INTEGRATED OIL SPILL RESPONSE ACTIONS AND ENVIRONMENTAL EFFECTS

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Integrated oil spill response actions and environmental effects
GRACE
2016-2019

OBJECTIVES

- Improve the observation and predictions of oil movements in the sea using **novel on-line sensors** on vessels, fixed structures, smart buoys or gliders, and smart data transfer to operational awareness systems;

- Explore the true environmental impacts and benefits of a suite of marine **oil spill response technologies** in the cold climate and ice-infested areas in the northern Atlantic Ocean and the Baltic Sea. Methods included are:
  - **mechanical collection** in water and below ice,
  - **in situ burning,**
  - use of **chemical dispersants**,
  - natural **biodegradation**
  - and combinations of these;

- Assess in particular the **impacts on fish, invertebrates** (e.g., mussels, crustaceans) and macro algae of naturally and chemically dispersed oil, in situ burning residues and non-collected oil using highly sensitive biomarker methods, and to develop specific methods for the rapid detection of the effects of oil pollution on biota

- Develop a **strategic Net Environmental Benefit Analysis tool (sNEBA)** for oil spill response strategy decision making in cold climate and ice-infested areas.

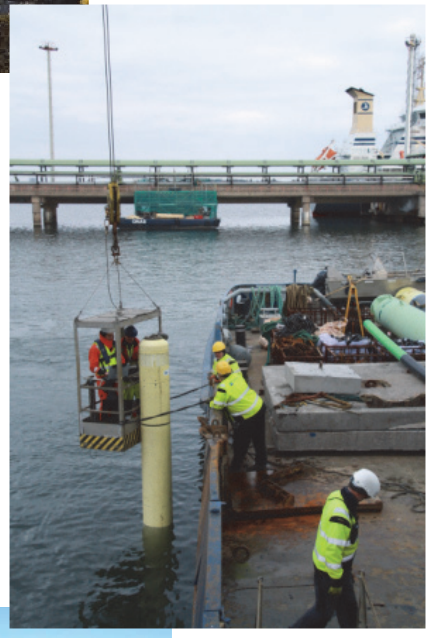
PARTNERS

Participant No	Participant organisation name	Country
1 Kirsten Jørgensen	Finnish Environment Institute SYKE	Finland
2 Susse Wegeberg	Aarhus University	Denmark
3 Jaak Truu	University of Tartu	Estonia
4 Tarmo Kõuts	Tallinn University of Technology	Estonia
5Thomas Benjamin-Seiler	RWTH Aachen University	Germany
6 Ionan Marigomez	University of the Basque Country	Spain
7 Bjørn Munro Jenssen	Norwegian University of Science and Technology	Norway
8 Lonnie Bogø Wilms	Greenland Oil Spill Response A/S	Greenland
9 Rune Högström	Lamor Oy	Finland
10 Seppo Virtanen	Meritaito Oy	Finland
11 Björn Forsman	SSPA Sweden AB	Sweden
12 Christian Petrich	Norut	Norway
13 Feiyue Wang	University of Manitoba (no EU funding)	Canada

Total costs 5.5 mill €, total grant 5.3 mill €, 1.3.2016-31.8.2019

GRACE ACTIONS

- Much field and laboratory work performed
- Unique possibilities to perform field tests e.g with in situ burning in Greenland, oil sensor trials with Smart buoy in oil harbour, oil sensor in FerryBox on passenger ship, electrokinetic treatment in the heart of Helsinki for oil-polluted sediment cleaning
- Successful communication of the project to the right end users
- New oil spill response strategy tool EOS launched



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WP 1 OIL SPILL DETECTION, MONITORING, FATE AND DISTRIBUTION –MAIN RESULTS

1. Application of FerryBox technology for operational oil spill detection and monitoring. Data is available on http://on-line.msi.ttu.ee/GRACEferry/

