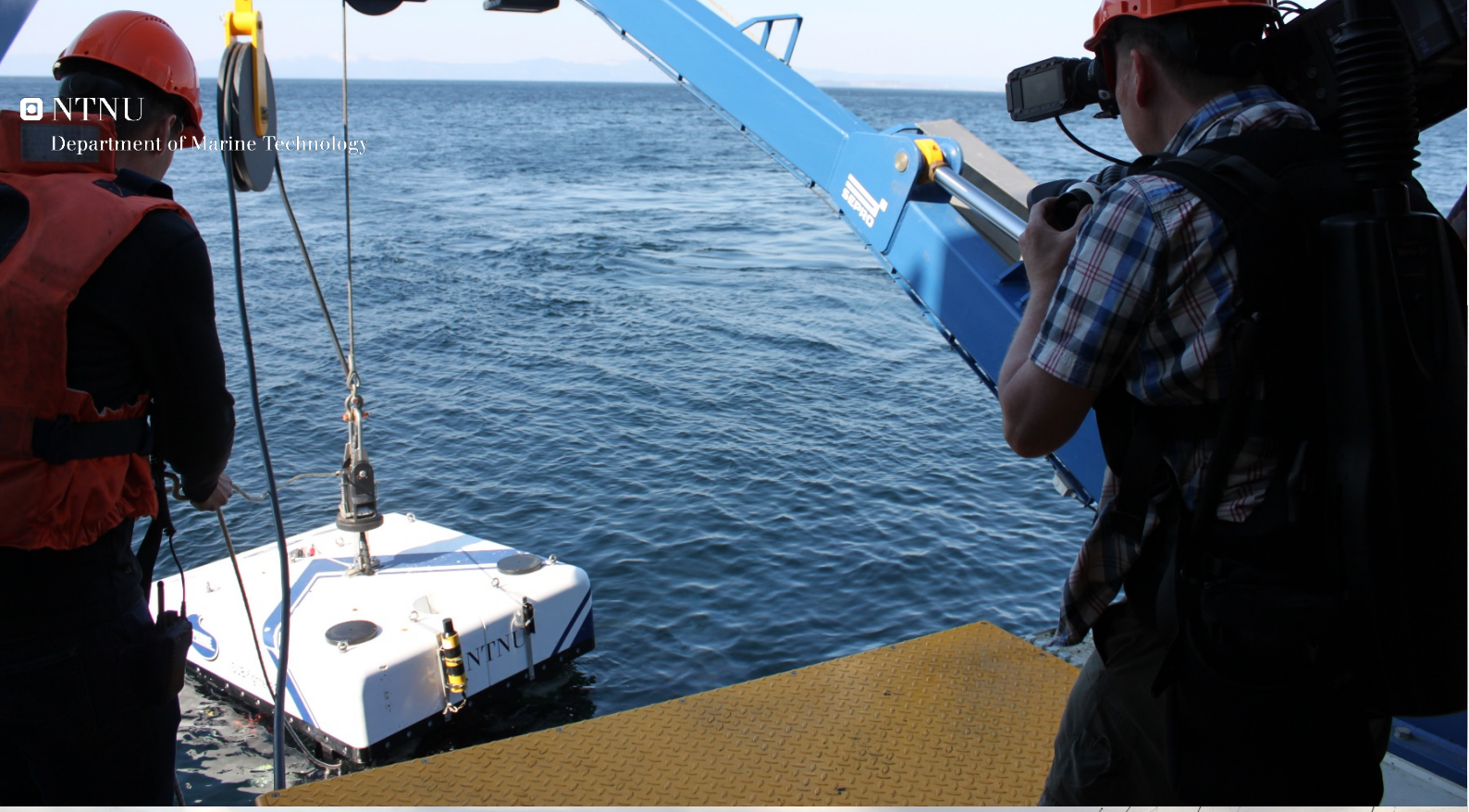


DEPARTMENT OF MARINE TECHNOLOGY

Annual report 2019

Contents

The year in Summary

The year 2019 was another good year for Department of Marine Technology. We maintain our position as one of the internationally leading institutes within ocean engineering and marine technology – we have been ranked #2 on the Shanghai Jiao Tong University ranking in this area for many years. This is particularly satisfying since we have an ongoing generation change in our department. We see that we are able to attract promising new staff, like associate professor Astrid Brodtkorb, and that the young associate professors are able to take the next step and become full professors, like Erin Bachynski did in 2019

We see an increasing interest in both protection and utilization of the oceans, and it seems this development is accelerating. Ocean mining is coming up again, and it is pointed out that there are enormous resources beneath and on the ocean floor in many places, including in the Norwegian economic zone, but it is also clear that there are huge challenges with respect to technology development, cost, and environmental concerns. On one hand, this means that it might take a while before ocean mining will be of industrial significance, on the other hand the need for development of subsea technology is an opportunity for an institute like ours. Also, the more well-established ocean-based industries show increasing importance – in fact, ocean-based industries contribute with 85% of the exports from Norway!

