Introduction of the Recently Started Research Project:

Macroplastics Pollution in the Southern North Sea – Sources, Pathways and Abatement Strategies

Financed by:
Niedersächsisches Ministerium
für Wissenschaft und Kultur

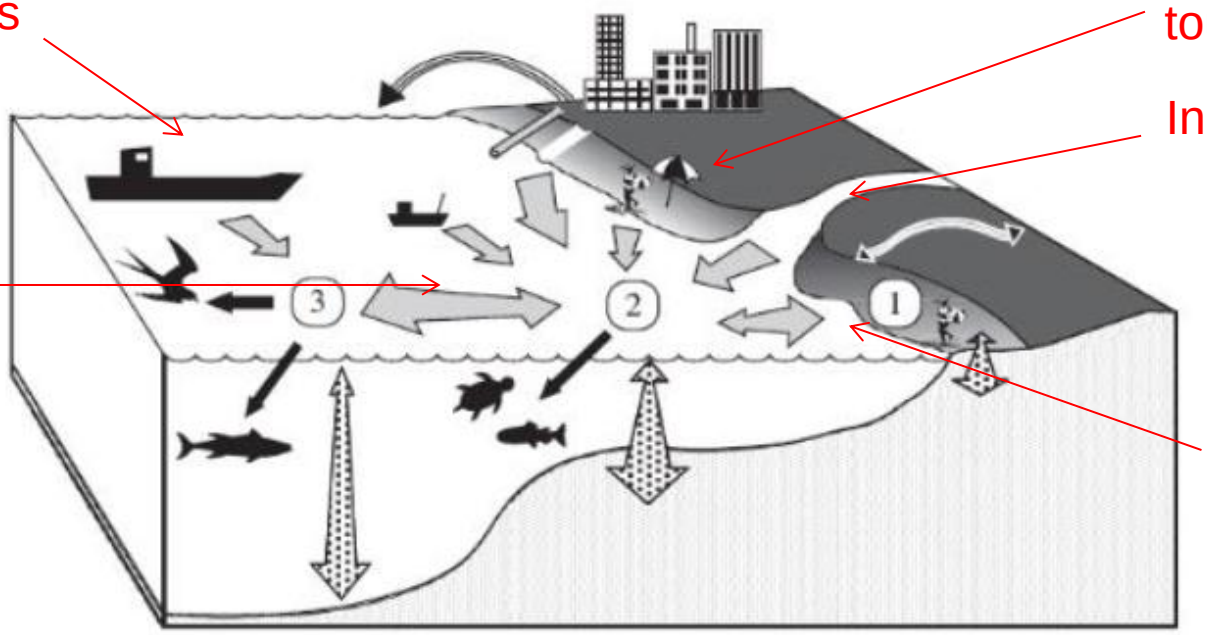
Possible pathways of marine litter

Input from ships

Interaction with tourists

Input via rivers

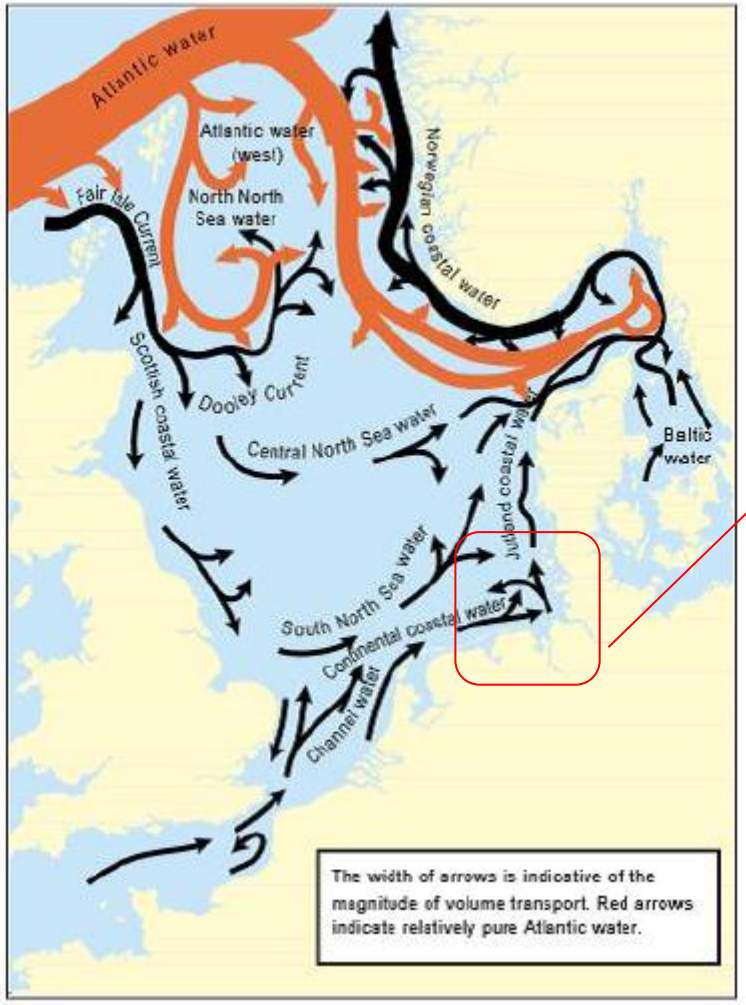
Transport in the ocean by currents and waves