2. Operational oil spill detection on fairways using SmartBouy technology

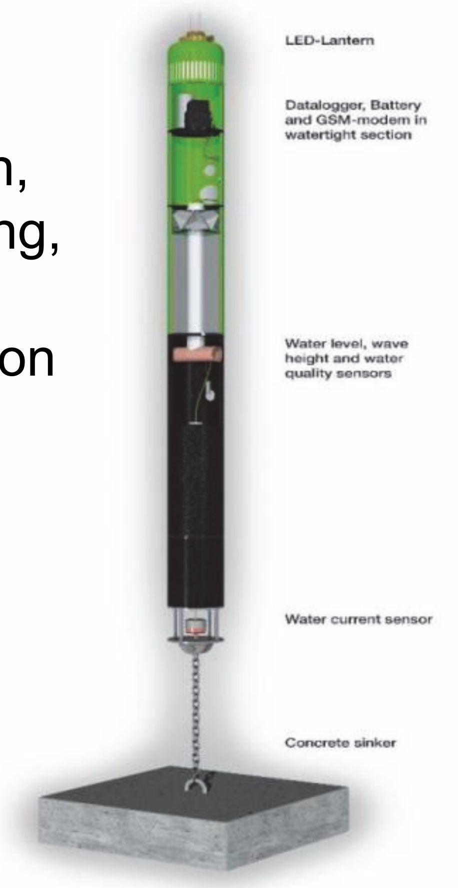
3. Development of biosensor technology for oil spill detection in sea water using hatched zebrafish. The first prototype of the system has been made. Test in ferry box will be only after the project end.

4. Model developed for local scale oil distribution and fate, in open water, as well ice covered sea case.

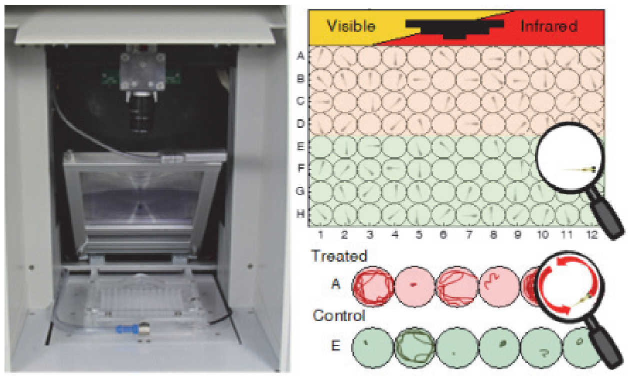
5. Oil spill risk assessment tool including arctic factors developed

WP1 Oil spill detection, monitoring, fate and distribution

Lead:
Tarmo Kõuts

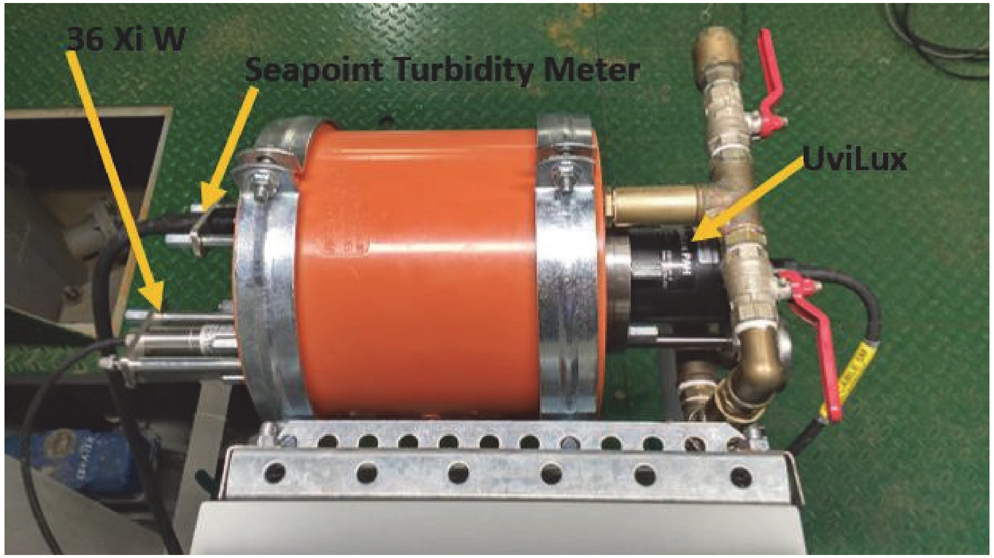


Schematic diagram of the SmartBuoy concept



Zebrafish larvae behaviour assessment scheme: DanioVision observing system and trajectories

MS Baltic Queen FerryBox data is available on http://on-line.msi.ttu.ee/GRACEferry



On-line sensors in FerryBox on board MS Baltlic Queen

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WP2 OIL BIODEGRADATION AND BIOREMEDIATION

1. The application of dispersants for enhancing oil removal from seawater by biodegradation provided contradictory results and more research is needed.

