Blue growth opportunities in changing kelp forests. (Forskerprosjekt - SANOCEAN)

Application Number: ES617086 Project Number: 287191

Project partners

Project Owner

Institution / company (Norwegian name)	HAVFORSKNINGSINSTITUTTET
Address	Postboks 1870 Nordnes
Postal code	5817
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Country	Norway
E-mail	post@imr.no
Website	
Enterprise number	971349077
Partner's role	Both research activity and financing
eAdministration	

Project administrator

First name	Jan Atle
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Personal number	
Gender	Male
Position/title	Program manager
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Confirmation	✔ The application has been approved by the Project Owner

Project manager

First name	Karen
Last name	Filbee-Dexter
Date of birth	070289

Personal number	
Gender	Female
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Address	Flødevigveien 20
Postal code	4817
City	HIS
Country	Norway
Position/title	Researcher
Academic degree	
Preferred language	English
Phone	
E-mail	post@hi.no

Partners under obligation to provide professional or financial resources for the implementation of the project

1

Institution/ company	The University of Western Australia
Address	35 Stirling Highway
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City	Crawley WA 6009
Country	Australia
Enterprise number	
Contact person	Thomas Wernberg
Contact tel.	
Contact e-mail	

Partner's role	Only research activity

2

Institution/ company	NORSK INSTITUTT FOR VANNFORSKNING

Blue growth opportunities in changing kelp forests. (Forskerprosjekt - SANOCEAN)

Application Number: ES617086 Project Number: 287191

Address	Gaustadalléen 21
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Country	Norway
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Contact tel.	Hancke
Contact e-mail	kasper.hancke@niva.no

Partner's role	Only research activity

3

Institution/ company	University of Western Cape
Address	Private Bag X17 Belleville 7353
Postal code	7535
City	Cape Town/ Wester...
Country	South Africa
Enterprise number	
Contact person	AJ Smit
Contact tel.	
Contact e-mail	

Partner's role	Only research activity

Project participants

First name	Last name	Institution/company
Thomas	Wernberg	University of Western Australia

AJ	Smit	University of the Western Cape
Kasper	Hancke	NORSK INSTITUTT FOR VANNFORSKNING
Mark	Rothmann	Department of Agriculture, Forestry, and Fisheries
Tove Margrethe	Gabrielsen	University of Agder
Kasper	Hancke	Norwegian Institute for Water Research
Kjell Magnus	Norderhaug	HAVFORSKNINGSINSTITUTTET

Project info

Project title

Project title	Blue growth opportunities in changing kelp forests.

Primary and secondary objectives of the project

Primary and secondary objectives	Primary objective: Establish a collaborative knowledge platform and build research capacity for knowledge-based management of kelp forest resources under changing ocean conditions. Secondary objectives: 1. Discover how climate change will impact ecosystem services provided by kelp forests in South Africa and Norway through a 4-year field research initiative. 2. Build capacity for kelp forest research in South Africa and Norway through high-level post graduate training, research, and networking opportunities. 3. Exchange scientific knowledge on sustainable development and management of kelp forests in Norway and South Africa.

Project summary

Project summary	BLUECONNECT will, for the first time, create strategic research partnerships and valuable training opportunities between South Africa and Norway that focus on coastal ecosystem health and sustainable development of marine resources. The project will focus on kelp forests, which are dominant coastal ecosystems in both countries; they provide a harvestable resource and habitats for fish and other marine organisms, and offer a suite of valuable ecosystem services for coastal communities. Kelp forests are expanding in parts of Norway and South Africa with changing environmental conditions, despite a global declining trend. However, the extent and impact of these changes are unclear. Increasing our understanding of how coastal communities can adapt to these changing ecosystems and the opportunities

	they provide is a key priority of BLUECONNECT. The project will explore climate-driven expansion of kelp forests and changes to ecosystem services in both South Africa and Norway. Through post graduate training, research opportunities and multidisciplinary workshops, the project will develop the capacity for high level kelp forest research and management in both counties. Additionally, BLUECONNECT will facilitate the exchange of scientific knowledge relating to sustainable development, management, and use of kelp forests in both countries. This will kindle cooperation between South Africa and Norway on ocean research related to climate change, natural resources, and the environment. This, in turn, will create opportunities and inform decision making and management in support of the blue economy in changing oceans.

Funding scheme

Supplementary info from applicant

Programme / activity	SANOCEAN
Application type	Forskerprosjekt
Topics	
Other relevant programmes/ activities/projects	
Discipline(s)	Ecology, Biology, Oceanography, Social-Environmental Science
If applying for additional funding, specify project number	
Have any related applications been submitted to the Research Council and/or any other public funding scheme	No

Progress plan

Project period

From date (yyyymmdd)	20190101
To date (yyyymmdd)	20221231

Main activities and milestones in the project period (year and quarter)

	Milestones throughout the project	Hovedaktivitetskategori	From		To	
1	T1.1. Research activity: Ecosystem services	✔	2019	2	2022	2
2	T1.2. Research activity: Climate impacts	✔	2019	2	2022	2
3	M1.1. Scientific publication		2019	3	2022	4
4	M1.2. Scientific publication		2019	3	2022	4
5	T2.1. Field course no. 1	✔	2019	2	2019	2
6	T2.2. Field course no. 2	✔	2020	2	2020	2
7	T2.3. Field course no. 3	✔	2021	2	2021	2
8	T2.4. Field course no. 4	✔	2022	2	2022	2
9	M2.1. Student-led 1 day conference	✔	2020	2	2020	2
10	M2.2. Student-led 1 day conference	✔	2021	2	2021	2
11	M2.3. Student-led 1 day conference	✔	2022	2	2022	2
12	M2.4. Student publications other outputs		2019	2	2022	4
13	T3.1. Workshop1 Climate Change Challenges	✔	2019	4	2019	4
14	T3.2. Workshop2 Kelp Forests & Blue Growth	✔	2020	2	2020	2
15	T.3.3. Workshop3 Developing kelp cultivation	✔	2021	4	2021	4
16	T.3.4. Final Dissemination Meeting	✔	2022	4	2022	4
17	M.3.1 State of knowledge reports		2019	2	2021	4
18	M.3.2. Scientific publication		2020	4	2020	4
19	M.3.3. Policy recommendation document		2021	2	2021	4
20	SANOCEAN Launching Conference	✔	2019	1	2019	2
21	SANOCEAN Concluding Conference	✔	2022	3	2022	4
22	Student travel awards	✔	2019	2	2022	4

Dissemination of project results

Dissemination plan	Scientific publications: BLUECONNECT will produce a minimum of 4 papers, to be published in high impact journals. 3 papers have been explicitly identified in the proposal, including a high-profile paper on climate-driven patterns of change in kelp forests and impacts on ecosystem services provided by at the end of the project. All papers will be published with open access or made available in online university repositories, to ensure the

research is available to all potential users, as required by NFR's policy for open access. Additional to these core papers, the graduate and postdocs students participating in the BLUECONNECT field course and concurrent research will be encouraged and mentored to publish their research conducted during the course.

Symposia: The results will be presented in at least 2 relevant international symposia, including the 13th International Temperate Reefs Symposium (expected dates: 2021/2020) and the 49th Benthic Ecology Meeting (BEM 2020) Wilmington, North Carolina (Spring 2020). Additionally, we will make an effort to present BLUECONNECT results in other national meetings relevant to the project in Norway and South Africa. Each year the field course will end with an annual student-driven symposium open to the public. Here students will present both BLUECONNECT results and their own research.

Graduate theses: multiple MSc and PhD thesis will be published from participating students in both countries. These will be shared throughout the BLUECONNECT network, and presented at conferences and symposia.

Dissemination to other academia and other users: research outputs will be shared with the marine research community in South Africa through the South Africa Network for Coastal and Oceanic Research (SANCOR). In addition, the Norwegian Blue Forest Network (NBFN, https://nbfn.no) will aid in the use and dissemination of communication outputs from the project. NBFN aims to jointly strengthen the Norwegian competence and know-how in blue forests, so that its full potential in addressing the global climate challenge and provisioning of other ecosystem services can be met nationally and abroad. Norderhaug is a key player in this network, providing easy collaboration with the project.

Online popular publishing: Dissemination to the wider community will be through the BLUECONNECT website and twitter feed, which will be regularly updated throughout the project. Results will also be communicated as popular articles in online journals such as forskning.no and the public websites of the partner institutes. Workshops reports will be made available online. Students will drive a key part of the dissemination strategy by producing blogs, vlogs or podcasts as a part of the curriculum of the field course to shed light on key questions, ongoing research, and value of kelp forest ecosystems.

Budget

Costs per project partner per main activity (NOK 1000)

The top line shows the number for main activities from the progress plan (when these have been specified)

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	1	2	5	6	7	8	9	10	11
HAVFORSKNINGSINSTITUTTET	395	290	55	55	55	55	0	0	0
The University of Western Australia	40	40	40	40	40	40	0	0	0
NORSK INSTITUTT FOR VANNFORSKNING	0						0	0	0
University of Western Cape	295	275	220	230	230	230			
Totals	730	605	315	325	325	325	0	0	0

	13	14	15	16	20	21	22	Sum
HAVFORSKNINGSINSTITUTTET	135	120	30	140	5	35	120	1490
The University of Western Australia	40	30	15	30	0	0	0	355
NORSK INSTITUTT FOR VANNFORSKNING	20	10	150	5	0	0	0	185
University of Western Cape	80	110	80	80	20	5	210	2065
Totals	275	270	275	255	25	40	330	4095

Costs per project partner per year (NOK 1000)

	2018	2019	2020	2021	2022	2023	2024	2025	Sum
HAVFORSKNINGSINSTITUTTET		400	380	290	420				1490
The University of Western Australia		100	90	75	90				355
NORSK INSTITUTT FOR VANNFORSKNING		20	10	150	5				185
University of Western Cape		505	540	510	510				2065
Totals	0	1025	1020	1025	1025	0	0	0	4095

Cost plan (in NOK 1000)

	2018	2019	2020	2021	2022	2023	2024	2025	Sum
Payroll and indirect expenses		206	156	196	156				714
Procurement of R&D services		505	540	510	510				2065
Equipment									0
Other operating expenses		314	324	319	359				1316
Totals	0	1025	1020	1025	1025	0	0	0	4095

Specification	Payroll: this will cover researchers time (IMR, NIVA, and UWA), and includes 1) administration, planning, and coordination for the training course, field work, and workshops; 2) data collection, analyses, and scientific publication for the research components; and 3) reports and other outputs from the workshops. R&D services will cover costs from the South Africa partner outlined in the Partner form. These include: 1. Field costs to cover equipment, boat rental (3.5k NOK/day), technicians, and other support for field research in South Africa (total 565k NOK). 2. Flight costs and accommodation to/from Norway for the 2 workshops and the final meeting (200k NOK) 3. Accommodation of national and international researchers and students during field course (venue will be provided by University of Western Cape). 4. Catering, meeting room, and travel costs for workshop 2 in South Africa. 5. Funds for South African students to obtain commercial dive licenses (260 k NOK total) 6. Participation of the South African PI (Smit) in the 2 SANOCEAN annual meetings (25 kNOK). 7. Consumables for field course (170k NOK) and field research (155k NOK). 8. Travel funds for students from South Africa to Norway to maintain ongoing research and collaborations (210 kNOK). Other operating expenses will cover:

1. Equipment and boat time for field research in Norway (total 320k NOK). Of this, 100k NOK will be funded by internal IMR funds and 200k NOK requested from the NFR.
2. Flight costs to/from Norway to South Africa (2 X 7.5k NOK) and Australia to South Africa (1 x 10k NOK) for annual field course and field work.
3. Transport and accommodation of international and national participants to workshop 1 (IMR) and workshop 3 (NIVA), and the final meeting (IMR) in Norway.
4. Catering and meeting room costs for workshops 1 and 3, and the final meeting.
5. Travel and accommodation to Workshop 2 in South Africa
6. Diving equipment servicing and parts.
7. Participation of Norway PI in the 2 SANOCEAN annual meetings (25k NOK).
8. Travel funds for students from Norway (30k NOK per year) to attend the field course in South Africa.
9. Field and laboratory consumables.
10. Dissemination costs

Cost code (in NOK 1000)

	2018	2019	2020	2021	2022	2023	2024	2025	Sum
Trade and industry									0
Research institutes		420	390	440	425				1675
Universities and university colleges		100	90	75	90				355
Other sectors									0
Abroad		505	540	510	510				2065
Totals	0	1025	1020	1025	1025	0	0	0	4095

Funding plan (in NOK 1000)

	2018	2019	2020	2021	2022	2023	2024	2025	Sum
Own financing		25	25	25	25				100
International funding		505	540	510	510				2065

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	2018	2019	2020	2021	2022	2023	2024	2025	Sum
Public funding									0
Private funding									0
The Research Council		495	455	490	490				1930
Totals	0	1025	1020	1025	1025	0	0	0	4095

Specification	Own funding: 1. IMR will provide a total of 100k NOK of internal money to cover part of the direct costs for field work in Norway (boat time and consumables) 2. The PAM Fluorometer comes at no rental cost to the project (PAM:5000 NOK/day = 70k NOK) in South Africa. 3. 4. Dive tanks, basic field equipment, and sensors will be covered by the University of Western Cape. 4. SAEON will provide access to boats for field research. 5. Venue for the field course will be provided by University of Western Cape at no rental cost 6. Ancillary environmental data to contribute towards the experiments at Olifantsbos and Buffels Bay, Cape Peninsula, will be provided by SAEON as part of the kelp Long Term Ecological Research infrastructure (ADCP, thermistor arrays, etc.). 7. Graduate student bursaries from the National Research Council in South Africa will support 2 students that will help with the research and organization of the South African components of BLUECONNECT: R120k for one PhD and R90k for one MSc. The PhD will go for three years, and the MSc for two years.

Person for whom a fellowship/position is being sought

Allocations sought from the Research Council (in 1000 NOK)

	2018	2019	2020	2021	2022	2023	2024	2025	Sum
Student fellowships									0
Doctoral fellowships									0
Post-doctoral fellowships									0
Grants for visiting researchers									0

	2018	2019	2020	2021	2022	2023	2024	2025	Sum
Grants for overseas researchers									0
Researcher positions									0
Hourly-based salary including indirect costs		206	156	196	156				714
Procurement of R&D services									0
Equipment									0
Other operating expenses		289	299	294	334				1216
Total amount sought	0	495	455	490	490	0	0	0	1930

Attachments

Project description

Project description	ES617086_001_4_Prosjektbeskrivelse_20180425
Reference	SANOCEAN Project Description.v5.pdf

Curriculum vitae (CV) with list of publications

Curriculum vitae (CV) with list of publications	ES617086_002_1_CV_20180418
Reference	Norderhaug short CV 2018.pdf
Curriculum vitae (CV) with list of publications	ES617086_002_4_CV_20180424
Reference	CV KHancke 4pg_Apr18.pdf
Curriculum vitae (CV) with list of publications	ES617086_002_5_CV_20180424
Reference	Wernberg 4 page CV SANOCEANApr18.pdf
Curriculum vitae (CV) with list of publications	ES617086_002_6_CV_20180424
Reference	Filbee-Dexter CV 2018 (4 page).pdf
Curriculum vitae (CV) with list of publications	ES617086_002_7_CV_20180424

Reference	Smit CV 2018 (4 page).pdf

Confirmation from partner(s)

Confirmation from partner(s)	ES617086_008_1_AktiveSamarbeidspartnere_20180424
Reference	Confirmation letter of intent NIVA.pdf
Confirmation from partner(s)	ES617086_008_2_AktiveSamarbeidspartnere_20180424
Reference	UiA.pdf
Confirmation from partner(s)	ES617086_008_3_AktiveSamarbeidspartnere_20180424
Reference	Confirmation letter of intent UWC.pdf
Confirmation from partner(s)	ES617086_008_4_AktiveSamarbeidspartnere_20180424
Reference	Confirmation letter of intent DAFF (Rothman).pdf
Confirmation from partner(s)	ES617086_008_5_AktiveSamarbeidspartnere_20180425
Reference	Confirmation letter of intent UWA.pdf

Other items

Other items	ES617086_010_5_Annet_20180425
Reference	SANOCEAN 2018 PartnerForm signed SA and NOR.pdf

BLUECONNECT. Blue growth opportunities in changing kelp forests.

1. Relevance relative to the call for proposals

BLUECONNECT will create new strategic research partnerships and valuable training opportunities between South Africa and Norway that centre on coastal ecosystem health and sustainable development. The project will focus on 'blue' kelp forests, which are dominant coastal ecosystems that provide a suite of valuable ecosystem services for coastal communities in both countries. BLUECONNECT will quantify how climate change is likely to impact kelp forests and their services in South Africa and Norway through a 4-year field research project. The project will develop the capacity for high level coastal ecosystem research through post graduate training and research opportunities, and multidisciplinary workshops. Additionally, BLUECONNECT will facilitate the exchange of scientific knowledge on sustainable development, management, and use of kelp forests in both countries. BLUECONNECT will a) enable discussions and future collaborations that will enhance knowledge-based policies and decisions for sustainable development of kelp forest resources in the blue economy (SANOCEAN priority 1), b) increase our understanding of these important environments (SANOCEAN priority 2), and c) characterise the impacts of climate change on expansion of kelp forests in South Africa and Norway (SANOCEAN priority 3). Importantly, this will kindle ocean science cooperation between South Africa and Norway, which is a larger goal of SANOCEAN.

