived data are available. Having multiple sites means that significant data gaps will not lead to the incompletion of the project.
R15	Mesocosm equipment failure	Med	2-5	There are 24 mesocosms in LakeLab failure across all is unlikely; there also two other mesocosms facilities available to the project.
R16	Loss of project leadership	Low	All	In addition to the CC, Prof. Bas Ibelings will serve as substitute leader. Both have permanent positions and project management experience.

3.3 Appropriateness of the infrastructure of the participating organisations

MANTEL brings together partners with state-of-the-art instrumentation, global level research expertise, strong links to the management and policy sector and world class training in a range of skill sets (see section 1.2). ESRs will receive scientific, technical and complimentary and transferable skills at as part of the PhD offered at all MANTEL network institutions. As part of the Career Development Plan each ESR will, in conjunction with their supervisor, devise an individual training plan. MANTEL will thus provide ESRs with a suite of complimentary and transferable skills to enhance their job prospects in future employment. These include training in communication, dissemination, public engagement and outreach. ESRs will also gain valuable experience in event organisation and event management as they will be responsible for the MANTEL Symposium.

MANTEL Partners have previously supervised a total 55 PhDs and are currently supervising 32 PhDs and 15 Post-docs across the consortium. In addition, partners have supervised a total of 85 MScs and as such have a significant supervisory experience. The Coordinator (DkIT), several recruiting beneficiaries (UB, IGB, ICRA and CEH) and two degree awarding bodies (DCU, WU) have achieved the HR Excellence in Research Logo and it highlights out **commitment to implement fair and transparent recruitment and appraisal procedures for ESRs**. Other partners including PO, ETH and BSC have all endorsed the Charter and Code as an initial step in obtaining the Excellence in Research Logo. All partners will provide **excellent employment and working conditions and a supportive environment for ESRs.** ESRs will have access to International Offices, Student services, and careers advice at their host institution. In addition MANTEL ESRs (and their families) if relocating to another country.

EURAXESS services will be accessed by ESRs moving to, or living in a foreign country: Visas, Work permits, Accommodation, Legal issues, Social security, medical care and taxes, Family support, language lessons, etc. This in addition to the supervisory support for each ESR including supervisors and co-supervisor and the existence of the ESR Ombudsperson will ensure that all ESR needs are met. In addition to the technical and scientific infrastructure MANTEL have administrative and financial support from their institutions. In additional to The EU Research support at DkIT, ICRA has a dedicated EU Research Support Office while NIOO researchers are supported by more than 55 administrative staff. All partners are committed to communication of results and are active in public engagement and have included WPs on Communication and Public Outreach and Dissemination.

3.4   Competences, experience and complementarity of the participating organisations and their commitment to the programme
Consortium composition and exploitation of partners' complementarities:
MANTEL ESRs will have access to a significant wealth of expertise (see Table 1.4) as the network gathers together an **intersectoral and multidisciplinary** collaboration between universities, research institutes, stakeholders and industry participants from 9 European countries. It combines and shares expertise to offer training at an advanced level on new concepts for monitoring, modelling and resilience analysis of lakes and reservoirs. MANTEL will increase understanding of the effects of episodic and extreme events on lakes and increase our understanding of the climate change impacts by using new emerging theories and technologies (HFM, data analysis, and mesocosm experiments, modelling, and a unique gaming approach in the Benefit Game). It supports job creation by enabling a wider talent pool of skilled graduates with business, entrepreneurship, communication, project management and other transferrable skills. Through its program of stimulating, cutting-edge research and training achieved *via* trans-national and trans-sectoral mobility, and inter- and multi-disciplinary, MANTEL clearly addresses both the spirit and substance of the European Charter for Researchers. The overall approach of MANTEL is to integrate 12 Individual Research Projects which respond to specific research needs. Within this framework, the MANTEL proposal involves partnerships at a variety of levels. At the most basic level, there will be a number of bilateral collaborations, centred on individual research projects. All beneficiaries and partners contribute to **3** essential components required to advance knowledge of the effects of episodic climatic events in lakes and reservoirs, and ensure MANTEL researchers have the skillsets necessary to safeguard European freshwater resources:

1. State-of-the-art instrumentation: Only 7 lakes with data archives of greater than 10 years duration exist in Europe: 5 of these are maintained by consortium members (**UU, CEH, MI, IGB**). These were all established in the late 1990s/early 2000s in EU FP4 REFLECT and FP6 CLIME projects, which also forged strong collaborative bonds. Not only have these systems been maintained, but they have been continuously updated to ensure that they use cutting edge sensor technology. For example, instrumentation in the Irish site now includes not only an updated platform on Lough Feeagh, but also a profiling system on the downstream Lough Furnace, and 3 HFM stations on rivers (**MI and DkIT**). A new profiling system has just been added to the monitoring systems in Lake Erken. This infrastructure represents a high level of expertise and established collaborations that will provide a strong foundation and ensure successful careers for the MANTEL ESRs. In addition to the established monitoring systems, LéXPLORE, a collaboration between MANTEL partner **UG** (CH) and Swiss institute Ecole Polytechnique Federale de Lausanne (EPFL), will become operational on Lake Geneva in 2016. This is equipped with instruments that are truly 'beyond state-of-the-art'. The in-lake data will also be integrated with earth observations from hyperspectral instruments on a dedicated Ultralight Aviation plane and the new generation of SENTINELS satellites. Added to this impressive suite of instrumented sites are the consortium mesocosm facilites including LakeLab (DE), and the indoor Limnotrons (NL)