2. Seawater pollution by oil affected the microbiome of the mussels and this effect was dependent on water salinity.

3. Experiments revealed the potential for oil biodegradation in the seawater-ice interface.

4. Electrokinetic remediation indicated the prospects for removal of oil from polluted marine sediments.

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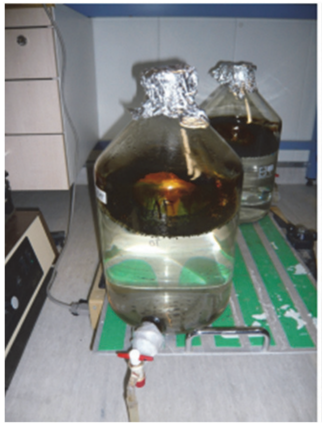
WP2 Oil biodegradation and bioremediation

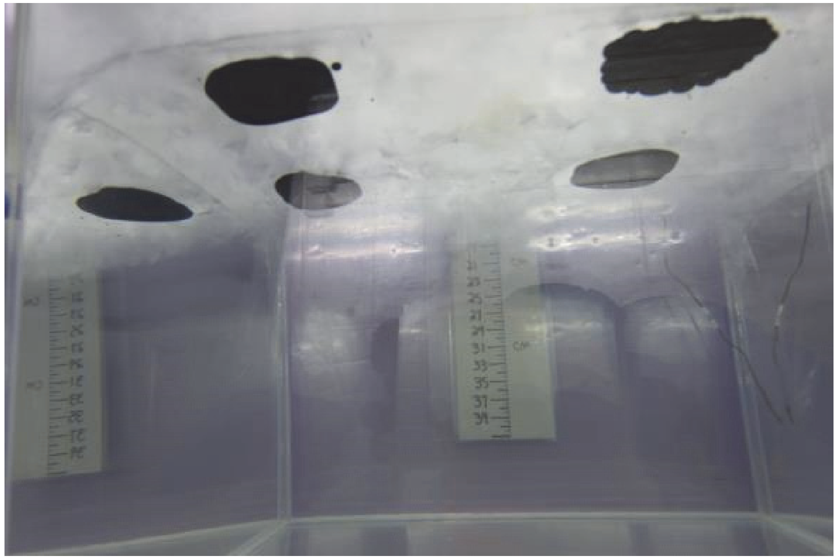
Lead: Jaak Truu

Oil in seawater



Dispersed oil in seawater

Biodegradation tests at 4 ^{o}C



Oil under ice biodegradation experiment, Seawater from Svalbard

Töölö Bay, Helsinki, site for electrokinetic treatment of sediment

Electrodes for electrokinetic treatment of sediment

WP3 OIL IMPACTS ON BIOTA USING BIOMARKERS AND ECOLOGICAL RISKS ASSESSMENT

- Background level and status of biota must be known:
  - The natural variation in biomarker levels in mussels in the Baltic Sea depends on the season and salinity, and this must be taken into account when collecting baseline information on these parameters.
  - Environmental Specimen Banks may be useful for obtaining background info on biota.

- Low concentrations of oil are more relevant for the assessment of the likely concentrations in the environment after a spill. The use of water accommodated fraction (WAF) and dilutions hereof has shown to produce relevant concentrations and help to reveal effects at sub-lethal concentrations. Concentrations in water must be measured.

- Adverse Outcome Links (AOL) is a concept to explain effects on an organismal level through cellular and subcellular effects. Cellular and subcellular effects were identified as potential biomarkers. Measurement of the metabolome profile they identified novel biomarkers in copepods. AOL in zebrafish revealed eye development disturbances observed both by transcriptomics, visual observations and in swimming behavior. This approach was extended to blue mussels, where a genomic study was added to the biochemical biomarkers to reveal linkages.