2. Aspects relating to the research project

2.1. Background and status of knowledge

Cooperation and capacity building in ocean science

Climate-driven impacts in global ocean ecosystems, such as changes in major marine habitats and resources, are creating critical social-ecological challenges that can only be met through broad collaborations harnessing international perspectives and diverse expertise (Visbeck 2018). To sustain a broad ocean science community, it is essential that graduate students are afforded appropriate training, research experience, and networking opportunities (Colón-Rivera et al. 2013; Peach and Scowcroft 2016). BLUECONNECT will bring together national and international experts in marine climate change, kelp forest ecology, and kelp harvesting to conduct joint research, provide high level training for students, and share results and knowledge on the services provided by kelp forests (both social and ecological), as well as how climate change and other stressors will impact these services in the future. This will enable the development of requisite skills that are normally not part of any formal graduate school curriculum, increasing potential spillover into professional practice and better enabling students to apply an ocean science-based approach to future research and management. Thus, BLUECONNECT will be foundational to building ocean science capacity in both countries.

Substantial efforts are being directed towards understanding and predicting major ecological changes in kelp forests in both South Africa, Norway, and internationally. Kelp forests of South Africa were studied extensively in the 1970s, but significantly less research has been undertaken subsequently (Moloney et al. 2013; Blamey and Bolton 2017). In contrast, Norway currently has some of the best studied kelp forests in the world with the highest number of publications per country in Europe by a factor of 4 (Smale et al. 2013). However, a better communication and integration of results among different international research groups and professionals would add value to the ongoing research activities, by sharing historical data, available knowledge and discussing methodologies and results obtained in different regions. BLUECONNECT will provide a platform from which to start or strengthen these scientific collaborations. This information sharing will enhance cooperation between South Africa and Norway in kelp forest research and promote science-based decision making in support of the blue economy.

Climate-driven changes to kelp forest communities

Climate change is rapidly affecting our oceans (Doney et al. 2012; Deutsch et al. 2015), altering the valuable services they provide and the industries they support (Barnosky et al. 2012; Filbee-Dexter and Wernberg 2018). Kelp forests are structurally complex habitats of large seaweeds that cover ~25% of the world's coasts,

and dominate the rocky subtidal coasts of Norway and South Africa (estimated to 700 km of coastline in South Africa and 8000 km^2 area in Norway (Wernberg et al. 2018)). In the past half century, threats to kelp forests have increased in number and severity, leading to a global decline of kelp abundances of ~2% per year (Krumhansl et al. 2016). The drivers and trajectories of these changes vary considerably across regions (e.g. Filbee-Dexter and Scheibling 2014; Wernberg et al. 2018) and have triggered a strong need to understand how climate-driven changes impact these habitats regionally and develop effective, adaptive management strategies to cope with these new conditions.

However, despite global declines of kelp forests, **kelp forests in parts of Norway and South Africa are expanding** (Bolton et al. 2012; Fagerli et al. 2013). In South Africa *Ecklonia maxima* recently expanded 70 km southeast of its previous distribution (Bolton et al. 2012) and its biomass is increasing within False Bay (Reimers et al. 2014). This is likely due to increased intensity and duration of upwelling that bring cool, nutrient-rich waters. In Norway, kelp forests are increasing in Svalbard due to retreating sea ice (Bartsch et al. 2016) and are reestablishing near the Russian border and along the mid-western coast following wide-scale shifts to urchin barrens in the 1980s. Kelps are reestablishing along the northern coast due to the invasion of king crabs, which prey on sea urchins and limit their presence, and in the west due to combined influence of warmer temperatures that reduce urchin recruitment, and increases in urchin predators (Fagerli et al. 2013, 2014). Evidence suggests that these re-established kelp forests are particularly vulnerable to harvest compared to the robust kelp forests further south (Steen et al. 2018).

Blue growth opportunities provided by kelp forests

The **'blue-growth economy'** encapsulates the development of sustainable ocean-resource industries (Mazarrasa et al., 2014). Kelps are harvested globally, and can be processed for a wide variety of products, ranging from human foods, fertilisers, animal and fish feed, cosmetics, medicines and pharmaceuticals, new materials for the biotechnological industry, and biofuels (Smit 2004, Kim et al. 2012, Correa et al. 2016). Kelp forests in South Africa are estimated to be worth 3.2 million NOK $year^{-1}$ (ZAR 5.8 billion $year^{-1}$). Of this total, tourism contributes to 40%, recreational fishing 28%, commercial fishing (15%) and illegal fishing (16%) (Blamey and Bolton 2017). In Norway, kelp forests provide valuable ecosystem services (one metric ton of kelp in Northern Norway is estimated to support 17.6 tons of fish and fix CO_2 worth 70.6 million NOK). At present in Norway, 160 000 tonnes per year of *Laminaria hyperborea*, worth approximately 1 billion NOK, is harvested commercially along the coast from Trøndelag and southwards (Steen 2016). As kelp forests are expanding northward, test harvesting has been performed in Nordland from 2013 (Steen et al. 2018). An industry report commissioned by DKNVS and NTVA estimated the value of kelp harvesting in Norway to be ~40 billion NOK by 2050 (Olafsen et al. 2012).

Expansion of kelps will also impact **ocean health** by increasing marine biodiversity and ecosystem functioning. Kelps are foundation species for a plethora of habitat-associated plants and animals, many of which are socio-economically important (Wernberg et al. 2018). These **'bright spots'** of increasing kelp should provide valuable ecosystem services for coastal communities (e.g. industrial harvest of kelps). In Norway, the expansion of kelps in the Arctic and the recovery of kelp forests in the northwest is expected to provide a carbon storage and sink (Wilmers et al. 2012; Krause-Jensen and Duarte 2014). Anticipating these changes and adapting to opportunities they provide is a key priority for coastal communities in both countries.

2.2. Approaches, hypotheses and choice of method

Aim and hypothesis

The overall aim of BLUECONNECT is to create collaborative research and training programs that address the broader research question: **How can kelp forest change in Norway and South Africa promote ocean health and develop the blue economy in these regions?** This will be achieved through a multi-disciplinary approach that combines collaborative field research, graduate and postgraduate training opportunities, and workshops in both countries.

BLUECONNECT is organised in **3 main components**: 1) joint research activities, 2) student training and competence building, and 3) exchange of scientific and technical information. The student training and research activities will both take during an annual 2-week field course in South Africa, where graduate and

post-graduate students from both countries will have the opportunity to acquire the necessary skills to conduct kelp field research, with direct relevance to this proposal.

Through these components the project will integrate the empirical data to provide guidelines to managers and relevant users, and ensure effective dissemination through scholarly publications and workshops with participation of researchers, managing agencies, and end users (i.e. the County Council, the Directorate of Fisheries, the Norwegian Environment Agency, the South African Department of Agriculture, Forestry and Fisheries and the Department of Environmental Affairs, and key industry players).

Study area

In South Africa the focus will be on two regions. The first is the Cape Peninsula, both within False Bay and along its Benguela Current-dominated west coast side. Within False Bay, kelps are increasing in biomass and distribution (Griffiths et al. 2010) while ocean temperatures are stable or slightly increasing. Along the west-coast, upwelling intensity is increasing, but little is known about how kelps are responding in terms of abundance, biomass, or ecological functioning here. The second site is De Hoop, where kelp has expanded to (Bolton et al. 2012). Here ocean temperatures have been decreasing. These sites are currently being monitored as part of an International Long-Term Ecological Research (ILTER) experiment.

In Norway data will be obtained from previous studies near Finnøy (mid-west coast where *Laminaria hyperborea* kelps reach maximum biomass and are actively harvested), Malangen (northwest coast where kelp forest have been overgrazed by sea urchins and show early warning signs of recovery), Porsangerfjord (northeast coast where kelps are recovering following expansion of king crabs), and Kongfjorden (in the Arctic where kelp biomass of *L. digitata* is increasing due to reduced sea ice). All these areas are currently the foci of several NFR, MDIR, and Ministry of Trade, Industry and Fisheries funded projects (e.g. KELPEX, Blått Karbon, Norwegian Blue Forest Network NBFN, Kelp forest ecosystem) and international projects (LINK: Latitudinal and Inter-hemispherical Network in Kelp ecophysiology).

2.3. Objectives, tasks, and methods

OBJ1. **CLIMATE-DRIVEN EXPANSION OF KELP FORESTS AND IMPACTS ON ECOSYSTEM SERVICES**

Participants: IMR (Lead Filbee-Dexter), UWC, UWA

We will use a combination of field surveys in South Africa and previous field data from Norway to quantify the ecological services provided by kelp forests, including elevated secondary production, energy capture and flow, and biodiversity repositories. We will also test the function and resilience of these expanding ecosystems. Field experiments will be set up in South Africa and monitored by a team of student divers that are led and assisted by the PIs during the annual field course (OBJ2).

Task 1.1. Ecosystem services

Productivity and erosion measures. The net productivity of kelp and rates of export of kelp detritus (which fuels secondary food webs) will be quantified in South Africa. Detrital production and changes in kelp standing stock will be measured annually during 4 successive 2-week field campaigns over the 4-year period. Site-specific density, biomass, and production will be quantified, providing annual estimates. Beach surveys of kelp detritus and their associated communities will also be quantified during the intertidal component of the field course to estimate productivity exported to terrestrial habitats. **Associated community structure**. Fish and large invertebrates in kelp habitats will be counted along transects and other smaller fauna associated with kelp forests will be collected using airlifts and identified and counted by students. These data will be used to calculate biodiversity, secondary production, and to identify key links with other commercial species (e.g. abalone, fish). Previously collected data on production, erosion, and associated secondary communities in existing and expanding kelp forests in Finnøy, Malangen, and Kongsfjorden, Norway (Christie et al. 2009; Norderhaug and Christie 2011; Filbee-Dexter et al. 2018) will be used to value the ecosystem services provided by changing kelp forests. Additional measures of associated community will be taken in Porsangerfjorden, where northern expansion is occurring.

Task 1.2. Future conditions, climate change impacts and recovery from industrial harvest
We will uncover current and future threats posed to kelp forests by measuring their performance (photosynthetic, growth, strength) under different levels of environmental stress and disturbance.
Impacts of disturbance and harvest. To quantify processes that destabilise these habitats and drive kelp recovery, clearing experiments will be conducted in intact, newly developed kelp forests along the coast of South Africa. Canopies will be removed from plots varying in areal extent (3 to 12 m^2) and removal density (0, 30, 60, 100%) (in a manner that mimics natural disturbance (e.g. Filbee-Dexter and Scheibling 2012) and kelp harvesting impacts (Steen et al. 2018). Concurrent small-plot experiments (3 m^2) testing interactions with canopy removal (60%) and nutrient addition and herbivore exclusion (important stressors in these systems) on kelp performance will be conducted. Nutrients will be added to these small plots by fixing nylon-mesh bags containing Osmocote fertiliser pellets (Gorgula and Connell 2004) to the center. Herbivores will be excluded using cages attached to the seafloor with underwater drills. Clearings will be set up during the first field course of the project. In each plot understory cover, canopy cover, kelp recruitment and survival will be measured annually. The diversity of algae and fauna on and between kelp stipes will be quantified. Experiments will be replicated across a temperature gradient, which will be measured and used as a covariate to examine the ways in which response to disturbance might change with the environment.

In Norway, a clearing experiment in an area where kelps are expanding (e.g. Porsangerfjord) will be performed in years 1 and 3, to supplement data from recent kelp clearing experiments in Finnøy and Malengen (conducted within the KELPEX project). Results from these similar field manipulations will be compared to South Africa field data, and to clearing experiments in other systems globally.

OBJ1 Deliverables:

- A scientific paper on kelp productivity, detrital export, and community biodiversity in South Africa (M1.1).
- A large synthesis paper on resilience and recovery time of kelp forests to disturbance (kelp clearing experiments globally) (M1.2).

OBJ2. **DEVELOP CAPACITY FOR KELP FOREST RESEARCH AND INNOVATION IN SOUTH AFRICA AND NORWAY** THROUGH HIGH LEVEL POST GRADUATE TRAINING AND RESEARCH OPPORTUNITIES
Participants: UWC (Co-lead Smit), IMR (Co-lead Norderhaug), UWA, University of Agder (UiA).
A key limitation for coastal ecosystem research is reduced training and opportunity for subtidal scientific diving, which can result in a workforce without the skills to properly study or effectively manage these ecosystems (Smale et al. 2013). Each year, the BLUECONNECT project will provide 8-12 graduate and postgraduate students from South Africa and Norway with a unique opportunity to interact with high-profile scientists as part of a transdisciplinary and advanced training program. This competence building will enhance science-based ocean research in the future, with strong application for management and industry. The course will be modified slightly each year, with the goal that some students will participate multiple times, and that all students will be part of a wider BLUECONNECT network (with access to course material online). This will ensure strong connections, network building, and mentorship over the project (both among peers and between researchers and students).

Task 2.1. 2-week graduate-level training course in subtidal research. The course will be taught by Filbee-Dexter, Smit, Norderhaug, and Wernberg and will use a multi-faceted approach that includes lectures, case studies and practical field experience. In this way, participants will obtain a hands-on and integrative experience that covers a wide range of topics, including marine ecology, benthic ecosystems, kelp forest ecology, experimental design, and scientific data collection and analysis. Under the supervision of expert researchers in this field, practical activities will be conducted as part of an actual kelp research program (OBJ1). The students will be given the opportunity and funding to participate in the field work, gaining first-hand experience in sampling and experimental design and methods. The intensive training will also foster the development of transversal skills such as networking and international scientific collaboration, as well as science communication, and planning in a multidisciplinary research context.
The course **syllabus** will include

- Scientific research techniques (6-day practical field work covering 200 km coastline in South Africa)

- Advanced statistics and analysis of biological data (2-day R workshop)
- Fundamental principles and recent advances in Marine Ecology, Theory, Experimental Design and Kelp Forest Ecology (2-day classroom lectures)
- Job opportunities, Blue Growth, and Insights from Industry (1.5 days; lectures and practical components).
- Science communication, publication and grant writing skills
- Guest lectures from industry, government researchers, and key participants from Norway and South Africa that will attend the formal workshops (OBJ3)

Task 2.2. Student research projects. Students will be given the opportunity to conduct their own research within the structure of the field course. They will select their research topics from a list of potential projects, research questions, and experiments provided by the project (e.g. kelp carbon uptake by pelagic food webs, drivers of kelp morphology in cold and warm environments, modes of *Ecklonia maxima* attachment and wave energetics, cross comparison studies using historical data on Norwegian and South African kelp). During the course and in the following weeks, participants will actively contribute to the data collection, analysis, and (in some cases) authorship of scientific paper(s), in collaboration with mentors and research professionals. The course will finish with a student-driven conference where they present BLUECONNECT research and/or ongoing thesis work. This will promote knowledge sharing and networking for young researchers on ocean science.

OBJ2 Deliverables*:* 1) Certifications from field course. 2) Student-led 1-day conference in years 2, 3 and 4 (M2.1), 3) Student-led scientific publications/outputs (M2.2).

OBJ3. **EXCHANGE SCIENTIFIC KNOWLEDGE AND TECHNOLOGICAL INFORMATION** ON SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF KELP FORESTS IN NORWAY AND SOUTH AFRICA
Participants: IMR (Co-leads Filbee-Dexter and Norderhaug), UWC, UWA.
Data and knowledge sharing is critical step in promoting evidence-based decision-making in the blue economy. BLUECONNECT will hold a series of workshops that will provide the necessary framework for data and knowledge sharing amongst leading world scientists in kelp research. This will strengthen cooperation and promote future research collaborations.

Task 3.1. Climate change challenges for blue forests in Norway and South Africa. 2-day workshop in Norway at IMR Flødevigen. The workshop will include BLUECONNECT researchers from both countries (listed in section 3.3) and center on kelp ecosystem services and drivers of change, allowing for comparisons of ecosystems with different drivers of change, both environmental and anthropogenic.

Task 3.2. Kelp ecosystems: targets, unknowns, and next steps for sustainable blue growth in a changing ocean. 1-day workshop at University of Western Cape, South Africa with researchers the Department of Agriculture, Forestry, and Fisheries (DAFF) (Dr. Mark Rothman), UWC, Norwegian Institute for Water Research (NIVA), and IMR. The workshop will start dialogue with these key agencies currently providing policy advice on kelp forests. Other agencies will be invited, including: The National Advisory Council on Innovation (NACI), The Academy of Science of South Africa (ASSAF), and the Department of Environmental Affairs (DEA), and The National Science and Technology Forum (NSTF).