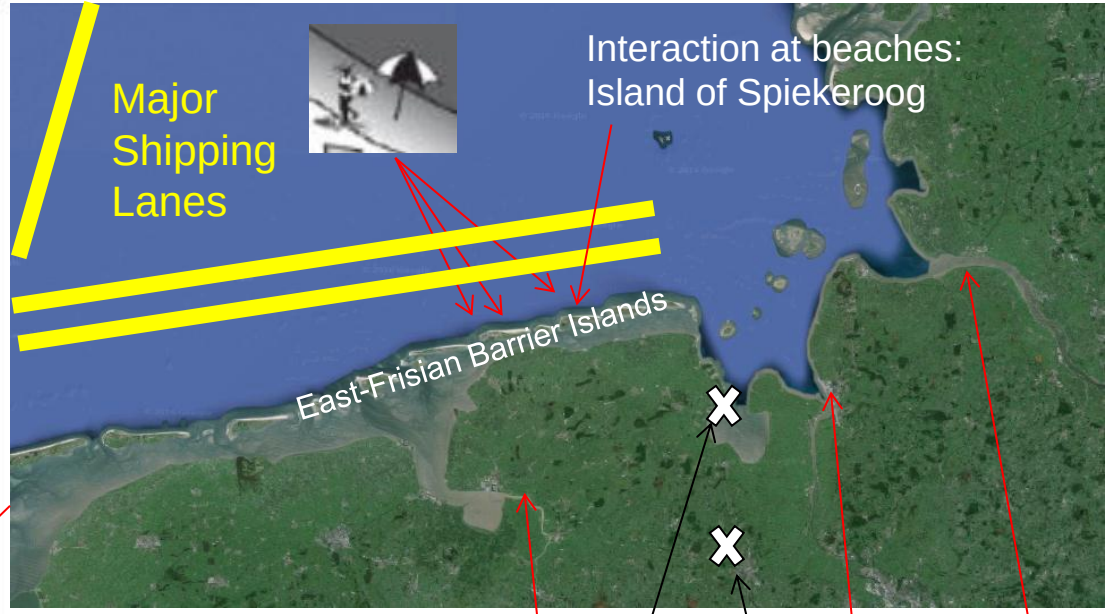


Interaction with beaches

Fig 1. Schematic diagram showing the main sources and movement pathways for plastics in the marine environment, with sinks occurring (1) on beaches, (2) in coastal waters and their sediments and (3) in the open ocean. Curved arrows depict wind-blown litter, grey arrows water-borne litter, stippled arrows vertical movement through the water column (including burial in sediments) and black arrows ingestion by marine organisms (Ryan et al., 2009).