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WP3 OIL IMPACTS ON BIOTA USING BIOMARKERS AND ECOLOGICAL RISKS ASSESSMENT

- Effect on biota collected during the in situ burning test in Greenland were investigated. Burning residues (IFO180-BR LEWAF) were less toxic than the original oil as for the two model toxicity test organisms employed herein, zebrafish embryos and copepods.

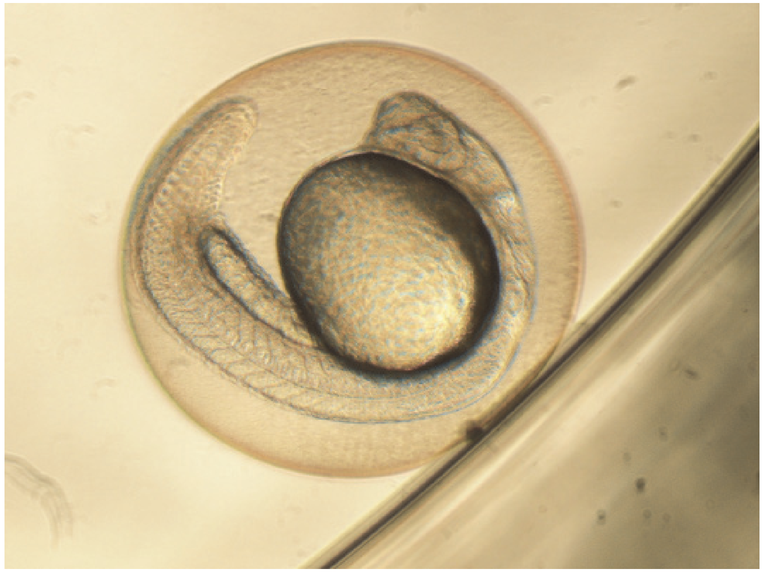
- Oil and dispersed oil toxicity on zebrafish and the marine stickleback were compared. The first results indicate that acute toxicity to high concentrations of petroleum components cause similar effects in both species. The suitability of the marine medaka fish as a bridging species between freshwater and marine systems also requires further investigation.

- A principal component analysis (PCA) was used to statistically evaluate the multivariate approach combining the different bioassays. A sensitive petroleum product toxicity profiling toolbox was recommended to contain endpoints on both acute and mechanism specific toxicity.

WP3 Oil impacts on biota using biomarkers and ecological risks assessment

Lead:
Thomas-Benjamin Seiler

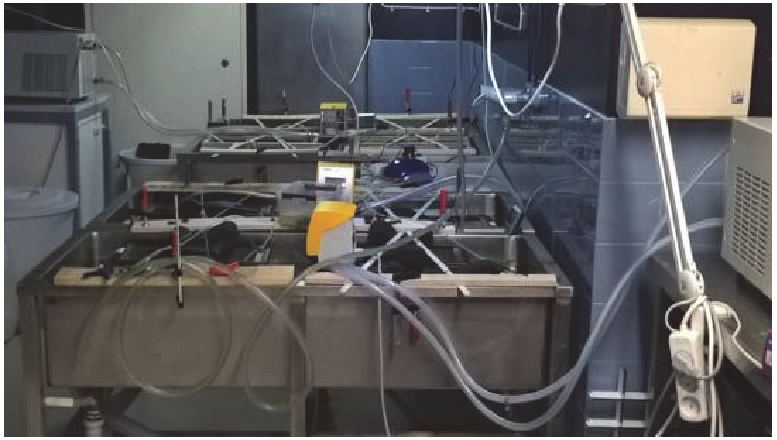
Preparing to sample mussels by scuba diving in the Baltic Sea in -20C temperature



Zebrafish embryo at well wall, normal development (no effects), 24 h post fertilization

Sampling Limnocalanus

Preparation of WAF (water accommodated phase



Oil exposure experiments with blue mussels in aquariums

WP4 COMBAT OF OIL SPILL IN COASTAL ARCTIC WATER - EFFECTIVENESS AND ENVIRONMENTAL EFFECTS

1. In situ burning (ISB):
   1. Burning of heavy fuel oil spill on sea surface and test of burn residue recovery equipment and effects on biota showed that this method can be a relevant option in remote Arctic areas