In 2019, the problem of climate change got much more attention than it has had in many years. For us, this attention means increased interest in development of renewable offshore energy, and then first and foremost offshore wind, but it might also mean that the reduction in the offshore oil & gas industry will be accelerated. Also, the IMO target of reducing the CO2-emissions from international shipping by 50% within 2050 is an important, inspiring and challenging goal for our department. Here our involvement in SFI Smart Maritime is an important research activity!

Another mega-trend of importance for the Department of Marine Technology is digitalization. We have worked with development of simulation methods and digitalization for more than 40 years, but see a significant increase in the interest in this field, where particularly “big data” and machine learning methods are rapidly taken into use as tools. We think that it is of crucial importance to have solid domain knowledge in order to develop digital tools and methods for the shipping and ocean industries!

Trondheim, 1. April 2020

Sverre Steen
Head of department

Facts and figures

The Department of Marine Technology (IMT) at NTNU educates and conducts research about methods and techniques which facilitate the assessment and development of technical and operational solutions for Norway's biggest export industries: oil and gas extraction at sea, ship technology with corresponding equipment industry, fisheries technology and aquaculture technology.

The research and education at IMT emphasize the development of environmentally friendly and energy-efficient solutions within our areas of expertise.

Staff:

20 professors
6 associate professors
2 assistant professors
17 adjunct professors
3 adjunct associate professors
9 researchers
17 postdocs
10 professors emeritus
111 PhD candidates
10 administrative staff
16 technical staff
5 apprentices

Students:

Close to 600 students

Graduates 2019:

21 PhD graduates
143 graduated master students

Budget 2019:

130,7 MNOK

Scientific Publications in 2019:

Academic journal articles: 193

Academic conference lectures: 68

Books: 2

Book chapters: 60

Studies at the Department:

Master programs

- Marine technology (MSc, 5 years)
- Marine technology (MSc, 2 years)

International master programs

- Marine Technology (Master of Science, 2 years)

PhD studies

- PhD in Engineering (PhD degree, 3 years)

News

Here are some of the news stories from 2019. For more news see the department pages.

Ocean Week 2019

The future of the oceans was the topic when NTNU gathered activists, politicians, scientists, artists and even royalty at Ocean Week 2019.

Ocean week is the annual conference hosted by NTNU-Oceans, one of NTNU's four strategic research areas, and the conference is a vital part in NTNU's work to contribute to Norway's role as an ocean nation.

This year's conference had the overarching theme "Oceans in change", and gathered hundreds of Norwegian and international speakers and participants. From politicians and researchers to activists and artists, Ocean week is a venue where all those who care for the oceans can come together to discuss challenges and opportunities that face the world's oceans. The presence of his Royal Majesty King Harald V of Norway, who visited the conference on the second day, was a great honour, and helps underline the importance of the issues that were discussed.

Threats to the oceans was an important topic at this Ocean Week. Professor Richard Thompson, the scientists who created the term "microplastics", spoke on the massive challenges and possible solutions to plastic pollution. – Plastic as a material is not really the problem. The problem is how we have chosen to use it. In order to fix this, we need to redirect the flow of plastic away from the oceans, as well as clean up what is already there, says Thompson.

Kristine Berg, who spoke at the Wednesday parallel session "Ocean Health", told a captivated audience how eXXpedition, an all-women science expedition, sailed through the "Great Pacific Garbage Patch".

The thing that scared her the most was that they could hardly see the plastic at all, said Berg. Instead of bags, bottles and other detritus, the garbage patch mostly consists of billions of tiny plastic pieces.

– I would have loved if it looked like a big landfill of plastic. That would have made it easier to clean it up. However, it is not a plastic island as some think, it is a plastic soup, says Berg.