Task 3.3. Developing kelp cultivation industry: potential for sustainable blue growth, possible ecosystem impacts and transfer of best practices between Norway and South Africa. 2-day workshop in Norway at NIVA with researchers, industry, and environmental managers (regional and national). The workshop will facilitate discussions and insight on how cultivation of kelp in coastal areas can provide options for a sustainable industry that support the development of a 'blue growth' economy. Potential ecosystem impacts and environmental trade-off will be highlighted and current scientific knowledge shared between students,

researchers, and invited environmental managers. The workshop will focus on knowledge-transfer between Norway and South Africa with emphasis on similarities and differences in sustainable blue growth.

Task 3.4. Final Dissemination Meeting. Main results, conclusions, knowledge gaps and future challenges will be highlighted in a 2-day meeting for BLUECONNECT participants. Opportunities for a joint research proposal will be discussed (e.g. NFR, NERC, ERC) and, if relevant, a plan with a responsible lead and timeline will be established. A specific plan for international collaboration will be discussed including data sharing, student exchanges, and joint publications. Lead persons, participants and timing will be identified for each activity.

OBJ3 Deliverables:

- A summary of the main discussions and conclusions will be shared amongst all participants no later than 1 month after each meeting (M3.1).
- A scientific paper on climate-driven patterns of change in South African and Norwegian kelp forests, and its impacts on ecosystem services (M3.2).
- Policy recommendation document for sustainable kelp forest management that identifies key knowledge gaps, and drivers of change (M3.3).

3. The project plan, project management, organisation, and cooperation

3.1. Project plan and implementation

BLUECONNECT is organised in **3 main components** that will run concurrently over the 4-year period: 1) joint research activities, 2) student training and competence building, and 3) exchange of scientific and technical information. The timing of deliverables for these components is specified in the electronic form.

Joint research activities will integrate new field data, previously collected data, and expert knowledge from partners in Norway and South Africa to answer key questions regarding expanding kelp forests in these regions. **Graduate training opportunities will take place** through field-based courses, workshops, and annual conferences. In turn, these MSc and PhD students will provide support and significant added value to the project. The field course will be advertised in the South Africa Network for Coastal and Oceanic Research (SANCOR), a network of marine scientists in South Africa that includes 100-150 post graduate students, and in Norway through the UiA, University of Oslo, University of Tromsø, NIVA and IMR.

The combined graduate student training and collaborative research approach is modelled on the Canadian Healthy Oceans Network (CHONe), which was a highly successful strategic partnership between university researchers and government scientists in Canada that Filbee-Dexter (Project Leader) participated in for 4 years. The goal of CHONe was to build Canadian marine science capacities to develop scientific guidelines for conservation and sustainable use of marine biodiversity resources. Annual student training workshops and opportunities played a key role in CHONe and provided continuity for students, leading to valuable scientific contributions and strong network building.

3.2. Project management

Dr Filbee-Dexter (IMR) will lead the BLUECONNECT project. She will be responsible for ensuring timely progress, communication among participants and dissemination, organising annual meetings, budget management, and reporting to the NFR. **Research Prof Kjell Magnus Norderhaug** (IMR) will be the project administrator. Together they will find solutions for any issues that may arise during the project. The scientific work will be led by senior researchers from IMR, UWC and UWA who will constitute the BLUECONNECT **Scientific Committee (SC)**. The SC will be in charge of research activities, project meetings (skype), and ensuring data sharing. The student training will be led by **Norderhaug**, **Assoc Prof AJ Smit** (UWC), and **Prof Tove Gabrielsen** (UiA). Smit will, together with the SC, be in charge of organising the 2-week field course in South Africa. Participation in the course will be determined through an open call. Applications will be assessed by the SC according to the following criteria: 1) academic excellence, 2) aptitude for research and leadership, 3) relevance of the candidate's research field. Gender equality and geographic representation will be included in assessments (considering students from disadvantaged backgrounds, especially in South Africa)).

3.3. National and international cooperation and expertise

BLUECONNECT is a **multidisciplinary** project that integrates expertise and exchange of information across a variety of marine biology, social science, and industry topics. It will use national expertise and strong international collaboration to promote network building across multiple nations, disciplines, socio-economic demographics, and career stages. The project is built on strong collaborations between **IMR, UWC, UWA**. The project team provides complementary expertise and scientific excellence, integrating national and international experts across ocean science; with outstanding track-records of publications, teaching experience, science communication and project management (see CVs).

Dr. Karen Filbee-Dexter has >7 years of experience leading field research on kelp forests in Norway and Canada, and is an emerging expert on dynamics of change in kelp ecosystems. As an early career researcher, she has already published 13 scientific papers, book chapters and reports in top journals including *Ecology*, *J Appl Ecol* and *BioScience*. **Assoc Prof Kjell Magnus Norderhaug** is a leading kelp researcher in the Northeast Atlantic and has extensive research experience with kelp forest ecology, effects from climate change, and sea urchin grazing. He has 35 research publications and extensive experience in teaching (e.g. 10 point MSc/PhD course "BIO4331 Human impact on the marine environment" through his 20% position at University of Oslo). **Prof AJ Smit** is a marine scientist at the University of the Western Cape and a Research Associate with the South African Environmental Observation Network (SAEON). His interest and expertise center on the intersection between coastal oceanography and kelp ecology. Specifically, the abiotic drivers of coastal ecosystem structure and function, and consequences of climate change. His ~50 publications cover a diversity of fields, including satellite remote sensing, kelp ecology, stable isotope ecology, and marine biodiversity. **Dr. Kasper Hancke** is a biological oceanographer and biogeochemist with experience from both pelagic and benthic ecology. He is a senior researcher at the Norwegian Institute for Water Research. With core expertise on coastal carbon turnover and the contribution of phototrophic organisms to coastal life he has published ~30 publications on primary production, photosynthesis, ocean optics, benthic biogeochemistry, and novel method development. Recently, he has turned his attention towards the environmental trade-offs of kelp cultivation and coastal regions. Hancke has taught >7 university courses and workshops on BSc, Msc and PhD levels and supervised 6 MSc and PhD students. **Assoc Prof Thomas Wernberg** (UWA) is a leading marine ecologist with broad expertise across global kelp ecosystems, including those in Norway and South Africa, and a particular focus on impacts of changing climate on kelp. He has a strong record of outstanding research contributions in kelp ecology and marine climate change (127 research publications, 10 ranked top 1% of most cited in the field, with recent papers in Ecology Letters, Current Biology, Global Change Biology, Nature Climate Change, Nature Ecology & Evolution, Nature Communications, and Science. He will bring a high level of expertise and international breadth to the project, and facilitate outputs being published in high impact journals. As an editor-in-Chief of the journal Aquatic Botany, associate editor for 3 other journals and a frequent reviewer of grant proposals for a range of funding agencies in several countries, he will provide expert insights into science communication and proposal writing.

Collectively, the team has extensive background data on these study systems, and the field and logistical experience required to conduct the project. **Filbee-Dexter, Wernberg**, and **Norderhaug** have successfully worked together through the 8 million NOK KELPEX project, an intensive scientific diving project on kelps in Arctic Norway. **Wernberg** has substantial experience studying kelp ecosystems in both Norway and South Africa, and a strong history of collaboration with the key partners (e.g. 19 years with **Smit**, 4 years with **Norderhaug**, 2 years with **Filbee-Dexter**). Other key collaborators include the **University of Agder**, Norway and the **Department of Agriculture, Forestry, and Fisheries**, South Africa, who will provide important assistance for student training and workshops components, respectively.

3.4 Infrastructure, equipment, and institutional support

BLUECONNECT involves scientists which are certified scientific divers with several years of field experience, ensuring safe and efficient field research and field training. The institutions involved have all the resources needed to successfully achieve the proposed objectives. This includes field equipment, infrastructure, licenses and software needed for field work and statistical modelling. IMR is Europe's largest marine research

institute with more than 1000 employees and sorts under the Ministry of Trade, Industry and Fisheries. IMR's main activities are research, advisory work, and monitoring. IMR Flødevigen, is an emerging national and international power centre for coastal research, and kelp forests are one of the strategic research priorities. This project fits within IMR's strategy to secure sustainable blue growth. IMR will provide the field equipment for the work in Norway, and support through administration, budget, and financial assistance, which will ensure the efficient management of BLUECONNECT. IMR will also provide media support to promote outreach. This project will also make intensive use of the research infrastructure and platforms currently provided by SAEON as part of the Department of Science and Technology's (DST) Shallow Marine and Coastal Research Infrastructure. This includes research vessels, field equipment, laboratory, and classroom space.

3.5. Budget

A total budget of 3990k NOK is requested from the NFR. Of these requested funds, 48.3% are for national and international partners and 51.7% are for South African partners. A significant amount of the budget for the Norway partner will cover hours and travel for the 2-weeks in South Africa and field work in Norway for OBJ1 (665k NOK). Payroll, direct workshop and meeting costs for OB2 and OB3 total 985k NOK. IMR will provide own funding for a portion of the fieldwork in Norway (100k NOK). 18% of the Norwegian partner costs are requested for UWA, who will provide expert knowledge for training and research outputs, and which is justified by the benefits trained and high-level scientists provide to the project. Most of the South Africa budget will cover research and field course costs (895k NOK). **Student awards** will be available to cover 1) a portion of travel expenses (flights) for Norwegian and South African students to participate in the course (330 k NOK) and 2) costs of commercial dive licenses for 6-8 South African students (a barrier to their participation in field research) (260k NOK). Both awards will be based on merit, opportunity, and background.

4. Key perspectives and compliance with strategic documents

4.1. Compliance with strategic documents

The Department of Science and Technology's (DST) Ten-year Innovation Plan for South Africa identifies five key Grand Challenges for the National System of Innovation (NSI) over the next decade (DST 2009). One of these Grand Challenges in science and technology is the response to global change. This Grand Challenge has two main aspects, i.e. enhancing scientific understanding of global change, and developing innovations and technologies to respond to global change (DST 2009). South Africa is well positioned to lead research on the continent in terms of understanding and projecting changes to the marine environment, the impact of these changes, and mitigation to limit their long-term effects. Mitigating climate change also provides an economic opportunity for South Africa, the 'Blue Economy' (DST 2009). In the development of the blue economy, the exploitation of living (fisheries, aquaculture, tourism) and non-living (oil and gas, minerals, energy) marine resources should be on a scale that is socially and economically justifiable and ecologically sustainable.

According to the National Marine Research Plan for South Africa (Skelton 2014), this project will address all three priority themes, i.e. 1) Oceans and marine ecosystems under global change; 2) Ecosystems, Biodiversity & Biodiscovery, in particular the sub-theme of Biodiversity and Ecosystem responses to global and climate change; and 3) Coastal and marine resources, society and development.

4.2. Relevance and benefit to society

BLUECONNECT will increase our understanding of ecosystem dynamics at a broad-scale, enabling us to predict and assess large-scale ecosystem change under different natural and climatic stressors. In this way, the project embraces the JPI Oceans strategic areas "*Science Support to Coastal and Maritime Planning and Management*" and the National Marine Research Strategy ("*Hav21*") by promoting sustainable value creation (Blue Growth) and good management of marine areas. Collaborations established in BLUECONNECT will provide support to decision making and sustainable management of our changing oceans. Importantly the training and competence building in ocean research for Norwegian and South African students will provide a balanced highly qualified expert pool that will create future opportunities and innovation in this field.

The project will provide new links between experts in South Africa and Norway working on similar questions who have not yet had opportunity to establish strong collaborations. Promoting such synergies will

ensure that existing research funding is maximized, providing added value to ongoing projects and setting the ground for future collaborations. All partners involved will benefit from data sharing and discussing complimentary expertise and approaches (methodologically and conceptually).

As the main advisor to Norwegian authorities on marine coastal issues and effects from climate change in the marine environment, this project falls within the strategic priorities for IMR in general and IMR Flødevigen as a coastal power centre in particular. BLUECONNECT will provide new and important knowledge on kelp forests along the Norwegian coast and the potential for blue growth in the future. The project will also be important for communicating these important issues to society as well as educating the future managers of coastal ecosystems, both important priorities for IMR.

4.3. Environmental impact and ethical perspectives

No negative environmental impacts are expected as a consequence of this project. Our sampling methods are non-destructive and very small-scale and no fragile habitats will be affected. The *in situ* experimental work is small scale and will not disturb the ecosystems significantly. BLUECONNECT will follow the **ethical guidelines** of the Research Ethics Committees (www.etikkom.no/en), which cover good research practice.

4.4. Gender issues (Recruitment of women, gender balance and gender perspectives)

All institutions strongly support **gender equality**. The project manager is a female early career scientist (2 years out of PhD). The field course will aim to have gender-balanced student participants.

5. Dissemination and communication of results

5.1. Dissemination plan

See online form for a detailed description. A minimum of 3 scientific papers are to be published in leading journals, including a high-impact synthesis paper on vulnerability and opportunities provided by expanding kelp forests in South Africa and Norway. 1 report targeted towards the end user will provide guidelines and a knowledge platform on blue growth and environmental impacts. Students are a key part of the dissemination strategy and will produce vlogs and podcasts during the 2-week field course. Workshops, conference contributions, web articles, and public outreach activities will be completed during the project.

5.2. Communication with users

The results from BLUECONNECT will be of importance for environmental agencies, the industry management, and the managing agencies involved with commercial kelp harvest. We will take steps to ensure focused communication of project results towards these parties through workshops, reports and out-reach activities. A facts **brochure** highlighting the major findings will be produced at the end of the project, aimed at decision makers and NGOs. In addition, the Norwegian Blue Forest Network (NBFN, https://nbfn.no) will aid in the use and dissemination of student vlogs, podcasts, and other communication outputs from the project.

6. Results Chain

<table>
<tr><td colspan="3">BLUECONNECT. Blue growth opportunities in changing kelp forests.</td><td>Duration: 2019 - 2023</td></tr>
<tr><td colspan="3">Purpose: establish a collaborative knowledge platform and marine research capacity to develop scientific guidelines for knowledge-based policies and sustainable use of kelp forest resources in Norway and South Africa under changing ocean conditions.</td><td>Budget: NOK 3,99 million</td></tr>
<tr><td>Activities:</td><td>Outputs/short-term results</td><td>Outcomes/medium term results</td><td>Impacts of long-term results</td></tr>
<tr><td>• joint research activities (OBJ1).
• student training and competence building (OBJ2).
• exchange of scientific and technical information (OBJ3).</td><td>3 scientific articles published in top journals (OBJ1,3).
Presentations at scientific conferences (OBJ1-2)
Policy recommendations for sustainable kelp forest management
Student video blogs, outreach (OBJ2).</td><td>A more balanced and competent workforce on coastal ecosystem research (OBJ2).
Standing collaboration and networks between IMR, NIVA, UiA and UWC (OBJ1-3)
Joint participation in international research call (OBJ3).</td><td>Increased policy relevant knowledge around sound management practices and opportunities provided by kelp forests
Highly qualified personnel
Adaption strategies for climate driven impacts on coastal ecosystems</td></tr>
</table>

• cooperation of project staff and postgraduate students (OBJ1-3).	Commercial diving and scientific field course certifications (OBJ2). Discussions on kelp ecosystem services and drivers of change (OBJ3) Increased demand for research by private and public sector Dialogue w policy makers/users (OB2)	Policy recommendation for sustainable management of kelp forests (OBJ3) Incorporation of collaborative projects into regular research programs Policy output for environmental agencies (OBJ3) Increased debate and dialogue about ocean sustainability (OBJ3)	Professional friendships for future collaboration Job creation in the kelp industry sector Contribution towards sustainable use of the kelp forest resources Use of results by government, industry etc.
Indicators	Number of publications Number of workshop participants Citations in media Dialogue with policy-makers	Increased share of global publication Increased citations Increased demand for results by public and private sector	Management strategies that reduce vulnerability of kelp forests Economic growth in kelp harvest industry
Beneficiaries	Researchers and students	Research institutions and government in both counties	General public and private sector

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CURRICULUM VITAE

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KEY QUALIFICATIONS:
Dynamics of coastal ecosystems, Kelp forest ecology, Environmental monitoring (eutrophication and climate change), Management and legislation

EMPLOYMENT RECORD:

2016		p.t.	Research Professor, Institute of Marine Research (IMR)
2011		2018	Associate professor, University of Oslo (20% position)
2003	-	2016	Research Professor (Research scientist 2003-11), Norwegian Institute for Water Research (NIVA).
2000	-	2003	PhD student, University of Oslo, Scholarship holder, Research council funded project.
1999	-	2000	Executive officer, Norwegian Pollution Control Authority (Norwegian Environment Agency), Environmental management.