Research Area of the Project





Source: Ospar

The consortium consists of 5 research groups affiliated to the University of Oldenburg, Germany:

Physical Ozeanography (Theorie) (ICBM):
Jörg-Olaf Wolff, Karsten Lettmann, Florian Hahner

Coastal Research (ICBM / HZG)
Emil Stanev, Marcel Ricker

Marine Sensor Systems (ICBM)
Oliver Zielinski, Thomas Badewien, Jens Meyerjürgens

Geoecology (ICBM)
Holger Freund, Rosanna Schöneich-Argent

Applied Geography and Environmental Planning (IBU)
Ingo Mose, Peter Schaal, Christian Aden,
Katharina Stephan

Duration: April 2016 – 2020
Contact: Prof. Dr. Jörg-Olaf Wolff (wolff@icbm.de)
Web Page: www.macroplastics.de
Funding: 1.4 Mio € by Lower Saxony (MWK)

Research and working questions of the Project

- Where are the **main sources of debris entering the North Sea** – land-based versus ocean-based litter?
- Which role do **rivers** play in the distribution pattern of debris?
- What factors drive the **transport and the accumulation** of anthropogenic debris in the marine environment?
- Which role do specific **ecosystems** play **as catchment areas** (salt-marshes, reed communities, beaches, river banks etc.)?
- How could we improve the data management to evaluate and develop better and/or new **abatement strategies**?

- **Modelling**
- ***Hydrodynamic Modelling – Larger North-Sea***

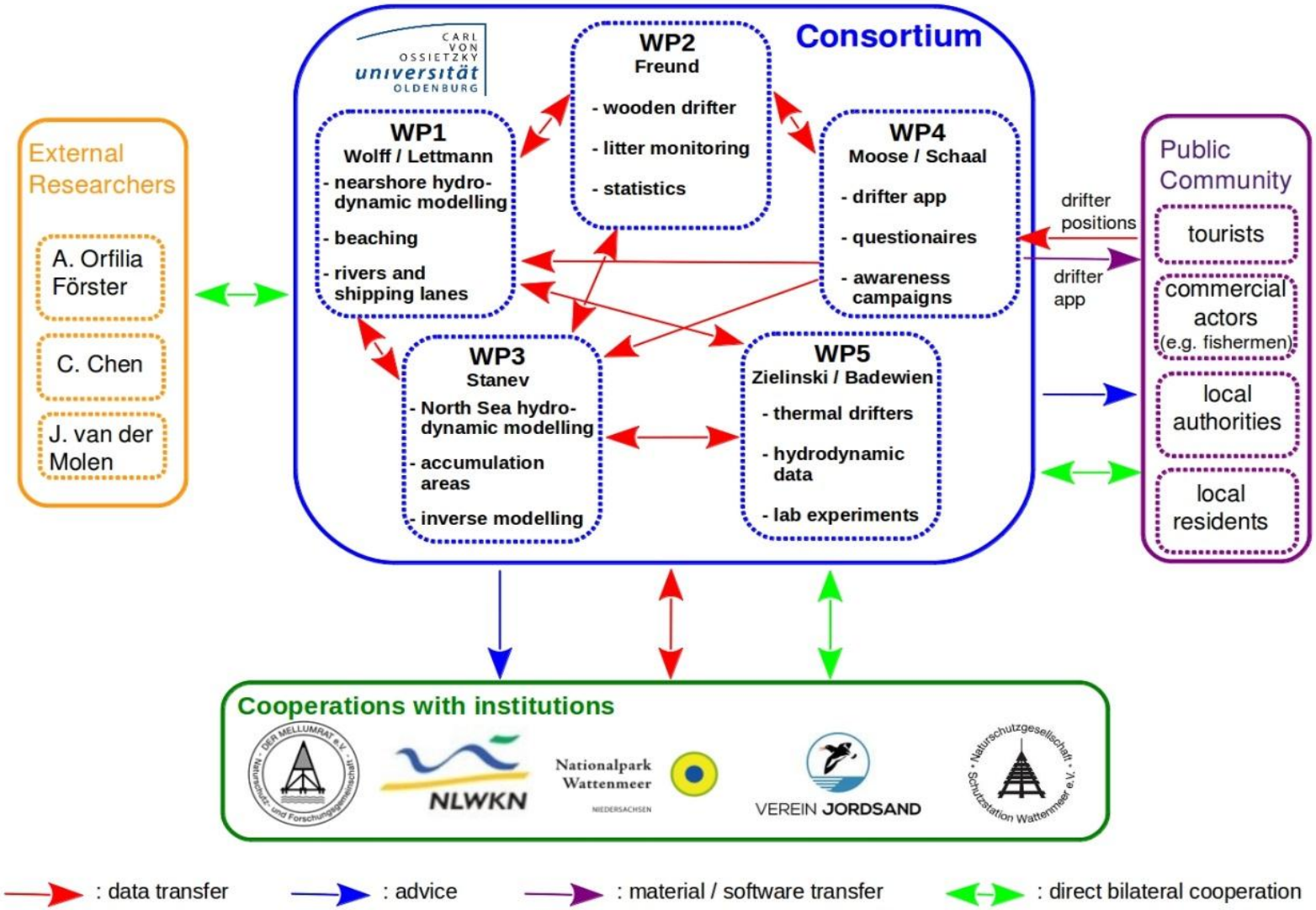
  Inverse Modelling of drifting litter
  Identification of possible accumulation areas
- ***Hydrodynamic Modelling – Coastal***