Despite all the threats to the oceans, they also provide great opportunities, something the director of NTNU Oceans and head of Ocean Week, Ingrid Schjølberg, made clear.

The ocean provides energy, food, and rare minerals, and Schjølberg argue that these resources will be vital if we are to maintain our standard of living in the coming years. Yet they must be carefully managed, and the oceans must be protected.

– The oceans are a crucial provider of resources, and are a fundament of wealth and good health, especially here in Norway. If the Oceans collapse, so does the world, said Schjølberg.

New technology can help us walk this tightrope, and parallel sessions on deep-sea mining, autonomous ships, and technology as a provider of solutions for sustainable oceans, all underscored the many opportunities that science and research is opening up.

NTNU opens laboratory 370 metres below the surface

Right now, more than 300 metres under the surface of the Trondheim Fjord, new technology is being developed at Norway's deepest subsea laboratory, the only one of its kind in the world.

The lab was officially opened in May 2019 at the 25th anniversary of Equinor's research centre at Rotvoll in Trondheim by rector at NTNU, Gunnar Bovim, and Executive Vice President at Equinor, Anders Opedal.

Before the opening, Asgeir Sørensen, the director of NTNU AMOS, and Kjetil Skaugset from Equinor told the audience how the collaboration between NTNU and Equinor is changing how drones are used, not just under water, but also on the surface and in the air.

Its purpose is to test new underwater drones, and it will allow NTNU, Equinor and other partners to develop new radical solutions and innovations for underwater operations. In addition to NTNU, the first user is Eelume and their snake robots. The lab's subsea docking station is the first of its kind in the world, and it will provide the future "janitors of the ocean" with a test-site where they can be refined and improved upon in realistic conditions. This is work that is necessary if snake robots are to become the efficient underwater workers that Eelume and Equinor envision.

Among the areas that will be explored is the possibility of having robots that live permanently on the ocean floor. Offshore maintenance, repairs and inspections today require ships and specialist equipment that can be expensive to operate.

Besides the oil and gas sector, other businesses like aquaculture, shipping and offshore-wind energy production can all benefit from cheap and efficient inspection and maintenance work.

If robots like this can be put into action on a large scale, they can provide considerable cost reductions, quicker response times and fewer emissions of gases such as CO2, NOX and SOX. They will also contribute to an increased safety and regularity for the industry that operates them.

The lab is operated by NTNU, but will also be available for businesses, research centres and other universities, cementing NTNU and Trondheim's position as a world leading research hub for subsea technology and underwater robotics.

The most adventurous students at NTNU

77 percent of the students at the Department of Marine Technology have had an exchange year. Far more than the 40 percent that NTNU has set as a goal.

For NTNU, the exchange programs create connections to other institutions and provide important international experience for the students. It also helps build networks that can be utilised for research in the future.

The Norwegian Government has stated that it wants all Norwegian students to spend time abroad as exchange students, and the department of Marine Technology is well on its way to achieve that goal.

The head of the department, Sverre Steen, is happy to see that so many students are taking the opportunity to spend time at a university outside of Norway.

– We have the highest number of students that take a year abroad compared to the rest of NTNU, but that does not mean that we cannot improve. Some of the students do not feel the need for an exchange period, and if we are to tempt these to go, we need to make it very easy for them to do so, says Steen.

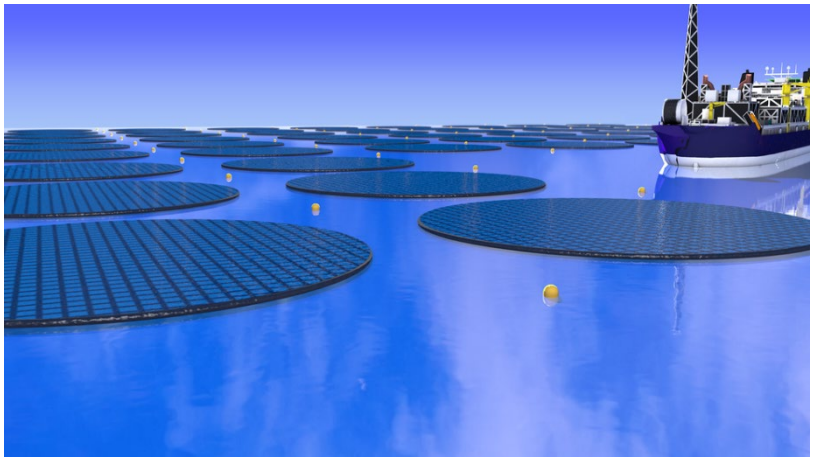
Ingvild Tveit Ulstein is on the final year of her master program and spent her exchange year at TU Delft in the Netherlands. She is very happy that she got the opportunity to spend some time at another university.