PROJECT References last three years:

Title: NBFN – Norw Blue Forest network 2017, Norway
Position: WP leader **Budget per year (NOK):** 1.2 mill
Client: IMR **Financed by:** NFD
Duties performed: WP leader research on carbon sequestration

Title: Macrophyte ecosystems 2017-20, Norway
Position: Project leader **Budget per year (NOK):** 6.3 mill
Client: IMR **Financed by:** Min. Trade, Industry and fisheries
Duties performed: Research, management advice on kelp, seaweeds and seagrass

Title: KELCO – Kelp export 2016-18, Norway
Position: Co-leader **Budget per year (NOK):** 0.1 mill
Client: Norwegian Research Council **Financed by:** Norwegian Research Council
Duties performed: Conference funding

Title: MERCES –Marine Ecosystem Restoration in Changing European Seas 2016-19, Europe
Position: National coordinator **Budget per year (NOK):** 16 mill
Client: EC Commision **Financed by:** Horizon2020
Duties performed: Restoration of benthic habitats

Title: KELPEX – Kelp export 2016-18, Norway
Position: Member steering committee, participant **Budget per year (NOK):** 2 mill
Client: Norwegian Research Council **Financed by:** Norwegian Research Council
Duties performed: Research, fate of kelp production on deep and shallow water

Title: OSPAR Common Procedure 2016, Norway
Position: Project leader **Budget per year (NOK):** 0.6 mill
Client: Environmental Agency **Financed by:** Environmental Agency
Duties performed: OSPAR Common Procedure for eutrophication, national report, input integrated report

Title: GENVAR – Genetic variability of sea urchin populations 2012-2016, Norway
Position: Project leader **Budget per year (NOK):** 0.5 mill
Client: NIVA **Financed by:** NIVA
Duties performed: Microsatellite marker studies of sea urchin populations, Svalbard to Denmark.

Title: ECOACID – OA Ecosystem 2016-17, Norway
Position: Project leader **Budget per year (NOK):** 1 mill
Client: NIVA **Financed by:** NIVA
Duties performed: Ocean acidifcation effects in benthic ecosystems, mesocosm experiments

Title: WFD macroalgae indexes 2015, Norway
Position: Participant **Budget per year (NOK):** 0.3 mill
Client: Environmental Agency **Financed by:** Environmental Agency
Duties performed: Further developing WFD macroalgae indexes MSMDI and RSLA

Title: Env Assessment MS Server 2015, Norway
Position: Project leader **Budget per year (NOK):** 1.2 mill
Client: Wiborg Rein, GARD Insurance **Financed by:** Dalnave navigation Inc, Greece
Duties performed: Environmental assessment of the wreck of MS Server.

Title: ECOCOAST Rogaland 2014-2016, Norway
Position: Project leader **Budget per year (NOK):** 0.7 mill
Client: Norw Environmental Agency **Financed by:** Norw Environmental Agency
Duties performed: National environmental monitoring, hard and soft bottom, plankton, hydrochemistry.

Leading/key role in 35 projects 2003-p.t.

REFEREE OF RESEARCH COUNCILS AND SCIENTIFIC JOURNALS

Referee User-driven Research based Innovation (BIA) Norwegian Research Council 2015, Færøyar Research Council 2013. Referee for PLOS ONE, Marine Ecology Progress Series, Marine Biology, Journal of Applied Phycology, Marine Ecology, Journal of Applied Phycology, Journal of the Marine Biological Association UK, Oikos, Marine Biodiversity and Journal of Natural History 2005-p.t.

Board member and professional societies/memberships:

2010 -	2016	Member NIVA board (elected and re-elected twice by employees) which is leading the NIVA foundation (including subsidiary companies). 254 mill NOK turnover (2014).
2013		Member program committee Nordic Marine Conference, Asker 28.-30. October 2013.
2012 -	p.t.	Working group member, Global impacts of climate change on kelp forest ecosystems, National Centre for Ecological Analysis and Synthesis (NCEAS) Univ of California USA. , Leader Jarrett Byrnes, University of Boston.
2012 -	p.t.	Member, The Kelp Ecosystem Ecology Network (KEEN) for assessing the impacts of global change on kelp forests, NCEAS Cal. USA.
2011	p.t.	Norwegian representative, OSPAR ICG for the Common Procedure
2007 -	2010	Member, ICES Working Group for Marine Habitat Mapping
2009 -	2009	Member, WG for action assessment sugar kelp loss, Ministry of Environment Norway

OTHER qualifications:

Winner NIVAs publication prize, scientific publications 2015 (Norderhaug et al.) and 2016 (Ramirez-Llodra et al.).
Called as an expert witness in the MS Server Court of Appeal trial (Wikborg Rein) 2016
Granted research fellowship for publication of environmental monitoring data, NIVA 2014.
Organizing and leading international workshops in the RESTORE project (Norw Res Council), 2008, 2013
Course in genetic statistics, ISEC2012 Sundvollen Norway, 2012
Leading workshop subgroup hard bottom monitoring at the Environmental monitoring of Kattegat and Skagerrak workshop, Lysekil Sweden, 2011.
Extensive field experience. Leader on monitoring cruises (SCUBA diving) 2008-p.t. and a number of field work periods along the Norwegian and Svalbard coast. Scientific diver (PADI Master Scuba Diver), 2000
Extensive media experience: Interviews on national television (e.g. NRK "Ut i naturen", 2003, 2010) and live interviews on national radio (e.g. NRK Ekko 2011). More than 30 articles 2009-p.t. in national and regional newspapers (source: Retriever Media Monitor). Presentations on the Norw Res Council news web pages and Forskning.no 2005-2014. Media handling course, Medialøven 2009. Nominated to NIVAs media prize 2011.
The Invited Review Norderhaug KM, Christie H. Sea urchin grazing and kelp re-vegetation in the NE Atlantic. Mar Biol Res 5:515-528 was the most frequently downloaded paper at MBR.
Acting head of section during vacations, NIVA 2007, 2009, Norw Pollution Control Authorities 1999, 2000
Project Management Course Module 1 and 2, Holte Consulting as, 2005, 2007.
ArcGIS course modul 1 and 2, and Spatial analyst, Geodata as, 2004.
Environmental management courses, EC legislation and media handling, Climate and Poll Agency 1999, 2000.

TEACHING EXPERIENCE

Supervisor for PhD students CW Fagerli (2008-2013, UiO) and B Taraldset (2015-2017, UiB) and a number of master students 2006-p.t. Responsible for master course BIO4331 Marine environmental issues (10 points, 2011-p.t.), UiO. Internal PhD committee member, lecturer and examiner for PhD and master students and master courses at UiO, 2006-p.t.

CONFERENCES AND MEETINGS

Invited speaker at 9 international conferences and meetings 2004-p.t. First author on 12 oral international presentations. Poster presentations and participation on a number of international conferences 1997-p.t. A number of co-author participations in oral and poster presentations in national and international conferences and meetings. A number of invited speaks at national meetings at e.g. Norwegian Research Council, Ministry of Environment, Clima and Pollution Control Authorities, Directorate for Nature Management, Directorate for Fiheries, Institute for Marine Research, Vannforeningen, Norsk Hydro, CIENS, University of Oslo.

RECENT INVITED REVIEWS, BOOK CHAPTERS AND THEME ISSUES

2016 Christie H, Norderhaug KM. 7 Secondary production. In: Marine Macrophytes as ecosystem engineers (E Olavsson Ed.) Chapter II Production of macrophytes. CRC press, London. 161-178.

2015 Ling SD, Scheibling RE, Johnson CR, Rassweiler A, Shears N, Connell SD, Salomon A, Norderhaug KM, Perez-Matus A, Hernandez JC, Clemente S, Blamey L, Hereu B, Ballesteros E, Sala E, Garrabou J, Cebrian E, Zabala M, Fujita D. Global regime-shift dynamics of catastrophic sea urchin overgrazing. Philosophical Transactions B. 370:20130269. http://dx.doi.org/10.1098/rstb.2013.0269

RECENT PUBLICATIONS PEER REVIEW JOURNALS

2018 Filbee-Dexter K, Wernberg T, Ramirez-Llodra E, Norderhaug KM, Pedersen MF. Movement of pulsed resource subsidies from kelp forest to deep fjords. Oecologia doi.org/10.1007/s00442-018-4121-7

2018 Nyhagen FO, Christie H, Norderhaug KM. Will altered climate affect a discrete population of the sea urchin *Strongylocentrotus droebachiensis?.* J Sea Res 132:24-34.

doi.org/10.1016/j.seares.2017.12.001

2016 Krumhansl KA, Byrnes J, Okamoto D, Rassweiler A, Novak M, Bolton JJ, Cavanaugh KC, Connell SD, Johnson CR, Konar B, Ling SD, Micheli F, Norderhaug KM, Perez-Matus A, Sousa-Pinto I, Reed DC, Salomon AK, Shears NT, Wernberg T, Anderson RJ, Barrett NS, Buschmann AH, Carr MH, Caselle JE, Derrien-Courtel S, Edgar GJ, Edwards M, Estes JA, Goodwin C, Kenner MC, Kushner DJ, Moy FE, Nunn J, Steneck RS, Vasquez J, Watson J, Witman J. Global patterns of kelp forest change over the past half-century. PNAS 113, early edition DOI: 10.1073/pnas.1606102113

2016 Araújo RM, Assis J, Aguillar R, Airoldi L, Bárbara I, Bartsch I, Bekkby T, Christie H, Davoult D, Derrien-Courtel S, Fernandez C, Fredriksen S, Gevaert F, Gundersen H, Le Gal A, Lévêque L, Mieszkowska N, Norderhaug KM Oliveira P, Puente A, Rico JM, Rinde E, Schubert H, Strain E, Valero M, Viard F, Sousa-Pinto I. Status, trends and drivers of kelp forests in Europe: 1 an expert assessment. Biodiv Conserv 25 published online DOI 10.1007/s10531-016-1141-7.

2016 Ramirez-Llodra E, Norderhaug KM, Rinde E, Christie H, Fagerli CW, Fredriksen S, Gitmark JK, Gundersen H, Norling K, Walday MG. Macrophyte beds fuel deep-sea communities – a pilot study. Scientific Reports 6:23800 DOI: 10.1038/srep23800

2016 Norderhaug KM, Gundersen H, Hobæk A, Anglès d'Auriac MB, Fagerli CW, Dahl K, Christie H. Genetic diversity of the NE Atlantic sea urchin *Strongylocentrotus droebachiensis* unveils chaotic genetic patchiness possibly linked to local selective pressure. Mar Biol 163:36-49.

2015 Norderhaug KM, Gundersen H, Pedersen A, Moy F, Green N, Walday M, Magnusson J, Gitmark J, Ledang AB, Bjerkeng B, Trannum H. Combined effects from climate variation and eutrophication on the diversity in hard bottom communities on the Skagerrak coast 1990-2010. Mar Ecol Prog Ser 530: 29–46.

2015 Fagerli CW, Stadniczeñko SG, Christie HC, Fredriksen S, Pedersen MF, Norderhaug KM. Population dynamics of the green sea urchin *Strongylocentrotus droebachiensis* in kelp forests and barren grounds in Norway. Mar Biol. 162:1215–1226

2015 Bekkby T, Angeltveit G, Gundersen H, Tveiten L, Norderhaug KM. Red sea urchins (*Echinus esculentus*) and water flow influence epiphytic macroalgae density. Mar Biol Res 11. 375–384. DOI: 10.1080/17451000.2014.943239

2014 Anglès d'Auriac MC, Hobæk A, Christie H, Gundersen H, Fagerli CW, Haugstetter J, Norderhaug KM. New microsatellite loci for the green sea urchin *Strongylocentrotus droebachiensis* using universal M13 labelled markers. BMC Res Notes. 7:699. doi: 10.1186/1756-0500-7-699.

2014 Bekkby T, Gundersen H, Rinde E, Norderhaug KM, Gitmark JK, Christie H. Effekten av bølger og strøm på stortarens morfologi. In Norwegian with English abstract. Vann: 2:215-222

2014 Rinde E, Christie H, Fagerli H, Bekkby T, Gundersen H, Norderhaug KM, Hjermann D. 2014. Recovery of overgrazed kelp forests in the northeast Atlantic – important factors for recovery success across a wide latitudinal gradient. PLOS ONE 9:1-15.

2014 Bekkby, T., Rinde, E., Gundersen, H., Norderhaug, K.M., Gitmark, J., Christie, H. Length, strength and water flow - the relative importance of wave and current exposure on kelp *Laminaria hyperborea* morphology. Marine Ecology Progress Series 506:61–70 doi: 10.3354/meps10778

2014 Fagerli CW, Norderhaug KM, Christie H, Pedersen MF, Fredriksen S. Predators of the destructive sea urchin grazer (*Strongylocentrotus droebachiensis*) on the Norwegian coast**.** Mar Ecol Prog Ser 502:207-218.

2014 Norderhaug KM, Christie H, Rinde E, Gundersen H, Bekkby T. The importance of wave and current exposure to fauna communities in kelp *Laminaria hyperborea* forest. Mar Ecol Prog Ser 502: 295–301 doi: 10.3354/meps10754

2014 Sundblad G, Bekkby T, Isaeus M, Nikolopoulos A, Norderhaug KM, Rinde E, Stenström P. Comparing the ecological relevance of four wave exposure modeling methods. Estuarine, Coastal and Shelf Science 140:7-13

CURRICULUM VITAE FOR K. HANCKE

23. April 2018

Full name	**Kasper Hancke**
Born	3 April 1973, Copenhagen, DK
Nationality	Danish
Married	2 children
Current work address	Norwegian Institute for Water Research (NIVA) Research Centre for Coast and Ocean, Section for Marine Biology N-0349 Oslo, Norway

Educations and positions

2016 (May) –	**Research Scientist** at NIVA. Responsibilities on coastal ecology and climate impacts
2015 – 2016	**Research Associate** at Aarhus University (AU). Sea-ice ecology, ocean optics
2014	**Certified Commercial SCUBA Diver** (Danish Marine Authorities, Denmark)
2011 – 2014	**Postdoctoral Fellow** at University of Southern Denmark (SDU). Biogeochemistry, photosynthesis, carbon turnover in marine environments. Supervision of BSc, MSc and PhD students. Mentor: Prof. RN Glud
2010 – 2011	**Research Coordinator** at Marine Coastal Development, NTNU-Strategic Research Area "Ocean Science and Technology". Organization and coordination of interdisciplinary research and communication with stalk holders.
2008	Paternity leave (7 months, due to extremely premature birth of son)
2007 – 2010	**Postdoctoral Fellow** at the NTNU, involved in the Norwegian International Polar Year (IPY). WP lead, Marine Primary Production, Optical Oceanography, Ecosystem Modelling. Supervision of MSc and PhD students. Project lead by K Drinkwater.
2007 (May 16.)	**PhD in Marine Ecology** "Photosynthetic responses as a function of light and temperature: Field and laboratory studies on marine microalgae", Norwegian University of Science and Technology (NTNU), Norway.
2005	Paternity leave (3 months)
2003	**Scientific Diver** - 'Class S' diver issued by the Norwegian Directorate of Labor Inspection
2002 – 2003	**Research Fellow** at NTNU, funded through personal EC grants
2002	**MSc in marine microbial ecology**, University of Copenhagen and the Royal Veterinary and Agricultural University, Denmark

Research Interest

- Micro- and Macroalgae Ecology and Physiology
- Biological Oceanography and Benthic Biogeochemistry
- Bio-optics and Remote sensing
- Photobiology and Ecosystem Modeling

My research is focused on marine ecosystems and the biological, physical and chemical processes controlling their balance and activity. My interests are on benthic and pelagic ecology and physiology, and my core expertise on the energy flux and element turnover through the lower trophic levels of the food web, in particularly related to photosynthesis and primary production. I have extended field and laboratory experience, and have developed and improved a number of scientific methods and techniques for improved data sampling and marine monitoring, especially in the field of optical sensor techniques.

Project management, grants, and scholarships, last 5 years (Project and WP lead since 2001, PI on >13 nat. and int. research projects. Most including field, lab and/or modelling work)

2017 – 2020	Kelp industrial production: Potential impacts on coastal ecosystems (**KELPPRO**), The Research Council of Norway (RCN). **Project leader and Principal Investigator (PI)**
2017 – 2019	Blått Karbon. Norwegian Environment Agency (MDIR). **Work package (WP) leader and PI**
2017	Effects of terrestrial run-off and acidification on growth and productivity of key benthic species (ECODOM). NIVA research grant. **Project leader and PI**

2017	Evaluating drone-use and novel imaging technology for monitoring of aquatic environments (DRONING). NIVA research grant. **Project leader and PI**
2017	Kom-til-Tare. The Research Council of Norway's regional funds. **Work package (WP) leader and PI**
2016 – 2018	Nordic IPBES-like assessment of biodiversity and ecosystem services in coastal ecosystems. The Nordic Council of Ministers. **Lead author and PI**
2016	Test av drone med multispektralt kamera i kartlegging og overvåking (DRONE). NIVA research grant. **L Project leader and PI**
2016	Effects from ocean acidification on recruitment, growth and interaction (ECOACID). NIVA research grant**. Project leader and PI**
2015 – 2016	**PI** and **co-organizer** of two Arctic research campaigns. Arctic Research Center, Aarhus University.
2013 – 2015	**PI** and **Co-organizer** of field campaigns related to the Greenland Climate Research Center (GCRC) program on Marine Carbon Cycles in the Arctic. Program lead RN Glud.