  Interaction of litter with beaches
  Near shore interaction of wave and currents
- **Observations and Measurements**

  Labor and field experiments for drifting objects
  Measurements of waves and current near beaches
- **Monitoring**

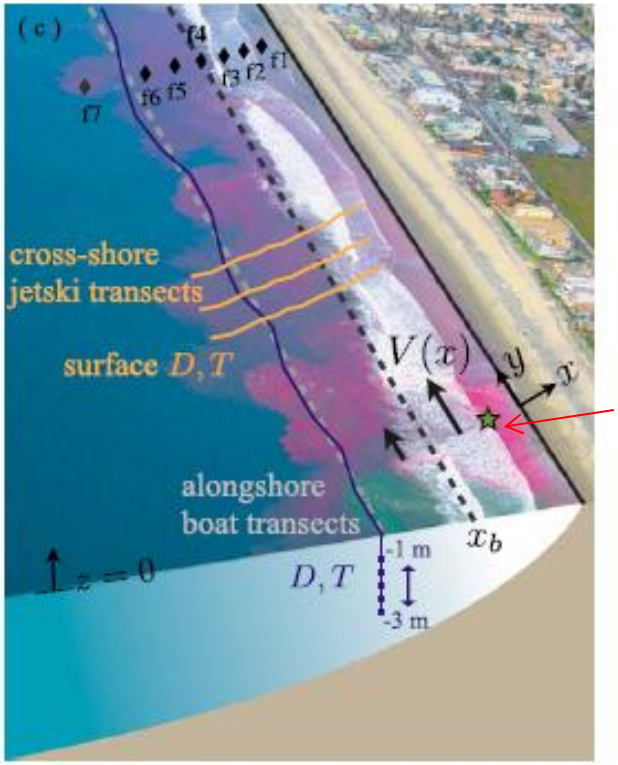
  Input of wooden drifters (open ocean, rivers)
  Litter monitoring and statistics, Data management
- **Citizen Science and Stakeholder-Analysys**

  App-Development, web page, interaction with tourists and stakeholders, public awareness


Consortium
CARL VON OSSIETZKY universität OLDENBURG
WP1
Wolff / Lettmann
- nearshore hydro-dynamic modelling
- beaching
- rivers and shipping lanes
WP2
Freund
- wooden drifter
- litter monitoring
- statistics
WP3
Stanev
- North Sea hydro-dynamic modelling
- accumulation areas
- inverse modelling
WP4
Moose / Schaal
- drifter app
- questionaires
- awareness campaigns
WP5
Zielinski / Badewien
- thermal drifters
- hydrodynamic data
- lab experiments
External Researchers
A. Orfilia Förster
C. Chen
J. van der Molen
drifter positions
drifter app
Public Community
tourists
commercial actors (e.g. fishermen)
local authorities
local residents
Cooperations with institutions
NLWKN
Nationalpark Wattenmeer
NIEDERSACHSEN
VEREIN JORDSAND
: data transfer
: advice
: material / software transfer
: direct bilateral cooperation