2. World-class research expertise: The MANTEL supervisors are at the forefront of their respective fields. They include expertise in lake physics (CEH), lake carbon cycling (**ICRA, UB, EMÜ, DkIT, MI**), phytoplankton and zooplankton dynamics and the microbial loop (**UG, EMÜ, IGB, NIOO**), modelling in lake and reservoirs (**CEH, ICRA, UU, UG, NIOO, WU**), development of theory on resilience (**UG, IGB, ETH**), climate change impacts (**UG, CEH, UU, IGB, NIOO, WU, DkIT**), and the management of lake ecosystem services (**NIOO, ICRA).** Six (**DkIT, UU, CEH, MI, IGB, EMÜ**) previously contributed to the first assessment on future climatic responses in lakes across Europe[39]. Prof. Martin Beniston (**UG**) was co-author on chapters in the IPCC assessment reports and, in 2007 as vice president of IPCC, shared the Nobel Peace Prize for that group's report. Dr Vasilas Dakos (ETH) is at the forefront of research on detecting early-warning signals in time series data. Drs L. de Senerpont Domis **(NIOO)** and Miquel

---

[39] George D.G. 2010 (ed.) The Impact of Climate Change on European Lakes. Springer

Lurling **(WU)** are chairs of International Society of Limnology (SIL) Plankton Ecology Group (PEG). The Coordinator is Chair of the NETLAKE COST Action which is strengthening links between scientists, and citizens groups, water managers, and SMEs. Many of the MANTEL consortium are also involved in GLEON, thus ensuring that the ESRs will be exposed to world class lake research on the global stage. Three of the supervisors, Prof. Bas Ibelings (**UG**), Dr Lisette de Senerpont Domis (**NIOO**), and Dr Alo Laas (**EMÜ**) are GLEON steering committee members.

3. Strong links to the management and policy sector (NIOO, ICRA, ATLL, ACA, BD, W+B) MANTEL will leverage strong, established relationships with the water sector and utilise expertise in communications between researchers and the management sector. These will ensure that the outputs become embedded in that community and that they inform policy and management at a pan-European level. The MANTEL consortium includes water utilities in Spain (**ATLL**), and the Netherlands (**WBD**) that are actively involved in HFM and have been working with MANTEL researchers, either through independent projects or through NETLAKE activities. In addition, **NIOO** brings world class expertise in research valorisation.

Commitment of beneficiaries and partner organisations to the programme (for partner organisations, please see also sections 5 and 7).

The training programme is structured into taught modules combined with original and impactful research supported by secondments that will give 12 ESRs insights and exposure to research and innovation in both academia and industry**.** It is structured in two ways: 1. supervised research towards a doctoral award and 2. network-wide and local training. Each ESR is assigned a project with a Supervisory Team composed by experts from at least 2 European countries. The effects of Episodic Events in lakes is a broad area of investigation and while training modules imparted in MANTEL provide researchers with an overall understanding and advanced skills, the individual research projects respond to specific research needs/questions. As part of MANTEL, each ESR will have meaningful placements. The PhD topics have been carefully selected to build on existing collaborations between participants thus providing ESRs with a ready-made network. They typically feature a researcher spending at least 70% of their time in their host institution, and a period of 3 to 6 months seconded to a participant from another environment with expertise that is considered important to their research. The placement will help to define and illuminate the subject of the student's research, and will provide practical experience of the application of the academic tools and transferable skills acquired in the taught modules.

i) Funding of non-associated third countries: Not applicable

ii) Partner organisations: The MANTEL consortium includes three classes of partner organisations:

1. Five degree awarding institutes for the four research institutes/institute of technology. Each of the supervisors in non-awarding bodies has strong established relationships with those awarding PhD degrees for their ESRs.

2. **Four research institutes and one supercomputer centre**: two of these maintain HFM stations and will be involved in provision of data and hosting ESRs. **Centre for Ecology and Hydrology UK** will give access to time series data from CEH HFM buoys, as well as hosting ESR1, and training in lake physics. **Marine Institute** IE will provide HFM data and all facilities required to host ESRs 4 and 6, including supervision by Dr Elvira de Eyto. **NIVA** (NO) have committed to provide access to data, models, and facilities for hosting visiting students. **ETH** will provide facilities to host ESR 7 and ESR 12 and time required by Dr Vasilis Dakos in developing new theory on resilience. **BSC** will host ESR 9, provide access to climate change data and expertise to the project.

3. **Four industry partners** or with strong links to industry: **ATLL** manage the drinking water supply (Sau Reservoir) for Girona (ES). They will provide access to data and will host a student for fieldwork at the site and treatment plant. The Catalan Water Authority **ACA** has committed to involvement in training for the MANTEL doctoral student and give insight into their applied perspective. **W+B** will work with ESR 10 to further develop their Benefit Game which helps stakeholders to plan for mitigating measures. This will also be used in training all ESRs on economic benefits. WBD will work with ESR 10, providing data and insight into water management.