Scientific experience and fieldwork, last 5 years, in total >23 moths abroad.

2017 Field work on drone-based remote sensing, mapping seagrass and seaweeds (2 weeks), Norway, **PI**
2016 Field work on seaweed and seagrass ecology (1 week), Norway, **PI**
2016 Field work on sea ice ecology, photosynthesis and sea-ice optics (1 weeks), W Greenland, **PI**
2015 Field work on sea ice ecology and photobiology in the High-Arctic (3 weeks), NE Greenland, **PI**
2014 Field work on benthic productivity and C turnover in the High-Arctic (3 weeks), NE Greenland, **Lead PI**
2013 Field work on primary production, dynamics and limitations (2 weeks), GCRC, Nuuk, **PI**
2013 *In situ* seasonal studies with eddy correlation, Odensefjord, Denmark, **PI**
2013 Macro nutrients land-to-oceans transport; Eddy correlation field work (1 week), Devon, UK
2013 Flume studies with Eddy correlation measurements (1 week), University of Landau, Germany
2013 Autonomous Underwater Vehicle (AUV) field campaign (2 weeks), Mariagerfjord, Denmark, **Lead PI**

Teaching experience (taught >7 different courses, in total >360 confrontment hours)

Teaching experience within biological oceanography, microbial ecology and experimental biology on BSc., MSc, and PhD level (2004-) at AU, SDU, NTNU and UNIS. I also teach courses for commercial SCUBA divers (SDU). I have made major contributions to the following subjects:

- Light, Climate and Primary Productivity in the Arctic (UNIS), Biological Oceanography (NTNU), Marine (Microbial) Diversity (NTNU), Experimental Marine Ecological Methods (NTNU), Experts in Team (an interdisciplinary teamwork training program, NTNU), Experimental marine biology: A field course (SDU), Commercial SCUBA diving education: Diving physics, physiology and barotrauma (SDU)

Supervised and Co-supervised MSc (4) and Ph.D. Students (2)

2014 – 2015 MSc Susan Guldberg Graungård Petersen
2012 – 2013 MSc Carmen Lorente Gallizo
2009 - 2011 MSc Inga Aamot
2009 - 2011 MSc Marit Norli
2008 – 2012 PhD candidate Erlend K. Hovland
2008 – 2014 PhD candidate Kristin Collier Valle

Reviewing for journal papers and funding proposals (>20)

Limnology and Oceanography (L&O), Aquatic Microbial Ecology (AME), Estuaries and Coasts, Microbial Ecology, Marine Chemistry, Polar Research Polar Biology, the European Commission EUROFLEET2, InovasjonNorge, NERC-Natural Environment Research Council in GB.

Publications & outreach (summery)

KH has published 26 peer-reviewed publications that have been cited > 580 times. Current H-score is 12 (Web of Science). Has contributed to >35 international conference publications, 8 as invited speaker, and 20 as first author. Participated in >10 outreach activities and publications, including TV-interviews and talks (NRK/DR2 'Danskernes Akademi').

Publications, peer-reviewed (In total 26, student publications underlines), last 5 years

2018 Lund-Hansen LC, T Juul, TD Eskildsen, I Hawes, BK Sorrell, C Melvad, **K Hancke** (submitted) A low-cost remotely operated vehicle (ROV) with an optical positioning system for investigating under-ice irradiance fields in landfast sea ice. Cold Regions Science and Technology

2018 **Hancke K**, LC Lund-Hansen, ML Lamare, SH Pedersen, MD King, P Andersen, BK Sorrell (2018) Extreme low light requirement for algae growth underneath sea ice: A case study from Station Nord, NE Greenland. Journal of Geophysical Research: Oceans 123 (2), 985-1000

2017 Murniati, E, D Gross, H Herlina, **K Hancke**, A Lorke (2017) Effects of bioirrigation on the spatial and temporal dynamics of oxygen above the sediment-water interface. Freshwater Science. DOI: 10.1086/694854

2016 Murniati, E, D Gross, H Herlina, **K Hancke**, RN Glud, A Lorke (2016) Oxygen imaging at the sediment-water interface using lifetime-based laser induced fluorescence (τLIF) of nano-sized particles. Limnology and Oceanography:Methods 14(8):506–517. DOI: 10.1002/lom3.10108

2016 Attard, KM, **K Hancke**, MK Sejr, RN Glud (2016) Benthic primary production and mineralization in a High Arctic fjord: in situ assessments by aquatic eddy covariance. Marine Ecology Progress Series 554:35-50

2015 **Hancke K**, T Dalsgaard, M Sejr, S Markager, RN Glud (2015). Phytoplankton Productivity in an Arctic Fjord (West Greenland): Estimating Electron Requirements for Carbon Fixation and Oxygen Production. *PLoS ONE 07/2015; DOI:10.1371/journal.pone.0133275*

2015 Lund-Hansen LC, S Markager, **K Hancke**, T Stratmann, S Rysgaard, H Ramløv, BK Sorrell (2015). Effects of sea-ice light attenuation and CDOM absorption in the water below the Eurasian sector of central Arctic Ocean (>88°N). *Polar Research 34, 23978, doi.10.3402/polar.v34.23978*

2015 Donis D, M Holtappels, C Noss, C Cathalot, **K Hancke**, P Polsenaere, F Wenzhöfer, A Lorke, FJR Meysman, RN Glud, DF McGinnis (2015) An Assessment of the Precision and Confidence of Aquatic Eddy Correlation Measurements. *Journal of Atmospheric and Oceanic Technology 03/2015; 32(3):642-655. DOI:10.1175/JTECH-D-14-00089.1*

2015 Holtappels M, C Noss, **K Hancke**, C Cathalot, DF McGinnis, A Lorke, RN Glud (2015). Aquatic Eddy correlation: Quantifying the artificial flux caused by stirring sensitive O2 sensors. *PLoS ONE 01/2015; 10(1). DOI:10.1371/journal.pone.0116564*

2014 **Hancke K**, B Sorell, LC Lund-Hansen, M Larsen, T Hancke, R Glud (*2014*). Effects of temperature and irradiance on a benthic microalgae community: A combined two-dimensional oxygen and fluorescence imaging approach. *Limnology and Oceanography* 59(5): 1599-1611. DOI: 10.4319/lo.2014.59.5.1599

2014 Lorente, C, S Muñiz, J Val, D Merchan, J Causapé, RN Glud, **K Hancke,** E Navarro (*2014*) Impacts of agricultural irrigation on nearby freshwater ecosystems: the impacts of triazine herbicides in algal biofilms during an agricultural year. *Science of the Total Environment – 07/2014; DOI: 10.1016/j.scitotenv.2014.06.108*

2014 Valle KC, M Nymark, **K Hancke**, P Winge, K Andresen, G Johnsen AM Bones and T Brembu (*2014*) System responses to equal doses of Photosynthetically Usable Radiation of blue, green, and red light in the marine diatom *Phaeodactylum tricornutum*. *PLoS One 9(12):e114211. doi:10.1371/journal.pone.0114211*

2013 Nymark M, KC Valle, **K Hancke**, P Winge, K Andresen, G Johnsen AM Bones and T Brembu (*2013*) Molecular and Photosynthetic Responses to Prolonged Darkness and Subsequent Acclimation to Re-Illumination in the Diatom *Phaeodactylum tricornutum*. PLoS ONE 03/2013; 8(3):e58722

Conference publications & presentations, selected last 5 years (>16 as invited speaker, 40 as first author, >56 in total)

Hancke K, H Gundersen 2018 Bruk av droner i overvåking og kartlegging – NIVAs erfaringer, behov, idéer. Workshop vedr. droneovervåking av naturtyper. NINA, Trondheim 04.04.2018

Hancke K 2018 Visjoner og data for bruk av luftbårne droner innen kystovervåkning. Populær vit. Fordrag, CIENS park, Oslo, Norge. **Invited speaker**

Hancke K, LC Lund-Hansen, M Lamare, SH Pedersen, MD King, P Andersen, BK Sorrell (2018) Extreme Low Light Requirement for Algae Growth Underneath Sea Ice: A Case Study From Station Nord, NE Greenland. Talk at Arctic Research Center, Denmark **Invited speaker**

Hancke K (2017) How to quantify regime shifts to turf in carbon units? International workshop on turfalgae. CIENS, Oslo, 01.06.17. **Invited speaker**

Hancke K (2017) Miljø-effekter av makroalgedyrking: Positive og negative effekter på havbunnen, livet i vannsøylen og påvirkning et "kunstig" økosystem. LISTER Innovation seminar, Norway, 27.03.17. **Invited speaker**

Hancke K (2017) Blue carbon and kelp ecosystems. SKLEC-NIVA international seminar on Ocean Acidification and Marine Carbon Budgets. CIENS, Oslo. 20.03.2017. **Invited speaker**

Hancke K (2017) Miljø-effekter av makroalgedyrking: Positive og negative effekter på havbunnen, livet i vannsøylen og påvirkning et "kunstig" økosystem. LISTER Innovation seminar, Norway, 27.03.17. **Invited speaker**

Hancke K (2017) Blue carbon and kelp ecosystems. SKLEC-NIVA international seminar on Ocean Acidification and Marine Carbon Budgets. CIENS, Oslo. 20.03.2017. **Invited speaker**

Hancke K and K Magnussen (2016) Nordic IPBES-like assessment of biodiversity and ecosystem services in coastal regions. IPBES workshop, Seili, Finland, 29.11.16. Oral contribution

Hancke K, T Dalsgaard, MK Sejr, S Markager, RN Glud (2016) Primary productivity quantified from variable chlorophyll a fluorescence. Norwegian Association for Marine Research. Bergen. Nov. Oral presentation

Hancke K (2016) Primary productivity in coastal ecosystems: Novel technologies and new approaches. NIVA science seminar, CIENS park, Oslo, 16 Juni

Hancke K, T Dalsgaard, MK Sejr, S Markager, RN Glud (*2015*) Phytoplankton productivity quantified from chlorophyll fluorescence. 18. *Danske Havforskermøde, Jan 2015. Oral presentation*

Hancke K (2015) Benthic auto-heterotroph coupling: Application of Eddy Covariance and imaging techniques. Max Planck Institute for Marine Microbiology, Bremen, 21. Oct. ***Invited speaker***

Hancke K (2015) Primary production and photosynthesis in aquatic environments. Aquatic biology seminar, Aarhus University, 24. Sep, Oral presentation

Hancke K (2015) Marine biodiversity related to key-environmental variables in the Norwegian Sea. Trial lecture for the position as Associate Professor in Biological Oceanography. NTNU Norway, 15 June. ***Invited speaker***

Outreach, public and popular science talks, and presentations, selected last 5 years (in total >30)

2018

- Avset, LMM, R Lansbergen, **K Hancke** 2018 Et surere hav får denne taren til å vokse. www.forskning.no 09.04.2018
- **Hancke, K,** LC Lund-Hansen, B Sorrell 2018 Verdensrekord: Grønlandske isalger vokser næsten helt uden lys. Vitenskab.dk https://videnskab.dk/. 21.03.2018
- **Hancke, K**, LC Lund-Hansen, B Sorrell 2018 Climate change boosts algae growth in the Arctic. ScienceNordic http://sciencenordic.com/. 21.02.2018
- Avset, LMM, R Lansbergen**, K Hancke** 2018 Will climate change affect Norwegian kelp forests in a positive way? ScienceNordic http://sciencenordic.com/. 23.02.2018
- Bondo, P 2017 Sea ice algae blooms in the dark. On Arctic Science Partnership website. 07.02.18. http://www.asp-net.org/content/sea-ice-algae-blooms-dark
- Avset, LMM, R Lansbergen, **K Hancke** 2018 Et surere hav får denne taren til å vokse. www.forskning.no 09.04.2018

2017

- **Pilotprosjekt kan redde Viksfjord.** Østlandsposten. 07.08.2017
- **Nå inntar forskerne Viksfjord**: Østlandsposten. 09.07.2017
- Strømgren 2017 **Subsea Technology for Seaweed Blue Growth**. News article. Global Center of Expertise GCE Subsea. 12.06.17
- Avset LMM 2017 **Derfor må vi ta vare på økosystemene langs kysten**. Popular science online journal forskning.no. 08.06.2017
- **Radio interview** med NRK-Sogn-og-Fjordane. Florø, Norway. 07.06.17
- **TV interview** med NRK-Sogn-og-Fjordane. Florø, Norway. 07.06.17
- **Arktisk udforskning: Danskere udvikler billig undervandsrobot styret med Xbox-controller.** Ingenøren. 28.02.17

2016

- **Hancke K** (2016) Robotter under havet: Fremtidens overvågning af havområderne i Arktis. UDAYS AU. Student recruitment day, Aarhus University. 26.02.16.Talk
- **På jakt etter en mer effektiv måte å sjekke havet på: Prøvde ut dronefoto**. Newspaper article about testing UAV drones for costal mapping. "Øyene" newspaper, Norway. 22.09.16

Curriculum Vitae, Dr. Thomas Wernberg

Affiliation: UWA Oceans Institute & School of Biological Sciences, University of Western Australia, Crawley 6009 WA, Australia; phone +61 8 6369 4047, e-mail thomas.wernberg@uwa.edu.au.

Web page: http://wernberglab.org/

Qualifications & training

PhD (18/9/2003) in Marine Botany with Distinction (top 5%), University of Western Australia;
MSc (11/6/1998) in Environmental Biology & Geography, Roskilde University, Denmark;

Other: Scientific diver (>2,800 logged work dives), Dive master, Rescue diver, Commercial boat driver (incl towing), 4-wheel driver, Senior first aid, Oxygen provider;

Key positions held

2016-current: *Associate Professor, UWA Oceans Institute & School of Biological Sciences*, UWA
2012-2016: *Australian Research Council Future Fellow/Research Associate Professor*, UWA;
2010-2013: *Research Assistant Professor*, UWA (resigned 2012 to take up Future Fellowship);
2005-2010: *Postdoctoral Research Fellow*, Edith Cowan University;
2004-2005: *Research Associate*, University of Adelaide;

Research specialisation

Ecological interactions in changing environments, including effects of temperature on ecological and ecophysiological performance (recruitment, community development, mortality). My research bridges biogeography, ecology and physiology, and aims to provide support to ameliorate the impacts of changing environments and species responses (invasive species, fouling, herbivory) on biodiversity, humans and human activities now and in the future. A current priority is understanding the ecological and ecophysiological limitations imposed on kelp forest by increasing mean and extreme temperatures.

Current teaching

- Marine Systems (coordinator, 3rd year course).
- Global Change and the Marine Environment (coordinator, 5th year course).
- MSc Marine Biology (joint coordinator of Master program).
- Current primary supervisor for 9 PhD, 1 MSc and 1 BSc Honours students (past primary supervisor for 1 postdoc, 4 PhD, 4 MSc, 6 BSc Hons students);

Publications, citations and research income

- Career total **129 refereed journal articles (33 first-authored)**, 11 book chapters (6 first-authored);
- Total citations: 5,408, ***h*-index of 42** (Google Scholar 12/4/18): 3rd highest of all Australian Research Council Future Fellows (56) in my cohort;
- 11 ISI 'Highly Cited' papers (top 1% in their subject fields), 4 first-authored (ESI 5/2/18).
- Recent first-author publications in *Science*, *Nature Climate Change*, *Current Biology*, *Ecology Letters*
- Research grant income: **A$4.9 mio** career total; ~80% as leading chief investigator;

Research leadership

- **Editor-in-Chief** for Aquatic Botany (Elsevier). Editorial board positions for Journal of Phycology, Frontiers in Marine Science, Marine and Freshwater Research;
- Co-author of white papers on 'Benthic Ecosystems' and 'Climate Change' for Australia's National Marine Science Plan (2014).
- Organiser, chair and **host, 10th International Temperate Reef Symposium** in Perth, Jan 2014;
- Lead author and coordinator of the section on 'Macroalgae and temperate reefs' in both national assessments (2009, 2012) of marine climate change impacts in Australia;
- Leading chief investigator of several large multi-year research projects (cf projects & funding);
- Convenor and leading role in several national and international workshops and working groups;
- 'Future Research Leaders' (2010) and 'Senior Research Leadership' (2013) training;
- Mentored 27 student led papers, in top journals (*Nature Communications*, *Ecology Letters*, *Ecology*).