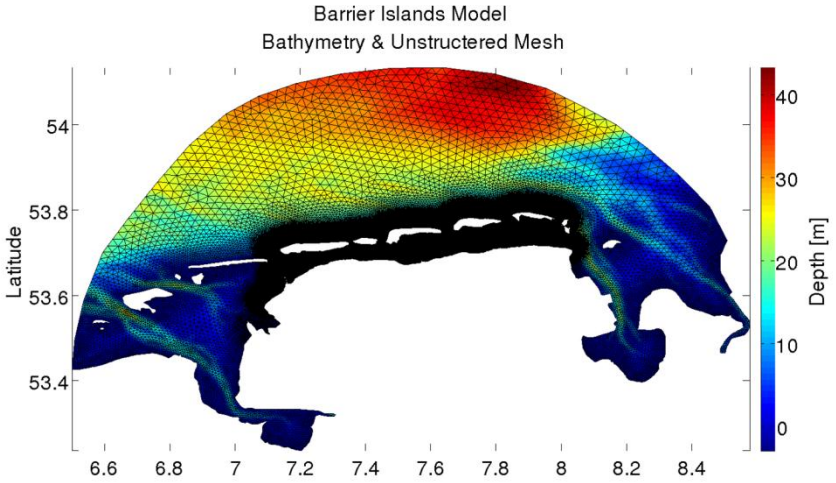
Interaction of litter with beaches

Beaches show complex hydrodynamic circulations

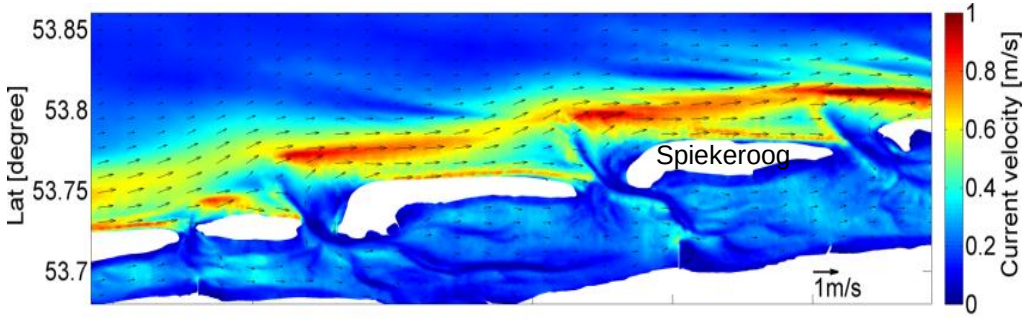


Source:
Hally-Rosendahl et al. (2014), JGR

Understand via modelling and measurements



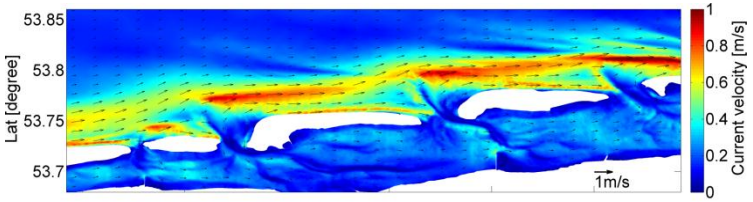
Dye source



Grashorn et al. (2015), Ocean Dynamics

Workflow (Modelling)