   2. New results from oil burning tests in ice conducted under controlled conditions on land created new data on the temperature during the burn in the ice and melt pool

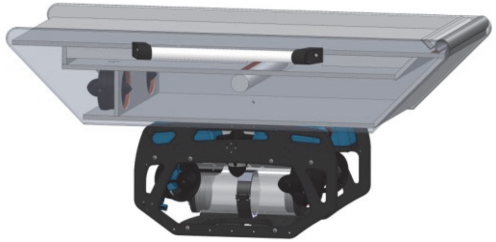
   3. Coastal in situ burning of stranded crude oil including short and long term environmental effects was tested and worked

2. New concept and model type for oil recovery under ice. The concept chosen was an under ice collection unit, which can be attached to already existing ROVs. A prototype was built and tested. To be put on the market

3. Oil-in-ice code for facilitation of communication/documentation of oil spill events in ice

WP4Combat of oil spill in coastal arctic water - effectiveness and environmental effects Lead: Kim Gustavson

Baseline study of shoreline before experiments (Ole Geertz-Hansen)



Under ice removal unit - Prototype

Test tank in Porvoo for testing oil collection

Shoreline experimental in situ burning

Collecting burning residue with Bucket Skimmer, Greenland

WP5 STRATEGIC NET ENVIRONMENTAL BENEFIT ANALYSIS (SNEBA)

1. Development of a Environment & Oil Spill Response (EOS) tool (formerly planned as sNEBA tool). The tool consists of an excel document with formulas for calculations and scores with references to explanatory boxes followed by screening through decision trees.

2. Operational support tools for implementation of EOS

3. Fuzzy Logic Model for EOS decision making support

4. EOS cases: Oil spill simulations performed for several locations in Greenland and in the Baltic sea, for four different seasons.

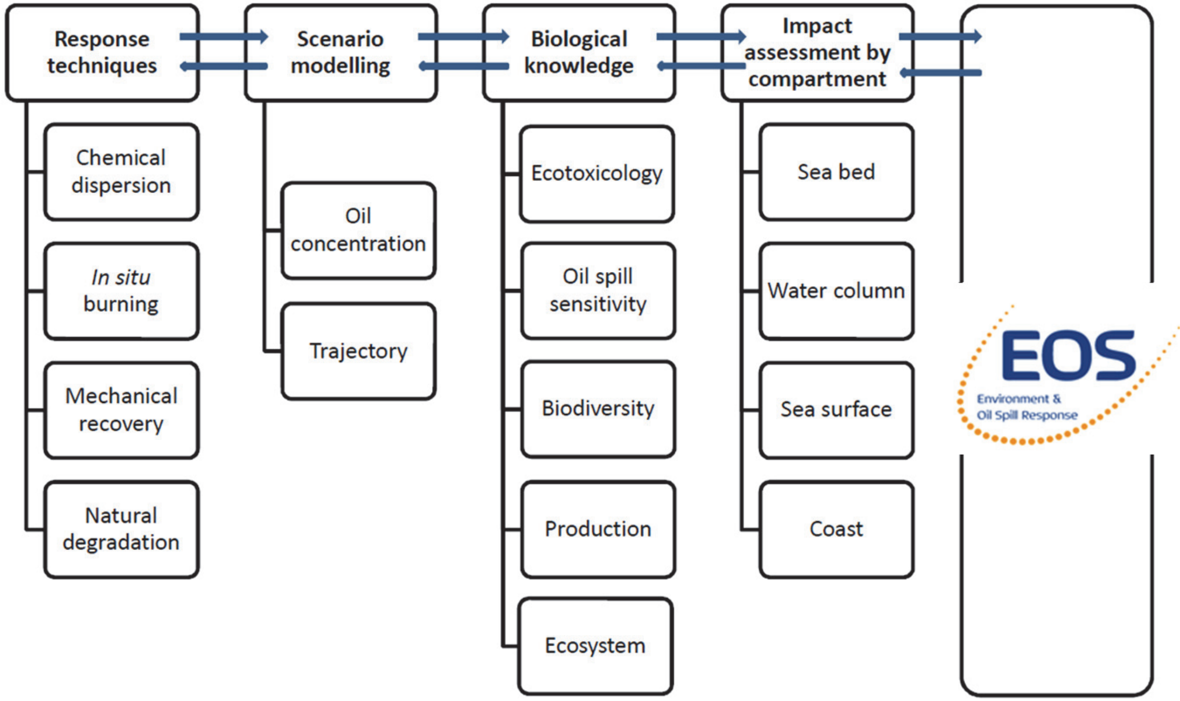
5. New title of the tool, which is Environment & Oil Spill Response (EOS) - an analytic tool for environmental assessments to support oil spill response design. The tool is now available on http://bios.au.dk/index.php?id=128153&L=1