– It was a wonderful opportunity to get to know a new country and a different culture, not to mention that I met so many great new people from across different studies and nationalities, says Ulstein.

Students at NTNU have several credits dedicated to optional courses that often explores topics outside their chosen field. By saving these credits for their exchange year, the students gain a lot of freedom to choose the courses that they find most interesting at their exchange university.

– We had a lot of freedom in what classes we took and in general, and we were able to travel a bit and see both the Netherlands and other parts of Europe. You learn a lot when on your exchange year and it good to see how other universities do things. Most Norwegian companies are also very international in their outlook and this is a great way to get experience and make yourself more attractive to them, says Ulstein.

From CO2 to fuel



A new study by scientists from NTNU and Switzerland show how floating solar farms can help transform CO2 in the oceans into fuel.

The scientists propose to create large scale "marine-based artificial islands, on which solar or wind energy powers the production of hydrogen and the extraction of CO2 from seawater and where these gases are catalytically reacted to yield liquid methanol fuel."

The solution will provide a climate neutral source of fuel that is far easier to store and transport than pure electricity, and the scientists hope that it will contribute to a reduction in the emissions of climate gas from the transport sector.

Trygve Kristiansen from the department of Marine Technology, has worked on the technical challenges of having large scale solar farms in the often rough conditions you find at sea. He is certain that the solar farms will be able to cope with wave, current and weather.

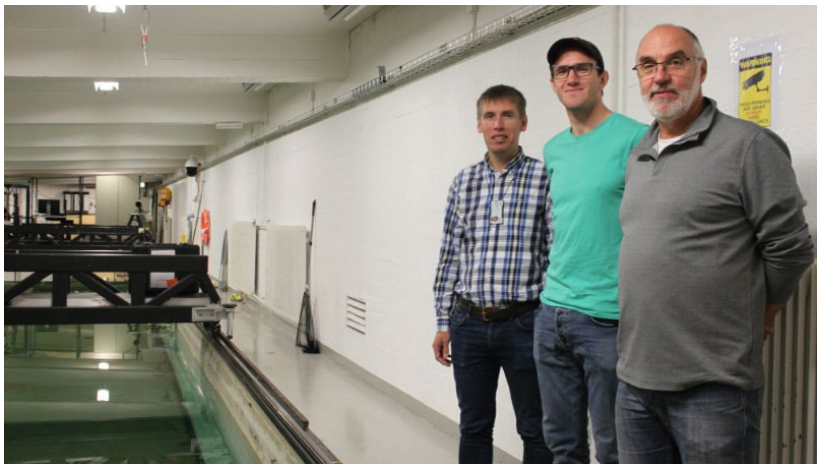
– We are sure they will. Several areas along the coasts close to the equator and in the Mediterranean have favorably weather and wave conditions, as well as water depths of less than 500-600 meters. To establish energy producing islands is a hot topic in in Singapore and other large cities with limited space, says Kristiansen to Gemini.

A Newsweek article about the study can be found here.

A Gemini article in Norwegian can be read here

The study can be read here.

The first candidate for the new Marine Technology researcher's program is ready



From 2019, the Department of Marine Technology at NTNU offers students that have a special interest for research a new program that prepares and kick-starts the participant for future PhD studies.

First out is Martin Kvisvik Larsen, a fifth-year master student who specializes in marine cybernetics.

The program is organised as an extra year between the 4th and 5th year of the master program for Marine Technology, and students both in their 3rd and 4th year can apply for admission.

– I am very pleased to be accepted. I wanted to know more about how it is to work as a scientist, and this is a great opportunity to do so. I considered applying for an integrated master and PhD, but by joining this program I am able to experience the life of a researcher without having to make a full commitment, says Larsen.

Professor Martin Ludvigsen is the head of AUR-lab at NTNU and will be Larsen's main supervisor and mentor; he is excited to have a new colleague. Ludvigsen explains that Larsen will work within a larger research group and will be exposed to many different scientific fields.