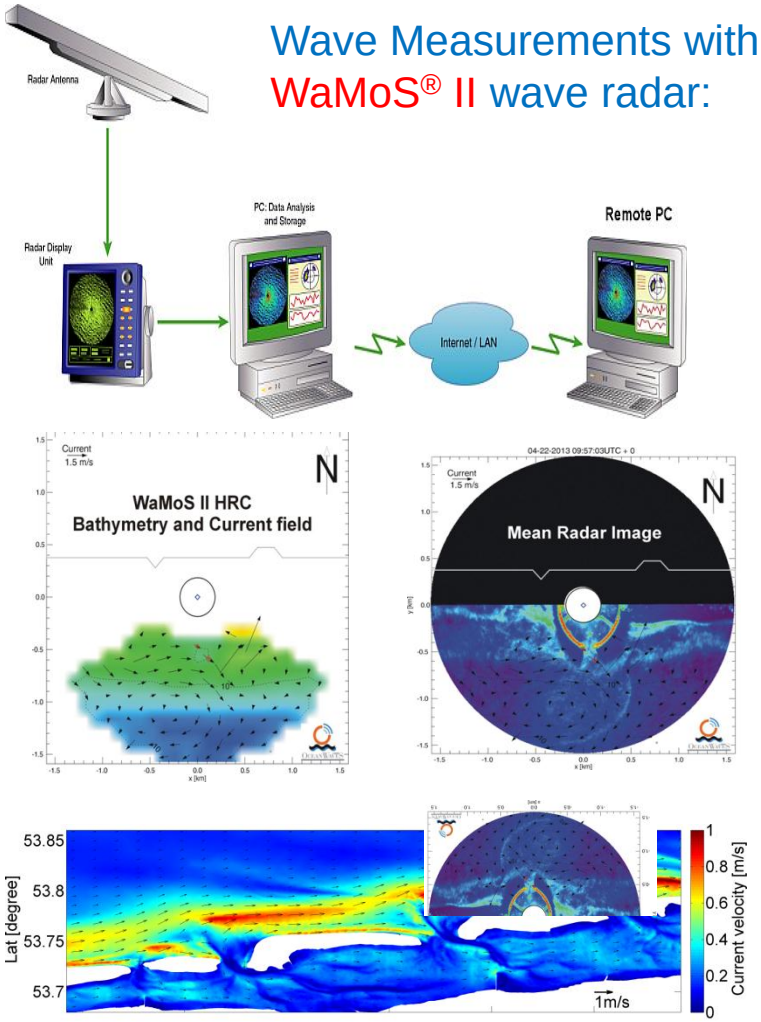
$$\frac{\partial uD}{\partial t} + \frac{\partial u^2 D}{\partial x} + \frac{\partial uvD}{\partial y} + \frac{\partial u\omega}{\partial \hat{\sigma}} - fvD$$
$$= -D\frac{\partial}{\partial x}(g\eta + p_{atm}) - D\int_{\hat{\sigma}}^{0}\left(D\frac{\partial b}{\partial x} - \varsigma\frac{\partial D}{\partial x}\frac{\partial b}{\partial \hat{\sigma}}\right)d\hat{\sigma}$$
$$-\left(\frac{\partial DS_{xx}}{\partial x} + \frac{\partial DS_{xy}}{\partial y}\right) + \hat{\sigma}\left(\frac{\partial D}{\partial x}\frac{\partial S_{xx}}{\partial \hat{\sigma}} + \frac{\partial D}{\partial y}\frac{\partial S_{xy}}{\partial \hat{\sigma}}\right) + \frac{\partial \tau_x}{\partial \hat{\sigma}}$$
$$\frac{\partial vD}{\partial t} + \frac{\partial uvD}{\partial x} + \frac{\partial v^2 D}{\partial y} + \frac{\partial v\omega}{\partial \hat{\sigma}} + fuD$$
$$= -D\frac{\partial}{\partial y}(g\eta + p_{atm}) - D\int_{\hat{\sigma}}^{0}\left(D\frac{\partial b}{\partial y} - \varsigma\frac{\partial D}{\partial y}\frac{\partial b}{\partial \hat{\sigma}}\right)d\hat{\sigma}$$
$$-\left(\frac{\partial DS_{xy}}{\partial x} + \frac{\partial DS_{yy}}{\partial y}\right) + \hat{\sigma}\left(\frac{\partial D}{\partial x}\frac{\partial S_{xy}}{\partial \hat{\sigma}} + \frac{\partial D}{\partial y}\frac{\partial S_{yy}}{\partial \hat{\sigma}}\right) + \frac{\partial \tau_y}{\partial \hat{\sigma}}$$
$$\frac{\partial Du}{\partial x} + \frac{\partial Dv}{\partial y} + \frac{\partial \omega}{\partial \hat{\sigma}} + \frac{\partial \eta}{\partial t} = 0$$
$$\frac{\partial \Theta D}{\partial t} + \frac{\partial \Theta uD}{\partial x} + \frac{\partial \Theta vD}{\partial y} + \frac{\partial \Theta \omega}{\partial \hat{\sigma}} = \frac{1}{D}\frac{\partial}{\partial \hat{\sigma}}\left(K_h\frac{\partial \Theta}{\partial \hat{\sigma}}\right) + D\hat{H} + DF_\Theta$$
$$\frac{\partial sD}{\partial t} + \frac{\partial suD}{\partial x} + \frac{\partial svD}{\partial y} + \frac{\partial s\omega}{\partial \hat{\sigma}} = \frac{1}{D}\frac{\partial}{\partial \hat{\sigma}}\left(K_h\frac{\partial s}{\partial \hat{\sigma}}\right) + DF_s$$
$$\rho = \rho(\Theta, s)$$