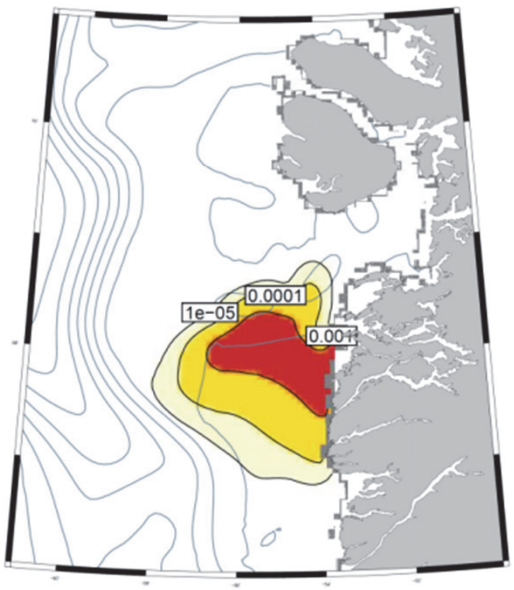
6. Ph.D course framework - highly qualified personnel education

WP5 Strategic Net Environmental Benefit Analysis (sNEBA)

Lead:
Susse Wegeberg

Flow chart for the Environment & Oil Spill Response (EOS) analytical tool





Oil dispersion simulation from scenario in Greenland

WP6. MANAGEMENT, DISSEMINATION, AND COMMUNICATION

- Grace consortium members work very well together, and the project was able to be finalized in time. All deliverables were submitted on time.

- Information about GRACE and the results have been disseminated through the GRACE final conference, GRACE web pages, presentations at international cross-border working groups, and presentations at other scientific meetings such as SETAC and AMOP.

- This has resulted in contacts from many stakeholders interested in the results of the project.

- An exploitation plan has been produced and prospects for companies involved in on-line monitoring technology and oil recovery and remediation technology looks promising.

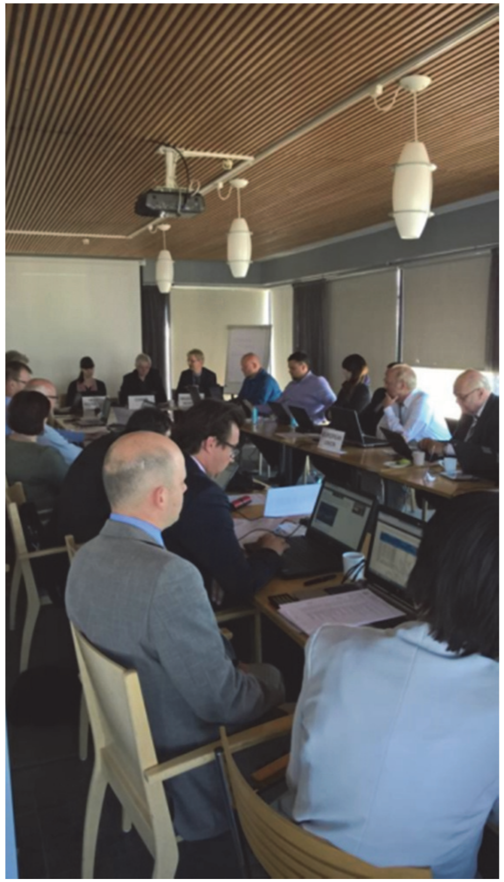
WP6 Management, dissemination and communication

Lead: Kirsten Jørgensen

Further information:

GRACE web site: http://www.grace-oil-project.eu

GRACE video stand at the MOSPA conference Oulu, 2018



GRACE presentation at HELCOM response meeting June 2017, Helsinki

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