– We do a lot of fieldwork at AUR-lab where everybody in the team participates, and this is a great way for Larsen to learn the methods behind the science, both how we conduct experiments and how to publish the results. He will also have a lot of autonomy and will be able to focus on his own field of study, says Ludvigsen.

Larsen will work on hyperspectral imaging in marine exploration and surveillance for his research project. A method that increases our opportunities for exploring the oceans.

– With hyperspectral imaging, we can observe far more colours than the human eye is normally capable of seeing. It allows us to examine objects and phenomena that we otherwise would not be able to observe, says Larsen.

The applications for this technology are many, from biology to geology. Ludvigsen explains that there are several areas where there are opportunities to advance this method, among others archaeology, which is the area that Larsen will most likely focus on.

– When exploring manmade structures, shipwrecks and other archaeological sites under water, it can be difficult to know exactly what you are looking at. Is that square stone a manmade brick or just a normal stone? Is the small mound a sunken ship or just a natural occurrence? Hyperspectral imaging cameras can help us see the difference more easily, says Ludvigsen.

Professor Eilif Pedersen at the Department of Marine Technology is head of the researcher's program; he explains that the program is there to help recruit prospective PhD candidates.

– The program will give the participants a head start, and allows them to start on an already defined project. We are working with the Norwegian Research Council on this, and we hope that it will inspire more of our best students to choose a career as researchers; the program opens up some opportunities that they would not otherwise get, says Pedersen.

During their extra research year, the students will participate in PhD courses in autumn and start working on their research project proper in spring.

– I am particularly looking forward to working with hardware, and in the field with other researchers, Larsen says.

AMOS director gets the Norwegian Research Council's innovation prize

Photo: Odd Richard Valmot, TU

Professor Asgeir Sørensen has received the Norwegian Research Council's innovation prize for 2019. The price is granted to a person or organization that through exceptional use of research result have laid the foundation for research based innovation.

Sørensen points to the whole of AMOS when asked about the prize.

– This is not just about me, but rather the center as a whole as well as the leadership at NTNU who have supported AMOS. I think that the research council wanted to show the great span that exists, the importance of good research, and that we are help provide an unique service that is needed for growth, says Sørensen to Universitetsavisa.

You can read more about it at UA or listen to TU's podcast with professor Sørensen (in Norwegian).

The Ocean Space Centre got government funding

Photo:Anne Katharine Dahl/NTNU

Prime Minister Erna Solberg and the Norwegian government allocated 55 million NOK in the 2020 government budget to the Ocean Space Centre project.

This means that the project has now entered a new planning phase.

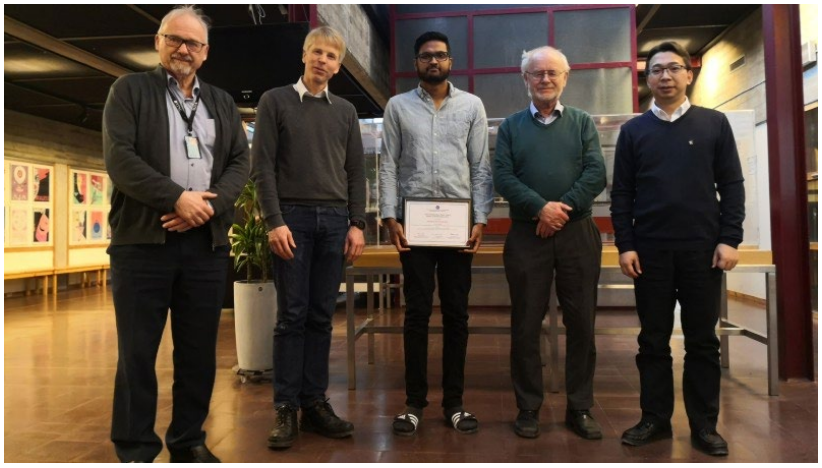
When completed, the Ocean Space Centre will be a modern and forward-looking centre for science, innovation, and education within the ocean space field.

We are currently experiencing rapid technological developments that are increasing our knowledge of the Oceans. Foremost among them are developments connected to digitalisation and BigData. Nevertheless, advanced real-world laboratories will still be necessary. By combining these approaches to science, and focusing upon interaction between physical laboratories, simulations, and a continuous stream of data from ocean based operations and sensors, we gain a more complete picture than we otherwise would.