Prizes, awards and recognition

- Appointed adjunct Professor, Roskilde University, Denmark (2018-2022).
- Visiting International Lecturer's award, University of Cape Town, South Africa (2015).
- Recent grants and collaborations in South Africa, NZ, China, UK, Norway, France and Portugal.
- Research recognised in the recent IPCC report (AR5);
- Invited technical reviewer for the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (2017);
- Invited expert testimony on temperate reefs for Australia's 2016 'State of the Marine Environment' report;
- Research highlighted by the Australian Research Council for outcomes of National Research Priority;
- PhD Thesis Distinction (top 5%), UWA, 2003;
- 4 invited reviews in international journals, 6 invited book chapters in the past 3 years;
- Invited presentations at 7 major international conferences and 4 national conferences;
- Research featured widely in the media, incl >50 news web sites in Australia, USA, China, India and Europe, live and recorded TV, national radio and newspapers;
- Invitations to 1-2 major national and international working groups per year (incl NCEAS);
- UWA Career Development Award, 2011;
- Vice-Chancellors Award for Research Excellence, 2014 (UWA);

Service to the discipline and the university

- Reviewer of competitive research grants in 7 countries and ms's for several prestigious journals;
- Hosted 5 international visiting researchers (post-docs to professors) in the past 5 years;
- Chair and member of several university committees and selection panels (2010-current);
- Opponent on 4 Australian and 1 international PhD Theses;

Selected projects and funding, Dr. Thomas Wernberg

- **Wernberg**, Verges, Steinberg: *Global threats to ocean forests: understanding impacts of heatwaves, herbivores and diseases in kelp ecosystems*, Australian Research Council, 2017-2019, A$385,000.
- **Wernberg**, Coleman: *Genes to ecosystems: drivers of resilience in underwater marine forests*, Australian Research Council, 2016-2018, A$364,000.
- Ramirez-Llodra, Pedersen, Fredriksen, Pedersen, Coll, **Wernberg**: *KELPEX: Kelp export – fuel for adjacent communities in changing Arctic ecosystems*, Norwegian Research Council, 2016-2018, (NOK 7,748,000) A$1,230,000
- Wu, Xiao, Duarte, **Wernberg**: *Bioremediation of coastal water pollution by large-scale seaweed farms and its carbon sequestration potential*, Ministry of Science and Technology of China, 2015-2017, (RMB 3,155,000) A$622,000.
- **Wernberg**, de Bettignies, Sousa Pinto, Davoult, Riera, Christie, Norderhaug, Fredriksen: *Latitudinal and Inter-hemispherical Network in Kelp ecophysiology (LINK)*, UWA Research Collaboration Award, 2014, A$20,000.
- **Wernberg**, Bennett: *Range contraction of kelp forests and tropicalisation of Australia's temperate marine environments*, The Hermon Slade Foundation, 2013-2016, A$84,000.
- Bolton, Anderson, Smit, **Wernberg**: *Kelps and climate change: South Africa in a global context*, National Research Foundation, South Africa, 2013-2015, (R 1,500,000) A$160,000.
- **Wernberg**, Gurgel: *Long-term changes in the phenology of Australia's temperate marine macroalgae: has climate change impacted the world's most diverse algal flora?* Australian Research Council, 2012-2014, A$315,000.
- **Wernberg**: *Climatic forcing of ecological function in temperate marine ecosystems: bridging the gaps*, Australian Research Council Future Fellowship, 2011-2015, A$698,000.
- Tuya, Bertocci, Duarte, Pinto, Arenas, Larsen, Castro, Cruz: *OCEANKELP: Effects of ocean climate on macro-ecology and resilience of 'kelps'*, Portuguese Science Council (FCT), 2011-2014, (€80,000) A$127,000 (**Wernberg** participant as consultant).
- **Wernberg**, Kendrick, Babcock: *Effects of physical disturbance on kelp-dominated reef communities across a temperate-tropical transition zone*, Australian Research Council, 2005-2007, $210,000.

Publications, Dr. Thomas Wernberg

Full publication list: http://wernberglab.org/publications/

Peer reviewed journal articles (selection out of 129)

Harris et al. incl **Wernberg** T (2018) Biological responses to the 'press' and 'pulse' of climate trends and extreme events. *Nature Climate Change*, accepted 12/3/18.

Martínez et al **Wernberg T** (2018) Distribution models predict large contractions in habitat-forming seaweeds in response to ocean warming. *Diversity & Distributions*, accepted 27 Januray 2018.

Kotta J, **Wernberg T**, Jänes H, Kotta I, Nurkse K, Pärnoja M, Orav-Kotta H (2018) Novel crab predator causes marine ecosystem regime shift. *Scientific Reports*, accepted 8/3/18.

Pan Y, **Wernberg T** et al (2018) Screening of seaweeds in the East China Sea as potential bio-monitors of heavy metals. *Environmental Science and Pollution Research*. [doi.org/10.1007/s11356-018-1612-3].

Filbee-Dexter K, **Wernberg T**, Ramirez-Llodra E, Norderhaug KM, Pedersen MF (2018) Movement of pulsed resource subsidies from kelp forests to deep fjords. *Oecologia*, accepted 11/3/18.

Oliver et al. **Wernberg T** (2018) Longer and more frequent marine heatwaves over the past century. *Nature Communications*, 9:1234.

Wernberg T, Coleman MA, Bennett S, Thomsen MS, Tuya F, Kelaher BP (2018) Genetic diversity and kelp forest vulnerability to climatic stress. *Scientific Reports*, 8: 1851.

Thomsen et al incl **Wernberg T** (2018) Secondary Foundation Species Enhance Biodiversity. *Nature Ecology & Evolution*, 2: 634–639.

Filbee-Dexter K, **Wernberg T** (2018) Rise of turfs: a new battle front of globally declining kelp forests. *BioScience*, 168(2): 64-76.

Bonebrake et al incl **Wernberg T** (2017) Managing consequences of climate-driven species redistribution requires integration of ecology, conservation and social science. *Biological Reviews*, 93: 284-305.

Zarco-Perello S, **Wernberg T**, Langlois T, Vanderklift MA (2017) Tropicalization strengthens consumer pressure on habitat-forming seaweeds. *Scientific Reports*, 7: 820.

Smale DA, **Wernberg T**, Vanderklift MA (2017) Regional-scale variability in the response of benthic macroinvertebrate assemblages to a marine heatwave. *Marine Ecology Progress Series*, 568: 17-30.

Pecl GT et al incl **Wernberg T** (2017) Biodiversity redistribution under climate change: impacts on ecosystems and human well-being. *Science*, 355, in press, doi: 10.1126/science.aai9214.

Krumhansl et al. incl. **Wernberg T** (2016) Global patterns of kelp forest change over the past half-century. *Proceedings of the National Academy of Sciences of the USA*, 113(48): 13785-13790.

Wernberg T, Bennett S, Babcock R, de Bettignies T, Cure K, Depczynski M, Dufois F, Fromont J, et al. (2016) Climate driven regime shift of a temperate marine ecosystem. *Science*, 353: 169-172.

Wernberg T, de Bettignies T, Bijo AJ, Finnegan P (2016) Physiological responses of habitat-forming seaweeds to increasing temperatures. *Limnol Oceanogr*, 61(6): 2180-2190.

Bennett S, **Wernberg T**, Bijo AJ, de Bettignies T, Campbell AH (2015) Central and rear edge populations can be equally vulnerable to warming. *Nature Communications*, 6:10280.

Hobday A, Alexander LV, Perkins, SE, Smale DA, Straub SC, Oliver E, Benthuysen J, Burrows MT, Donat MG, Feng M, Holbrook NJ, Moore PJ, Scannell HA, Sen Gupta A, **Wernberg T** (2016) A hierarchical approach to defining marine heatwaves. *Progress in Oceanography*, 141: 227-238

Bennett S, **Wernberg T** et al. (2016) The 'Great Southern Reef': social, ecological and economic value of Australia's neglected kelp forests. *Mar Freshw Res*, 67: 47-56.

Marzinelli et al. incl **Wernberg T** (2015). Continental-scale variation in seaweed host-associated bacterial communities is a function of host condition, not geography. *Environmental Microbiology*, 17: 4078–4088.

Franco JN, **Wernberg T**, Bertocci I, Duarte P, Jacinto D, Vasco N, Tuya F (2015) Herbivory drive kelp recruits into 'hiding' in a warm ocean climate. *Mar Ecol Progr Ser*, 536: 1-9 *Feature Article*

Sunday J, Pecl G, Frusher S, Hobday A, Hill N, Holbrook N, Edgar G, Stuart-Smith R, Barrett N, **Wernberg T**, Watson R, Smale D, Fulton E, et al. (2015) Species traits and climate velocity explain geographic range shifts in an ocean warming hotspot. *Ecology Letters*, 18: 944-953.

Bennett S, **Wernberg T**, Harvey ES, Santana-Garcon J, Saunders B (2015) Tropical herbivores provide resilience to a climate mediated phase-shift on temperate reefs. *Ecology Letters*, 18: 714-723.

Bennett S, **Wernberg T**, de Bettignies T, Kendrick GA, Anderson RJ, Bolton JJ, Rodgers K, Shears N, Leclerc J-C, Lévêque L, Davoult D, Christie HC (2015) Canopy interactions and physical stress gradients in subtidal communities. *Ecology Letters*, 18: 636–645.

Vergés A, Steinberg P, Hay M, Campbell A, Ballesteros E, Heck K, Booth D, Coleman M, Feary D, Figueira W, Langlois T, **Wernberg T** et al. (2014) The tropicalisation of temperate marine ecosystems: climate-mediated changes in herbivory and community phase shifts. *Proc Roy Society B*, 281: 20140846.

Thomsen MS, **Wernberg T** (2015) The devil in the detail: harmful seaweeds are not harmful to everyone. *Global Change Biology*, 21: 1381-1382.

de Bettignies T, **Wernberg T**, Lavery PS, Vanderklift MA, Gunson JR, Symonds G, Collier N (2014) Phenological decoupling of mortality from wave forcing in kelp beds. *Ecology*, 96(3): 850-861.

Bennett S, **Wernberg T** (2014) Canopy facilitates seaweed recruitment on subtidal temperate reefs. *Journal of Ecology*, 102 (6): 1462-1470.

Bates A, Pecl G, Frusher S, Hobday A, **Wernberg T**, et al. (2014). Defining and observing stages of climate-mediated range shifts in marine systems. *Global Environmental Change*, 26: 27-38.

Thomsen, M., **Wernberg, T.** (2014) On the generality of cascading habitat formation. *Proceedings of the Royal Society B: Biological Sciences*, 281(1777):20131994.

Andrews, S., Bennett, S., **Wernberg, T.** (2014) Reproductive seasonality and early life temperature sensitivity reflect vulnerability of a range-contracting seaweed. *Mar Ecol Progr Ser*, 495: 419-429.

Wernberg, T, Thomsen, M Kotta, J (2013) Complex plant-herbivore-predator interactions in a brackish water seaweed habitat. J Exp Mar Biol Ecol, 449(1), 51-56.

Wernberg, T., Thomsen, M.S., Connell, S.D., Russell, B.D.,et al. (2013) The footprint of continental-scale ocean currents on the biogeography of seaweeds, *PLoS One*, 8: e80168.

de Bettignies T, **Wernberg T**, Lavery P, Vanderklift M & Mohring M (2013) Contrasting mechanisms of dislodgement and erosion contribute to production of kelp detritus. *Limnol Oceanogr* 58:1680–1688.

Smale D.A. & **Wernberg T.** (2013) Extreme climatic event drives range contraction of a habitat-forming species. *Proceedings of the Royal Society B*, 280: 20122829.

Mohring, M, **Wernberg, T**, Kendrick, G & Rule, M (2013) Reproductive synchrony in a habitat-forming kelp and its relationship with environmental conditions, *Marine Biology*, 160: 119-126.

Wernberg, T., Smale, D.A., Tuya, F., Thomsen, M.S., Langlois, T.J., de Bettignies, T., Bennett, S. & Rousseaux, C.S. (2013) An extreme climatic event alters marine ecosystem structure in a global biodiversity hotspot, *Nature Climate Change*, 3: 78-82.

Tuya, F., Cacabelos, E., Duarte, P., Jacinto, D., Castro, J.J., Silva, T., Bertocci, I., Franco, J.N., Arenas, F., Coca, J. & **Wernberg, T.** (2012) Patterns of landscape and assemblage structure along a latitudinal gradient in ocean climate, *Marine Ecology Progress Series*, 466: 9-19.

Wernberg, T., Smale, D.S., Thomsen, M.S. (2012) A decade of climate change experiments on marine organisms: procedures, patterns and problems, *Global Change Biology*, 18: 1491–1498.

Russell, B.D., Harley, C.D.G., **Wernberg, T.**, Mieszkowska, N., Widdicombe, S., Hall-Spencer, J.M., Connell, S.D. (2012) Predicting ecosystem shifts requires new approaches that integrate the effects of climate change across entire systems. *Biology Letters*, 8: 164-166.

Wernberg, T, Russell, B, Thomsen, M, Gurgel, C, Bradshaw, C, Poloczanska, E, Connell, S (2011) Seaweed communities in retreat from ocean warming. *Current Biology*, 21: 1828-1832.

Wernberg, T, Thomsen, M, Tuya, F & Kendrick, G (2011) Biogenic habitat structure of seaweeds change along a latitudinal gradient in ocean temperature. *J Exp Mar Biol Ecol*, 400: 264-271.

Wernberg T., Russell B.D., Moore P.J., Ling S.D., et al. (2011) Impacts of climate change in a global hotspot for temperate marine biodiversity and ocean warming. *J Exp Mar Biol Ecol* 400: 7-16.

Wernberg, T, Thomsen, M, Tuya, F, et al. (2010) Decreasing resilience of kelp beds along a latitudinal temperature gradient: potential implications for a warmer future. *Ecology Letters*, 13: 685-694.

Book chapters (selection out of 11)

Wernberg T, Krumhansl K, Filbee-Dexter K, Pedersen MF (in press) Status and trends for the world's kelp forests. In: *World Seas: An Environmental Evaluation*, Vol III: Ecological Issues and Environmental Impacts, 2e. Ed. C. Sheppard. Elsevier. Accepted 1/2/18.

Wernberg T, Straub S (2016). Seaweeds. In: *Explaining ocean warming: causes, effects and consequences* (eds. Laffoley and Baxter). The International Union for Conservation of Nature, Switzerland.

Wernberg T, Arenas F, Olabarria C, Thomsen M, & Mohring M (2016) Threats to ecosystem engineering macrophytes: climate change. In: *Marine macrophytes as ecosystem engineers* (ed Ólafsson); Science Publisher/CRC Press, Boca Raton, USA. ISBN 978-1-498-72324-4, pp 201-225.

CURRICULUM VITAE

Dr. Karen Filbee-Dexter

AFFILIATION: KELPEX PostDoc, Marine Section, Norwegian Institute for Water Research, Gaustadalléen 21, NO-0349 OSLO; kfilbeedexter@gmail.com, www.kelpex.org

RESEARCH SPECIALISATION

Drivers and patterns of long-term change in coastal ecosystems. Regime shifts dynamics, Arctic kelp forests, Climate-driven shifts in marine ecosystems, Linkages between social and ecological systems during sudden ecosystem collapse.

RESEARCH EXPERIENCE

Oct 2016-current: KELPEX **Postdoctoral researcher** at NIVA
KELPEX quantifies detrital kelp production and export in Arctic Norway. The project is funded by the Norwegian Research Council and includes an international team of researchers, postdocs and MSc students from Norway, Denmark, Spain, Belgium, Germany, Canada and Australia.