Interaction of litter with beaches

Validate Models with Measurements

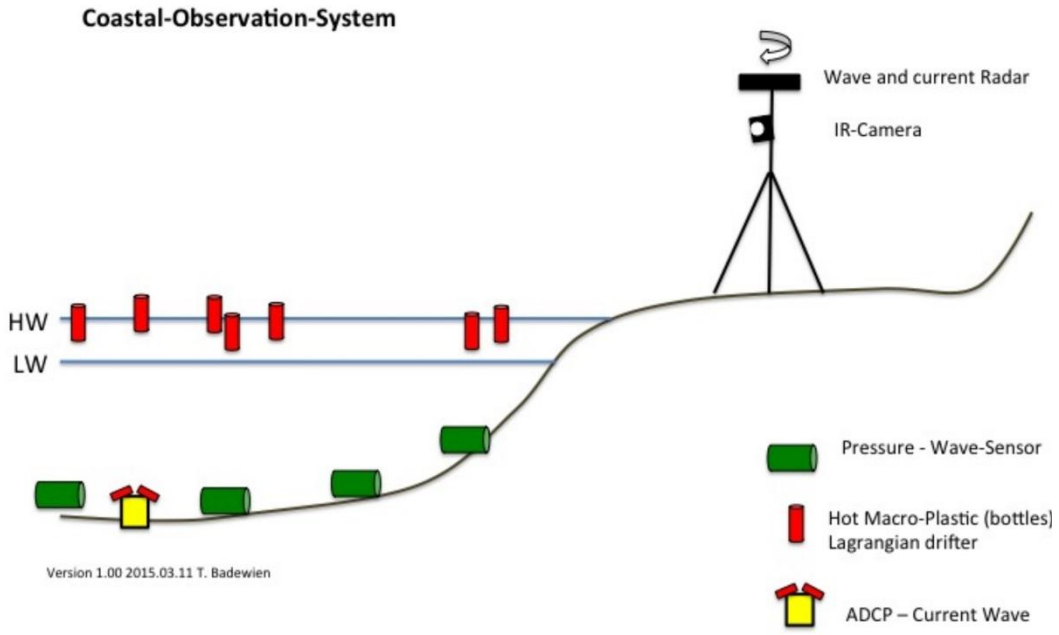
Wave Measurements with WaMoS® II wave radar:



Measurements of local currents and drifter paths

Thermal drifters in combination with infrared cameras:

- glass bottles filled with hot water
- simple ice blocks of frozen water



Investigation of the role of rivers

1) Monitoring of litter along rivers and at barrage facilities

2) Using large numbers of wooden drifters to investigate the drift paths of litter located within rivers:
   - different input locations along rivers and coastline
   - repeating each year

Wooden drifters:
- 7 x 8 cm
- with branding

3) Interaction with public community:
   - citizens are asked to report finding of drifters
   - cooperation with National Park authority (Guides, Ranger, etc.)
   - cooperation with local NGO
   - own monitoring activities

4) Using large-scale modelling to investigate drifting paths and validate with wooden-drifter paths.

Investigation of the role of rivers:

Using wooden drifters

Inspired by the work of Carson et al. (2013) for Hawai'i island.