In the Ocean Space Centre, simulations will be combined with experiments using models in order to prevent accidents and damage to the environment. Robotics and autonomous systems must be developed and tested in a controlled environment before they can be put to use.

If all goes as planned construction work on the new centre can begin in 2022.

Winner of the Moan-Faltinsen best paper award



From the left: Professor Torgeir Moan, Head of Department Professor Sverre Steen, Senthuran Ravinthrakumar, Professor Odd Magnus Faltinsen, Professor Zhen Gao.

Senthuran Ravinthrakumar at NTNU received the Moan-Faltinsen Best Paper Award in Marine Hydrodynamics 2019 during the IMT Department Christmas Lunch on December 20, 2019.

The awarded paper is ‘A Two-dimensional Numerical and Experimental Study of Piston and Sloshing Resonance in Moonpools with Recess’, which was published in

Journal of Fluid Mechanics and authored by Senthuran Ravinthrakumar, Trygve Kristiansen, Bernard Molin and Babak Ommani.

It is the fifth year for the Moan-Faltinsen Best Paper Award and only the best paper on marine hydrodynamics was awarded this year, according to the international selection committee's decision.

Professor Moan is a new member of CAE

Photo: Universitetsavisa

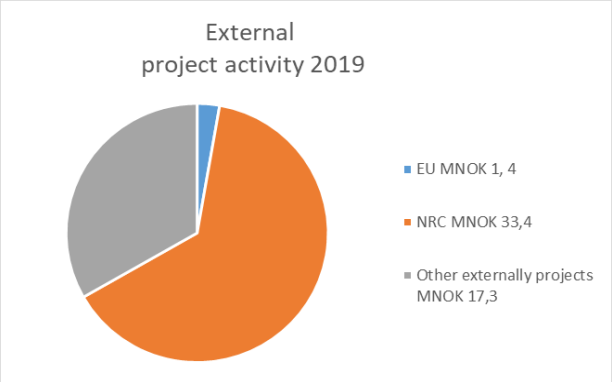
Professor Emeritus, Torgeir Moan, was elected "a Foreign Member of the Chinese Academy of Engineering (CAE)" in 2019.

The Chinese Academy of Engineering is Chinas national academy for engineering, and membership to the organisation is the is the highest academic title in engineering science and technology in China. Foreign members are all distinguished non-Chinese academics at the forefront of their field.

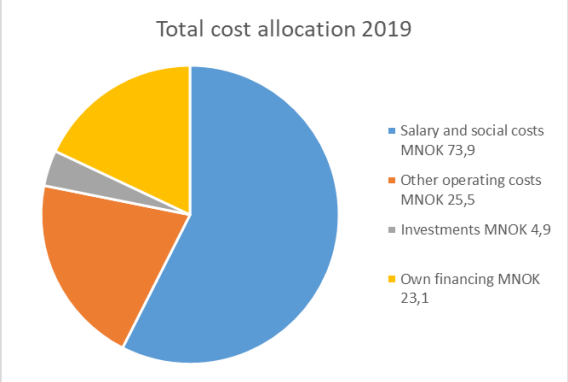
Li Xhiaohong, the President of the CAE, writes that Moan was elected member due to his "distinguished contributions to marine engineering and civil engineering and his promotion of China-Norway exchanges and cooperation in those fields".