Aug 2016- Sep 2016 World Wildlife Fund Canada **Research Contract** Sambro Benthic Diversity Studies

May 2010-Aug 2016: **PhD in Marine Biology**, Dalhousie University, Canada

RESEARCH PROJECTS

Jan 2017-Dec 2018: **Project Lead** in SUKER: Broad-scale 'litter bag' experiment in sugar kelp forests. Financed by: Norwegian Blue Forest Network. Institution: NIVA. Budget: 305 kNOK

Sept 2017: **Co-organizer** / **Co-Lead** in KELCO: The role of kelp export in shaping adjacent benthic ecosystems: steps for international collaboration. Financed by: Marinforsk. Institution: NIVA. Budget: 150 kNOK

Aug 2016-Dec 2016: **Lead Researcher.** Analysis of benthic biodiversity and distribution of marine habitats for the Sambro Ledges. Financed by: Department of Fisheries and Oceans Canada. Directly related to the data compilation step in the development of a Network of MPAs for the Scotian Shelf Bioregion. Institution: self-employed. Budget: 70 kNOK

EDUCATION

Doctor of Philosophy (Biology) Dalhousie University, Halifax, NS / 2010 – August 31st, 2016
Thesis: *Role of deep-living sea urchins in alternative state dynamics of kelp ecosystems* (Supervisor: Dr. Robert Scheibling) (sole nomination for the **CAGS Doctoral Thesis Award** from my department)
* 1-year leave of absence for Olympic sailing / 2011-2012

Honours Bachelor of Science (Biology), Dalhousie University, Halifax, NS / Graduated 2010
Honours thesis: *Effects of reef protection on coral health in Mesoamerican Barrier Reef*
With Distinction (**GPA 4.26**)

SCHOLARSHIPS AND AWARDS

Postgraduate funding and awards:

Norwegian Research Council 2017 Arctic Emerging Leader Scholarship (30,000 NOK)

Graduate funding and awards:

NSERC Postgraduate Scholarship-Doctoral Program ($84,000 CAD)
2nd Dalhousie Three Minute Thesis Competition (out of 740 contestants) ($250 CAD)
Izaak Walton Killam Pre-Doctoral Scholarship ($100,000 CAD)
President's Award (tuition waiver)
Joe Ghiz Memorial Scholarship ($1500 CAD)
NSERC Postgraduate Scholarship-Master's Program ($17,500 CAD)

Nova Scotia Yachting Association Support for Sport Bursary ($16,000 CAD)

Undergraduate funding and awards:

Hughes G. Bell Award for Excellence in Biology ($450 CAD)
Dalhousie University Entrance Scholarship ($20,000 CAD)
Dalhousie Residence Scholarship ($8,000 CAD)
Canada Wide Science Fair Research Bursary ($3000 CAD)

PEER-REVIEWED PUBLICATIONS

Summary:

- Career total of **12 publications (10 first-authored), 1 book chapter** and **1 scientific report**. Currently 3 manuscripts in submission.
- Lead author of recent papers in *BioScience* (2018), *Journal of Applied Ecology* (2018), *Oecologia* (2018), and *Ecology* (2016).
- **184 citations** (Google Scholar 10/3/2018), **H-index of 5** (Google Scholar 10/4/2018), accounting for time since PhD this is a m-quotient of 2.5, which is considered outstanding (Harzing 2016)

IF = Current journal impact factor (ISI Journal Citation Reports, 2016).
* = Publications particularly relevant to this proposal.
[#] = students under my direct mentorship.

Scholarly book chapters

1. ***Wernberg T**, Krumhansl, K, **Filbee-Dexter K**, and Pedersen, M. (in press) Status and trends for the world's kelp forests. In: World Seas: An Environmental Evaluation, Vol III: Ecological Issues and Environmental Impacts, 2e. Ed. C. Sheppard. *Elsevier*. Accepted 31/1/2018.

Refereed journal articles [12]

2. ***Filbee-Dexter K**, Wernberg T, Norderhaug, KM, Ramirez-Llodra, E, and Pedersen, M. (2018). Movement of pulsed resource subsidies from kelp forests to deep fjords. *Oecologia*. https://doi.org/10.1007/s00442-018-4121-7 [***IF = 3.1***]
3. ***Filbee-Dexter K**, Symons C, Jones K, Haig H, Pittman J, Alexander S, Burke M (in press) Quantifying ecological and social drivers of ecological surprise. *Journal of Applied Ecology.* [***IF = 5.2***].
4. ***Filbee-Dexter K**, **Wernberg T** (2018) Rise of turfs: a new battle front of globally declining kelp forests. *BioScience*. 68: 64–76. [***IF = 5.4, top 9% Biology***].
5. ***Filbee-Dexter K**, Pittman J, Alexander S, Burke M, Haig H, Symons C (2017) Ecological surprise: concept, synthesis and social dimensions. *Ecosphere.* 8:12. [***IF = 2.5***].
6. ***Filbee-Dexter K,** Scheibling RE (2017). The past is the key to the present: linking regime shifts in kelp beds to the current distribution of deep-living sea urchins. *Ecology*. 98: 253-264. [***IF = 4.8, top 14% Ecology***].
7. Scheibling RE, Patriquin D, **Filbee-Dexter K** (2017). Distribution and abundance of the invasive seagrass *Halophila stipulacea* and associated benthic macrofauna in Carriacou, Grenadines, Eastern Caribbean. *Aquatic Botany*. 144: 1-8. [***IF = 1.7***]
8. ***Filbee-Dexter K**, Feehan CJ, and Scheibling RE (2016). Large-scale degradation of a kelp ecosystem in an ocean warming hotspot. *Marine Ecology Progress Series*. 543: 141-152. [***IF = 2.3***]
9. **Filbee-Dexter K,** Scheibling RE (2016). Spatial patterns and predictors of drift algal subsidy in deep subtidal environments. *Estuaries and Coasts*. 39: 1724-1734. [***IF = 2.2***]
10. ***Filbee-Dexter K,** Scheibling RE (2014a). Sea urchin barrens as alternative stable states of collapsed kelp ecosystems. *Marine Ecology Progress Series*. 495: 1-25. [***IF = 2.3, FEATURE ARTICLE***]
11. **Filbee-Dexter K,** Scheibling RE (2014b). Detrital kelp subsidy supports high reproductive output of deep-living sea urchins in a sedimentary basin. *Aquatic Biology*. 23: 71-86. [***IF = 1.3***]
12. Francis FT-Y[#], **Filbee-Dexter K**, Scheibling RE (2014). Aggregations of stalked tunicates *Boltenia ovifera* form biogenic habitat in the rocky subtidal zone in Nova Scotia. *Marine Biology*. 161: 1375-1385. [***IF = 2.1***].

13. ***Filbee-Dexter K,** Scheibling RE (2012). Hurricane-mediated defoliation of kelp beds and pulsed delivery of kelp detritus to offshore sedimentary habitats. *Marine Ecology Progress Series*. 455: 51-64. [***IF = 2.3***]

Other publications

14. **Filbee-Dexter K** (2016). Distribution and abundance of benthic habitats within the Sambro Ledges Ecologically and Biologically Significant Area. *Canadian Technical Report of Fisheries and Aquatic Science*. 3190: vi+ 26p

Publications in review

15. **Filbee-Dexter K,** Wernberg T, Norderhaug KM, Ramirez-Llodra E, Fredrickson S, Pedersen, M. (invited review article). Arctic kelp forests: productivity, resilience, and future. *Global and Planetary Change*. [***IF = 3.9***]. Submitted Mar 5, 2018.

16. Wallen K, **Filbee-Dexter K**, Pittman J, Posner S, Alexander S, et al. Furthering perspectives on doctoral training in interdisciplinary team science and socio-environmental research. *PLOS1.* Submitted Feb 12, 2017. [***IF = 2.8***]

17. Francis F[†], **Filbee-Dexter K**[†], Yan H, Cote I. Contrasting fish and invertebrate herbivory: Should we rethink recovery strategies for heavily degraded coral reefs? *Conservation Biology*. Submitted January 20, 2018. [***IF = 4.8***]

CONFERENCE PRESENTATIONS [Last 5 years]

Filbee-Dexter K 2018. Arctic kelp forests: productivity, resilience and future. Ocean Science Meeting, Portland, Oregon, USA.

Filbee-Dexter K 2017. What does the green shift mean for the Arctic? Arctic Frontiers Emerging Leaders Reception, Tromsø, Norway.

Filbee-Dexter K, RE Scheibling 2017. Kelp forests in a changing Arctic. Emerging Leaders Program, Tromsø, Norway.

Filbee-Dexter K, RE Scheibling 2016. Deep-living sea urchins trigger shifts to barrens in a shallow kelp bed ecosystem. Benthic Ecology Meeting, Portland, Maine, USA.

Filbee-Dexter K, RE Scheibling 2016. Linking regime shifts in a kelp bed ecosystem to deep-living sea urchins. Patrick Lett Graduate Student Symposium, Halifax, Canada. [***runner-up Best Presentation***]

Filbee-Dexter K, RE Scheibling 2015. Predicting patterns of drift algal subsidy in deep subtidal environments. Western Society of Naturalists, Sacramento, California, USA.

Filbee-Dexter K, J Pittman, S Alexander, M Bass, M Burke, H Haig, C Symons 2015. Conceptualizing surprise in social-ecological systems. Western Society of Naturalists, Sacramento, California, USA. (poster).

Filbee-Dexter K, RE Scheibling 2015. Distribution of deep-living sea urchins and their connection to shallow barrens, Huntsman Marine Science Centre, St. Andrews, NB. [***runner-up Best Presentation***]

Filbee-Dexter K, CJ Feehan, RE Scheibling 2015. Ocean warming hotspots, phase shifts and large-scale degradation of a Nova Scotia kelp bed ecosystem. Benthic Ecology Meeting, Quebec City, QC, Canada.

Filbee-Dexter K, CJ Feehan, RE Scheibling 2014. Phase shifts from kelp beds to turf or invasive algal-dominated assemblages over decadal time-scales in Nova Scotia. Western Society of Naturalists, Tacoma, Washington, USA.

Filbee-Dexter K, RE Scheibling 2014. Sea urchin barrens as alternative stable states of collapsed kelp ecosystems. Benthic Ecology Meeting, Jacksonville, Florida, USA.

Filbee-Dexter K, RE Scheibling 2013. Detrital subsidy from kelp beds enhances sea urchin reproduction in adjacent sedimentary habitats in Nova Scotia. Western Society of Naturalists, Oxnard, California, USA.

Filbee-Dexter K, RE Scheibling 2013. Detrital kelp subsidies enhance reproductive output of deep-living sea urchins. Atlantic Canada Coastal & Estuarine Science Society, Centre for Geographic Sciences, NSCC, Lawrencetown, NS, Canada.

SEMINARS

"Regime shifts in kelp bed ecosystems." Friday Informal Seminar Hour, Biology Department, Dalhousie University / Nov 2015

"Sea urchin barrens and kelp collapse" SFU Seminar Hour, Biology Department, Simon Fraser University / Nov 2015

"Drift kelp subsidy to deep subtidal environments", Friday Harbor Labs Seminar, University of Washington, USA / Nov 2015

"How resilient are kelp beds to a changing ocean?" Friday Informal Seminar Hour, Biology Department, Dalhousie University / Feb 2015

RESEARCH COLLABORATIONS

Member of an interdisciplinary research pursuit funded by the National Socio-Environmental Synthesis Center (www.sesync.org). Our pursuit examined surprise in social-ecological systems. / 2016

Past member of the Canadian Healthy Oceans Network, a NSERC strategic network focused on biodiversity science for the sustainability of Canada's three oceans. / 2010 – 2013

TEACHING

FIL 4011: General Concepts in Philosophy, University of Oslo
- Guest lecture: *Conservation ethics* / 2017

Biology 5705: Graduate Module, Dalhousie University
- *Regime shifts and Alternative Stable State Dynamics* / 2016

Biology 5061: Experimental Design & Data Analysis in Biology, Dalhousie University
- Guest lecture: *Generalized Additive Models* / 2015

Biology 3761: Marine Ecology, Dalhousie University
- Guest lecture: *Regime shifts in coastal ecosystems* / 2016
- Guest lecture: *Pursuing Graduate Studies in Biology* / 2013 & 2014
- Teaching Assistant / 2012-2014

Biology 2060: Ecology, Teaching Assistant, Dalhousie University / 2010

ACADEMIC COMMITTEES AND OTHER PROFESSIONAL EXPERIENCE

- Graduate Admissions Committee, Biology Department, Dalhousie / 2016
- Climate Change and Environmental Rights Working Group - Young Liberals of Canada / 2016
- Lett Symposium Coordinator, Biology Department, Dalhousie / 2016
- Graduate Directorate, Biology Department, Dalhousie / 2015 & 2016
- Executive Member Biology Organization of Graduate Students, Dalhousie / 2014 – 2016
- Royal Nova Scotia Yacht Squadron Board of Management / 2016

CERTIFICATIONS AND PROFESSIONAL TRAINING

- Disentangling complex causal relationships in spatial and temporal ecological data / 2017
- PADI Dive Master, Advanced and Rescue Diver / 2016
- Scientific Diver I and II, Canadian Association for Underwater Science / 2016
- SESYNC Computational Summer Institute, Annapolis, Maryland / 2015
- Statistical techniques for Spatial Analysis, Atlantic Coastal and Estuarine Society / 2015
- Small Vessel Operator Proficiency license, Transport Canada / 2015
- Off-shore Personal Safety and Sea Survival Training, International Sailing Federation / 2015
- Species Distribution Modeling in the Marine Environment, DFO / 2014
- Software Carpentry Boot camp (GIT, R, SQL), Dalhousie University / 2014

PROFESSIONAL SKILLS

- Experienced diver with 450 scientific dives
- Experienced field ecologist and boat operator
- Expertise in statistical programs and software: R, GIS, GIT, PRIMER-e

Albertus Jacobus Smit (PhD) – Curriculum Vitae – 24 April 2018

CONTACT DETAILS: Associate Professor AJ Smit, Department for Biodiversity & Conservation Biology, University of the Western Cape, Private Bag X17, Bellville 7535, South Africa

Work tel.: +27 (0)21 959 3783 | **Fax.:** +27 (0)21 959 2312 | **Mobile:** +27 (0)78 300 6005 | **Email:** ajsmit@uwc.ac.za

ASSOCIATE POSITION: Research Associate, South African Environmental Observation Network (SAEON), Elwandle Coastal Node, Ocean Sciences Campus, Port Elizabeth, South Africa

ORCID ID: https://orcid.org/0000-0002-3799-6126

TERTIARY EDUCATION HISTORY

1989 – 1992: B.Sc. (Zoology and Botany majors) - University of Port Elizabeth (UPE)
1993: B.Sc. (Hons.) (Marine Botany) - UPE
1994: M.Sc. (Marine Botany) - UPE
1994 – 1998: Ph.D. (Botany) - University of Cape Town (UCT)

KEY POSITIONS

2012 – 2013: Climate Protection Scientist, eThekwini Municipality.
2004 – 2012: Senior Lecturer in Marine Biology, School of Biological and Conservation Sciences, University of KwaZulu-Natal.
2001 – 2004: Research Fellow, Department of Botany, UCT.
2001: Postdoctoral Research Fellow, Universidade do Algarve, Centro de Ciências do Mar (January 2001 – September 2001).
2000: Honorary Research Fellow, Department of Botany, The University of Western Australia (July – December).
2000: Environmental Scientist with D. A. Lord & Associates, Perth, Western Australia (May – December).
1999: Research Fellow at Edith Cowan University, Center for Ecosystem Management, Joondalup, Western Australia (February – May).
1998: Research Associate at the University of Western Australia.
1993: Seaweed mariculturist at Marine Growers (Pty.) Ltd.

RESEARCH GRANTS

2018 – 2020: Smit; National Research Foundation (NRF), Upwelling dynamics in kelp beds: implications for trophic function, ZAR654,000.
2016 – 2018: Smit, Bornman; South Africa (NRF) / Poland (NCBR) Science and Technology Research Collaboration programme, ZAR400,000.
2015 – 2017: Smit; NRF, Thermal Characteristics of the South African Nearshore, ZAR1,596,400.
2014 – 2016: Bolton, Smit, Anderson; NRF, Kelps and Climate Change, ZAR1,575,906.
2013 – 2015: Harris, Smit, et al.; African Coelacanth Ecology Programme (III).
2007 – 2011: Fennessey, Smit; NRF Focus Area, Tugela ecosystem function.
2007 – 2011: Smit, Schoeman; NRF Research Niche Area, Marine Biodiversity, ecology and ecotoxicology.
2008 – 2011: Fennessey, Smit, et al.; African Coelacanth Ecology Programme (II).
2007 – 2008: Smit; NRF Focus Area, A meta-analytical and experimental investigation into the assumptions underlying trophic-level isotopic fractionation in marine organisms.

2006 – 2007: Smit; NRF Focus Area, Studies into the accumulation of DMSP by abalone – physiological effects and its potential role in affecting the taste and odour quality of the product.

RESEARCH SPECIALISATION

- Coastal oceanography
- Climate change research
- Coastal ecology, with an emphasis on kelp beds
- Stable isotope ecology
- Phycology, with an emphasis on seaweed ecophysiology and coastal ecology

INTERNATIONAL PANEL FOR CLIMATE CHANGE

2017 – 2019: Lead Author on the IPCC Working Group 2 Special Report on the Ocean and Cryosphere in a Changing Climate, Chapter 4: Sea Level Rise and Implications for Low Lying Islands, Coasts and Communities.