Appendices

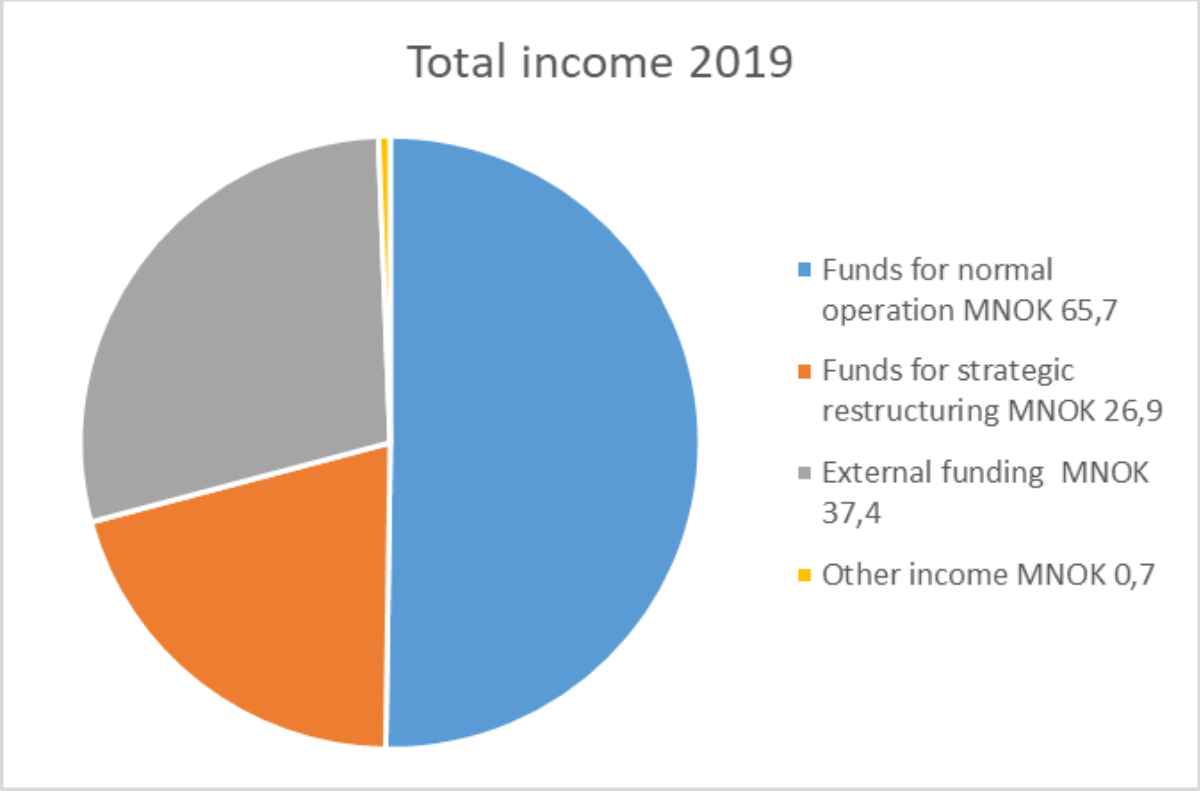
Department economy



*** Other externally funded projects: other private and public contributors for both commissioned and sponsored projects. Our research centers (SFF, SFF) are well represented in this category.*



Salary and social costs cover more than 57% of total costs.



Income is generated from two primary sources:
- funding from the government for normal operations and strategic restructuring, and
- external funding from private and public contributors for both commissioned and sponsored projects.

Staff, and other useful links

Information on the Staff at the department can be found at the department webpages here

Information on the department's laboratories can be found here

More information on our education programs can be found here

Research projects

Finans.kategori	Prosjekt	program
RCN	National Ship Risk Model	SMARTRANS
Sjøfartsdirektoratet	Forprosjekt risiko norske skip	Norwegian Maritime Authority
EU	Blue Mining: Breakthrough Solutions for the Sustainable Expliration and Extraction of Deep Sea Mineral Resources	7th Framework Programme
	Samarbeidsforum Marin	
EU	COLUMBUS: Monitoring, Managing and Transferring Marine and Maritime Knowledge for Sustainable Blue Growth	H2020
Kongsberg Maritime AS	University Technology Center (UTC): Providing an Integrated and Validated Approach to "Performance in a Seaway"	
RCN	SFI Smart Maritime	SFI
RCN	SFI Exposed	SFI
RCN	SFI Marine Operations (MOVE)	SFI
EU	AQUAculture infrastructures for EXCELlence in European fish research towards 2020 (AQUAEXCEL)	
EU	SWARMs: Smart and Networking Underwater Robots in Cooperation Meshes	ECSEL
RCN	Exploitation Technologies for Marine Minerals on the Extended Norwegian Continental Shelf (MarMine)	BIA
RCN	Reducing Risk in Aquaculture - Improving Operational Efficiency, Safety and Sustainability	
RCN	Prediction of ice-ship-interaction for icebreaking vessels	Maritim virksomhet og offshore operasjoner
RCN	Real-Time Hybrid Model Testing for Extreme Marine Enviroments	KPN
RCN	IEA HIA Hydrogen in the Maritime	ENERGIX
RCN	Fleksprop (2017 - 2021)	KPN
RCN	Taredyrkningsfartøy 2020	MAROFF-2
RCN	MOZEES: research centre for Mobility Zero Emission Energy Systems (2017-2022)	FME
RCN	Wave loads and soil support for extra large monopiles (WAS-XL)	ENERGIX

RCN	Design and Verification of large floating coastal structures	KPN
RCN	Arven etter Nansen	Nasjonalt forskningsprosjekt
RCN	Autonomous Subsea Intervention (Seavention)	KPN
RCN	Safe Operation of CLOSED aquaculture CAGES in WAVES	MAROFF-2
RCN	Unlocking the potential of autonomous systems and operations through supervisory risk control (UNLOCK)	FRINATEK
RCN	Aquaculture operations with reliable flexible shielding technologies for prevention of infestation in offshore and coastal areas (FLEXAQUA)	HAVBRUK2
RCN	BROHODE Havbruk 2050	FORREGION)
RCN	Improved lifetime estimation of mooring chains (LIFEMOOR)	PETROMAKS2
RCN	Online risk management and risk control for autonomous ships (ORCAS)	KPN
RCN	InnoCurrent: Ø.Ø Dalheim	IPN
RCN	Green energy at sea: Offshore wind turbines and energy systems for ships, ports and offshore structures	INTPART
EU	Marine robotics research infrastructure network	H2020
EU	Smart fisheries technologies for an efficient, compliant and environmentally friendly fishing sector (SMARTFISH)	H2020
RCN	Environmental impacts and risks of deep-sea mining (Miningimpact 2)	MARINFORSK
Næringsliv	Evaluation of an electric propulsion system and extension to future applications	
Utland	LRF - Recommended practise of scenario based risk management for polar waters	
RCN	aFerry - An integrated autonomy system for on-demand, all-electric and autonomous passenger ferries	FORNY2020
RCN	Advanced Wave and Wind Load Models for Floating Wind Turbine Mooring System design (WINDMOOR)	ENERGIX
RCN	Hydrogen and Fuel Cells for Maritime Applications (H2 Maritime)	KPN
Næringsliv	Development of Simulator Platform to verify integrated control systems based on digital twin for LNGC/LNG-DF (HHI-3)	-
RCN	Technology for New Ocean Industries and Infrastructures (TechNOII)	INTPART
RCN	Feasibility study of a concept for operating remotely controlled underwater vehicles from an unmanned surface vessel (ROV Revolution)	MAROFF-2
RCN	Fundamental investigations of violent wave actions and impact respones (SLADE)	MAROFF-2
Svalbards miljøvernfond	Smeerenburg tokt 2019	-

Publications

Find all the department publications for 2019 at Cristin here

Book publications

Ellefmo, Steinar Løve; Søreide, Fredrik.
Quantifying the Unknown. Marine Mineral Resource Potential on the Norwegian Extended Continental Shelf. Cappelen Damm Akademisk 2019 (ISBN 978-82-02-65035-3) 136 s.

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Proceedings of the First International Workshop on Autonomous Systems Safety. Norges teknisk-naturvitenskapelige universitet 2019 (ISBN 9788269112023) 128 s.

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Aggarwal, Ankit; Bihs, Hans; Shirinov, Seimur; Myrhaug, Dag.
Estimation of breaking wave properties and their interaction with a jacket structure. *Journal of Fluids and Structures* 2019 ;Volum 91. s. –

Ahmad, Nadeem; Bihs, Hans; Myrhaug, Dag; Kamath, Arun; Arntsen, Øivind Asgeir.
Numerical modeling of breaking wave induced seawall scour. *Coastal Engineering* 2019 ;Volum 150. s. 108-120

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Numerical modelling of pipeline scour under the combined action of waves and current with free-surface capturing. *Coastal Engineering* 2019 ;Volum 148. s. 19-35

Alagan Chella, Mayilvahanan; Bihs, Hans; Kamath, Arun; Myrhaug, Dag; Arntsen, Øivind Asgeir.
Breaking Wave Interaction with a Group of Four Vertical Slender Cylinders in Two Square Arrangements. *Journal of Offshore Mechanics and Arctic Engineering* 2019 ;Volum 141.(6) s. –

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Antuono, M; Valenza, S; Lugni, Claudio; Colicchio, Giuseppina.
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Azad, Md Samdani; Punurai, Wonsiri; Sinsabvarodom, Chana; Asavadorndeja, Pornpong.
Effects of redundancy in bracing systems on the fragility curve development of steel jacket offshore platform. *Engineering Journal (EJ)* 2019 ;Volum 23.(1) s. 123-133

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