TEACHING/LECTURING (2012 – 2018)

BDC212: Plant Ecophysiology
BIOL231: Marine Environment
BIOL341: Marine Systems
BIOL342: Marine Ecophysiology
BIOL784W: Marine Ecosystem Analysis
Plant Physiology (BCB740)
BCB700: Introductory R Workshop; Basic Statistics with R; Philosophy of Science

POST-GRADUATE SUPERVISION

South African Students		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Honours/BTech	20	0	0	2	1	5	1	6	5
Masters	15	2	0	0	0	7	2	1	3
Undergraduate diploma	7	0	0	1	0	4	0	2	0
Doctoral	7	0	1	1	0	0	1	0	4
Postdoctoral	1	0	0	0	0	0	0	0	1
Honours	2	0	0	1	1	0	0	0	0

Non-South African Students (other African countries)		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Masters	2	0	2	0	0	0	0	1	1
Masters/MTech	1	0	1	0	0	0	0	0	0

Non-South African Students (International)		Black		Coloured		Indian		White	
Degree	Total	Female	Male	Female	Male	Female	Male	Female	Male
Honours/BTech	2	0	0	0	0	0	0	1	1
Masters	2	0	2	0	0	0	0	1	1
Doctoral	1	0	0	0	0	0	0	0	1

MEMBERSHIP TO PROFESSIONAL SOCIETIES

2015 – President: Phycological Society of Southern Africa
2006 – Western Indian Ocean Marine Science Association
1999 – 2001: Australian Marine Science Association
1998 – 2000: American Society of Limnology and Oceanography
1995 – 1997: Mariculture Association of South Africa
1992 – Phycological Society of Southern Africa

MANUSCRIPT REVIEWING

African Journal of Marine Science; Estuarine, Coastal and Shelf Science; Hydrobiologia; Journal of Applied Phycology; Journal of Phycology; Journal of Marine Systems; Marine

Biology; Marine Ecology; Aquatic Botany; Diversity and Distributions; Frontiers in Marine Science; PLOS ONE.

JOURNAL ARTICLES

Kirsten, KL, Haberzettl, T, Wündsch, M, Frenzel, P, Meschner, S, **Smit, AJ**, Meadows, ME (2018) A multiproxy study of the ocean-atmospheric forcing and the impact of sea-level changes on the southern Cape coast, South Africa during the Holocene. Palaeogeography, Palaeoclimatology, Palaeoecology, 496(January), 282–291. http://doi.org/10.1016/j.palaeo.2018.01.045

Livingstone, T, Harris, J, **Smit, AJ**, Lombard, AT, Schoeman, DS (2017) Classification of Marine Bioregions on the East Coast of South Africa. *African Journal of Marine Science*, *Submitted*. http://doi.org/10.2989/1814232X.2018.1438316

Smit AJ, Bolton JJ, Anderson RJ (2017) Seaweeds in two oceans: beta-diversity. Frontiers in Marine Science DOI: 10.3389/fmars.2017.00404

Schlegel RW, Oliver ECJ, Perkins-Kirkpatrick S, Kruger A, **Smit AJ** (2017) Predominant atmospheric and oceanic patterns during coastal marine heatwaves. Frontiers in Marine Science DOI: 10.3389/fmars.2017.00323

Schlegel RW, Oliver ECJ, Wernberg TW, **Smit AJ** (2017) Nearshore and offshore co-occurrence of marine heatwaves and cold-spells. Progress in Oceanography 151: 189–205.

Ortega-Cisneros K, de Lecea AM, Smit AJ, Schoeman DS (2017) Resource utilization and trophic niche width in sandy beach macrobenthos from an oligothrophic coast. Estuarine Coastal Shelf Science 184: 115–125. DOI: 10.1016/j.ecss.2016.11.011

Schlegel RW, **Smit AJ** (2016) Climate change trends in coastal seas: time series properties affecting trend estimation. Journal of Climate 29: 9113-2124 DOI: 10.1175/JCLI-D-16-0014.1

Bornman TG, Schmidt J, Adams JB, Mfikili AN, Farre RE, **Smit AJ** (2016) Relative sea-level rise and the potential for subsidence of the Swartkops Estuary intertidal salt marshes, South Africa. South African Journal of Botany, 107, 91-100. DOI:10.1016/j.sajb.2016.05.003

de Lecea AM, **Smit AJ** (in review) First insights into the food web of a narrow continental shelf bight, eastern South Africa. Estuarine Coastal and Shelf Science.

de Lecea AM, **Smit AJ**, Fennessy ST (2016) Riverine dominance of a near-shore marine demersal food web: evidence from stable isotope and C:N ratio analysis. African Journal of Marine Science, 38(Supplement): S181–S192 doi: 10.2989/1814232X.2016.1142898

Naidoo T, Glassom D, **Smit AJ** (2016) Plastic ingestion by estuarine mullet in an urban harbour, KwaZulu-Natal, South Africa. African Journal of Marine Science doi:10.2989/1814232X.2016.1159616.

Cockburn J, Rouget M, Slotow R, Roberts D, Boon R, Douwes E, O'Donoghue S, Downs C, Mukherjee S, Musakwa W, Mutanga O, Mwabvu T, Odindi J, Odindo A, Proches S, Ramdhani S, Ray-Mukherjee J, Naidoo S, Schoeman C, **Smit AJ**, Wale E, Willows-Munro S (2016) How to build science-action partnerships for local land use planning and management: Lessons from Durban, South Africa. Ecology and Society 21(1):28. doi: 10.5751/ES-08109-210128

García-Reyes M, Sydeman WJ, Schoeman DS, Rykaczewski RR, Black BA, **Smit AJ**, Bograd SJ (2015). Under pressure: Climate change, upwelling and eastern boundary upwelling ecosystems. Frontiers in Marine Science 2:109. doi:10.3389/fmars.2015.00109

Naidoo T, Glassom D, **Smit AJ** (2015) Plastic pollution in five urban estuaries of KwaZulu-Natal, South Africa. Marine Pollution Bulletin 15: 473-80.

de Lecea AM, Cooper R, **Smit AJ** (2015) Identifying the Drivers of the Pelagic Ecosystem of an Oligotrophic Bight (Kwazulu-Natal, South Africa) using Stable Isotopes ($\delta^{13}C$, $\delta^{15}N$) and C:N Ratio Analyses. Marine and Freshwater Research 67(11), 1750-1761.

du Plooy S, Perissinotto R, **Smit AJ** (2015) Role of nutrient assimilation in facilitating prolonged bloom persistence of *Cyanothece* sp. in Lake St Lucia, iSimangaliso Wetland Park (South Africa). Aquatic Microbial Ecology 74: 73–83

du Plooy S, **Smit AJ**, Perissinotto R (2014) Nitrogen uptake dynamics of a persistent cyanobacterium *Cyanothece* sp. bloom in Lake St Lucia, South Africa, African Journal of Marine Science 36:2, 155-161, DOI: 10.2989/1814232X.2014.922124

Smit AJ, Roberts M, Anderson RJ, DuFois F, Dudley SFJ, Olbers J, Bornman T, Bolton JJ (2013) An inshore seawater temperature dataset for biogeographical studies: large biases between in situ and remotely-sensed data sets around the coast of South Africa. PLOS ONE.

de Lecea AM, Fennessy S and **Smit AJ** (2013) Processes controlling the benthic food-web of a mesotrophic bight (KwaZulu-Natal, South Africa) revealed by stable isotope analysis. Marine Ecology Progress Series, 484, 97–114.

Massé LM, Séré MG, **Smit AJ**, Schleyer MH (2013) Sexual Reproduction in Pocillopora damicornis at High Latitude off South Africa. Western Indian Ocean Journal of Marine Science 11: 55-65.

Anderson RJ, Bolton JJ, **Smit AJ**, da Silva Neto D (2012) The seaweeds of Angola: the transition between tropical and temperate marine floras on the west coast of southern Africa. African Journal of Marine Science 34: 1-13.

Bolton JJ, Anderson RJ, **Smit AJ**, Rothman MD (2012) South African kelp moving eastwards? The discovery of *Ecklonia maxima* (Osbeck) Papenfuss at De Hoop Nature Reserve. African Journal of Marine Science 34: 147-151.

van Os N, Sara J, Schoeman DS, **Smit AJ** (2012) Influence of heterotrophic feeding on the growth, survival and feeding rates of *Galaxea fascicularis*. Aquaculture 330-333: 156-161.

OTHER

Management of the South African Coastal Temperature Network (https://github.com/ajsmit/SACTN)
Author of RmarineHeatWaves (https://github.com/ajsmit/RmarineHeatWaves)

DIVING

1999:	PADI Advanced NITROX.
1993 – 2004:	Dive planning and support.
1994:	Scientific Diver Class IV Supervisor qualification (Department of Manpower, Machinery and Occupational Safety Act, 1983, South Africa); equivalent to sport diving instructor.
1994:	CMAS Openwater II.
1993:	Scientific Diver Class IV qualification (Department of Manpower, Machinery and Occupational Safety Act, 1983, South Africa); equivalent to sport diving dive master.
1993 – 2004:	More than 2000 dives obtained at all depth not exceeding 50 m during underwater experimentation, search and recoveries, and biological and oceanographic data gathering.
1989:	South African Underwater Union (SAUU) Openwater I diver.

Norwegian Institute for Water Research

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Organization No.: 855869942
www.niva.no
post@niva.no

The Research Council of Norway
P.O Box 564 N-1327 Lysaker, Norway

Your reference	Our reference	Date
		23/04/2018

Confirmation statement for the project proposal

BLUECONNECT

I hereby confirm that Norwegian Institute for Water Research will collaborate in the proposed project "**BLUECONNECT. Blue growth opportunities in changing kelp forests**" directed by Dr Karen Filbee-Dexter and Dr Kjell Magnus Norderhaug, Institute of Marine Research, Norway.

Collaboration and participation in the project will be through the participation of **Dr. Kasper Hancke** as detailed in the project proposal submitted to the Research Council of Norway, 25 April 2018.

NIVA and I personally are welcoming this exciting initiative which we find both timely, relevant, and most exciting. The proposed activites link very well with NIVA's current research activities and fits into the frame of our future directions concerning research and management needs related to wild and cultivated kelp forest functions.

NIVA strongly encourage support of this project and ensure delivery of the resources and expertice to the project as outlined in the proposal. Should you require any additional information, please contact Kasper Hancke (kasper.hancke@niva.no).

Yours sincerely
NORWEGIAN INSTITUTE FOR WATER RESEARCH

Tor-Petter Johnsen
Viseadm. Director
Direct line: +47 911 36 813
E-mail: tor-petter.johnsen@niva.no

UNIVERSITY OF AGDER

Kristiansand April 23, 2018

The Research Council of Norway
P.O Box 564 N-1327 Lysaker, Norway

Letter of Support for the project proposal BLUECONNECT

It is a great pleasure for me to commit my strong support to the proposed project "BLUECONNECT. Blue growth opportunities in changing kelp forests" directed by Dr. Karen Filbee-Dexter and Dr. Kjell Magnus Norderhaug, Institute of Marine Research, Norway.

Through my position at the University of Agder I will be able to provide a valuable link to Norwegian students interested in participating in this project. This valuable opportunity will enable the development of requisite skills that are normally not part of formal graduate school curriculum, better enabling students to apply an ocean science-based approach to future research and management. Thus, BLUECONNECT will be foundational to building ocean science capacity in both countries.

Should you require any additional information, please contact me.

Yours Sincerely,

Dag Olav Andersen

Dag Olav Andersen
Department Leader Natural Sciences
University of Agder

Prof. Albertus J. Smit
University of the Western Cape
Department of Biodiversity and Conservation Biology
Private Bag X17, Belville, 7535, South Africa
Tel: +27 (0) 21 959 3783, Fax: +27 (0) 21 959 2312/1237
ajsmit@uwc.ac.za

24 April 2018

Re: BLUECONNECT: Blue growth opportunities in changing kelp forests

I herewith offer my full support to the SANOCEAN BLUECONNECT project proposed by Drs Karen Filbee-Dexter and Kjell Magnus Norderhaug from the Institute of Marine Research, Norway.

My lab is actively working on aspects of kelp bed ecology and coastal ocean processes, and the work proposed by Dr Filbee-Dexter's team is fully aligned with some of the projects we are currently undertaking. I shall make my team's resources available in full support of BLUECONNECT's goals and objectives. I have every reason to believe that our collaboration on this project will be mutually beneficial to the Norwegian and South African parties.

My contact details are included herewith should any further details be required.

Yours sincerely,

Albertus J. Smit (PhD)
Biodiversity and Conservation Biology Department,
University of the Western Cape

agriculture,
forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

Dr Mark Rothman
Production Scientist
Directorate Inshore Research, Department of Agriculture, Forestry and Fisheries
Private Bag X2, Vlaeberg, 8018

Tel: +27 21 6503717. E-mail: mark.rothman@uct.ac.za

24 April 2018

Research Professor Kjell Magnus Norderhaug
Norwegian Institute for Water Research (NIVA)
Gaustadalleen 21
0349 Oslo, Norway

Confirmation of intent to participate in project "BLUECONNECT"

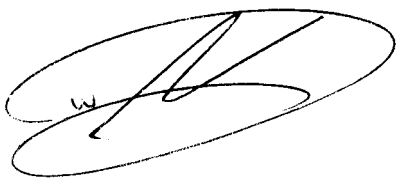
Dear Prof Kjell Magnus Norderhaug and Dr. Karen Filbee-Dexter,

It is my pleasure to confirm my intent to participate in the BLUECONNET project.

I am currently the only Seaweed Biologist working directly for the South African Government. I have close to 20 year of experience working in kelp beds in and around South Africa, focusing on their ecology. I also have close links to the University of Cape Town where I serve as a Research Affiliate. This allows me to have access to the major role players in the ocean space in South Africa.

South Africa is in a unique position where we have observed expansions of kelp beds and their distributions, possibly due to seawater cooling. These shifts could cause major ecosystem changes influencing ecosystem conditions. This is a valuable opportunity to compare systems and expose students to these variable environments.

I am looking forward to collaborate with you on this project.
Sincerely



Mark Rothman

Professor Sarah Dunlop
Head: School of Biological Sciences
Biology without Borders

Tuesday, 24 April, 2018

The Research Council of Norway

P.O Box 564 N-1327 Lysaker, Norway

Confirmation statement for the project proposal BLUECONNECT

To whom it may concern,

I hereby confirm that The University of Western Australia will collaborate in the proposed project "BLUECONNECT. Blue growth opportunities in changing kelp forests" directed by Dr Kjell Magnus Norderhaug, Institute of Marine Research, Norway.

Collaboration and participation in the project will be through the participation of Dr Thomas Wernberg as detailed in the project proposal submitted to the Research Council of Norway, 25 April 2018. Should you require any additional information, please contact me.

Please do not hesitate to contact me if you have any further questions.

Yours sincerely,

Professor Sarah Dunlop

Head: School of Biological Sciences

The University of Western Australia
M092, Perth WA 6009 Australia

T +61 8 6488 2237

E sarah.dunlop@uwa.edu.au

Norges forskningsråd
The Research Council of Norway

NRF

NATIONAL RESEARCH FOUNDATION
South Africa

SOUTH AFRICA – NORWAY COOPERATION ON OCEAN RESEARCH (SANOCEAN) PARTNER FORM

(to be completed by the South African partner and submitted as **mandatory** appendix to the standard RCN electronic application form)

Project Title:
BLUECONNECT. Blue growth opportunities in changing kelp forests.

SOUTH AFRICAN APPLICANT

Last Name	**First names**	**Race**	**Gender**
Smit	Albertus J.	White	Male
ID number		**ID number**	
7011125155085			

Full name	**Current Academic Qualification**	**Institution**	**Race & Gender**
Mark Rothman	Ph.D.	Department of Agriculture, Forestry and Fisheries	Coloured

PLANNED STUDENT/POSTDOC INVOLVEMENT:

Name	**Level (Masters, PhD, PostDoc)**	**Race**	**Gender**
Students TBD	M.Sc.	TBD	TBD

BUDGET (Note: Maximum 4-year (48 months) project)

Rands in thousands

Item	2019	2020	2021	2022	Total
Travel costs	156,000	31,200	124,800	132,600	312,000
Post-graduate exchange grants	0	109,200	109,200	109,200	218,400
Workshops and conferences	0	140,400	0	0	140,400
Research costs*	405,600	327,600	327,600	327,600	1,060,800
Equipment grant	0	0	0	0	0
Other (specify)	218,400	234,000	234,000	226,200	686,400
Total	780,000	842,400	795,600	795,600	3,213,600

*E.g. field staff, translators, consumables, project-specific administration, etc.

Funding plan (Note: Excluding funding to the Norwegian partner)

Source	2018	2019	2020	2021	2022	Total
Own funding		120,000	120,000	120,000	0	360,000
International funding		0	0	0	0	0
Other public funding		60,000	60,000	60,000	60,000	240,000
Other private funding		0	0	0	0	0
Amount sought from NRF's SANOCEAN programme		780,000	842,400	795,600	795,600	3,213,600
Total		960,000	1,022,400	975,600	855,600	3,813,600

Possible South African Evaluators (Max 6 names)

Name	Institution	E-mail address
Prof. John J. Bolton	University of Cape Town	john.bolton@uct.ac.za
Dr. Thomas Bornman	SAEON	tommy@saeon.ac.za
Prof. Christopher McQuaid	Rhodes University	c.mcquaid@ru.ac.za
Prof. Renzo Perissinotto	Nelson Mandela University	Renzo.Perissinotto@nmmu.ac.za
Dr. Deborah Robertson-Andersson	University of KwaZulu-Natal	robertsond@ukzn.ac.za

23 April 2018
Date

South African partner signature

24/4-2018
Date

Norwegian partner signature

23 April 2018
Date

Prof BC Fielding
SA Research Officer's Name

Research Officer's