Drift blocks made of wood simulate the fate of plastic debris

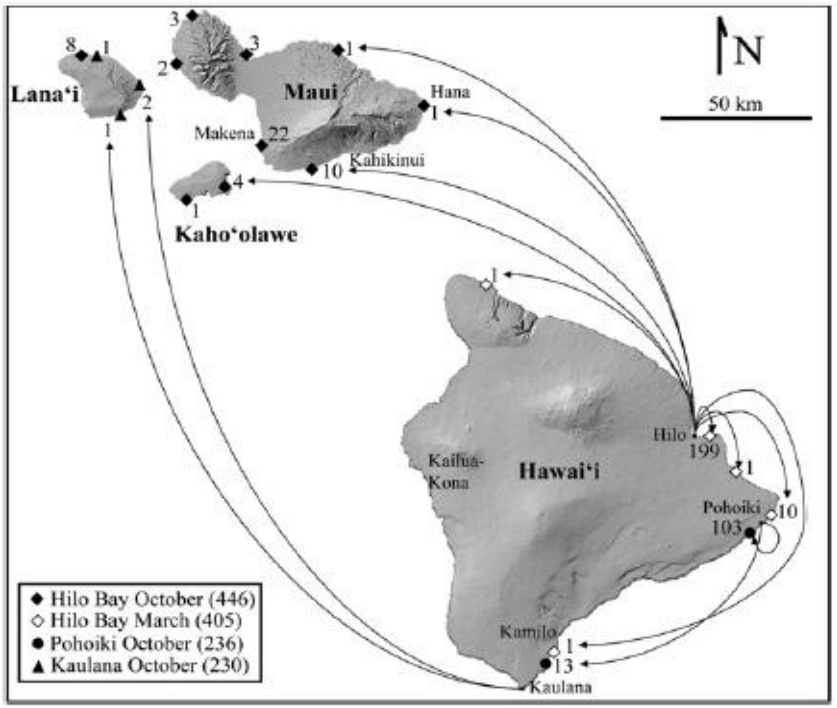


Fig 4. Locations of all reported drifter recoveries. Multiple recoveries in one area are represented by one symbol, with the adjacent numeral denoting the number of recoveries in that area. Numbers in parenthesis in the figure legend are the total number of blocks released at that event. Arrows connect release and recovery locations, and do not represent drift paths. Not all of the release-recovery connections are shown for clarity.

Slides provided by Henry S. Carson

H.S. Carson et al. / Marine Environmental Research 84 (2013) 76–83

Public Awareness and Citizen Science

Mounting campaigns in the project area to raise the awareness for marine debris of politicians, citizen, tourists and other stakeholders

GIS-based data-collection by activating residents and tourists via **smartphone app** and **web-application**

- reporting of marine litter (macroplastics) via georeferenced photographic images
- reporting the findings of the drifters

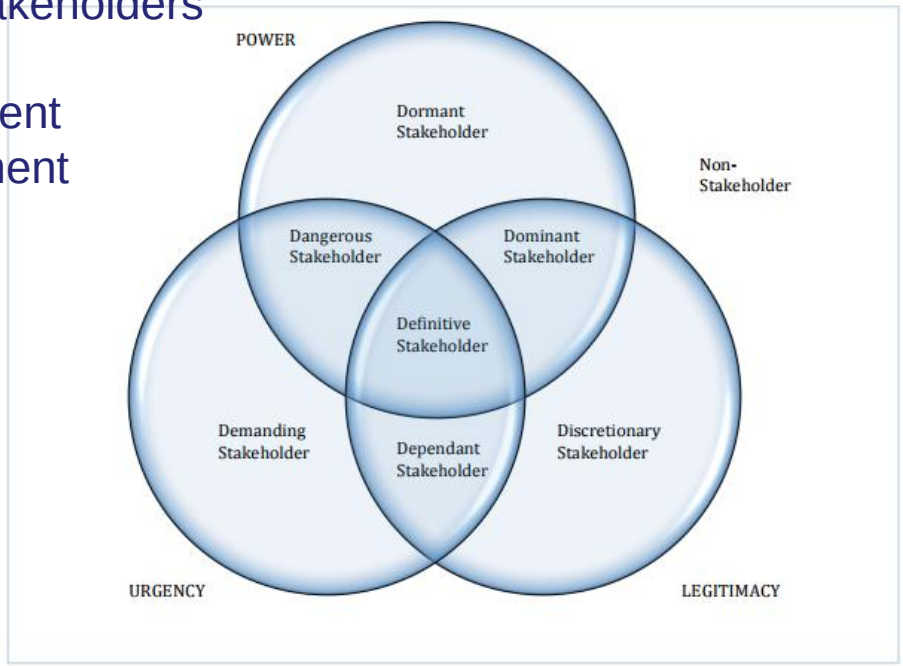
Cooperation in strategic networks against marine litter, e.g.

- „Round Table Marine Litter“ in the permanent representation of Lower Saxony with a Federal Government in Berlin
- Clean Europe Network etc.

Stakeholder-Analysis and Abatement Strategies

- **Stakeholder-Analysis**:
  - Who is a main stakeholder/shareholder of marine macroplastics debris and which stakeholder/shareholder play which specific part in Lower Saxony?
  - Which pathways / stakeholders are of a specific interest for initiating abatement strategies?

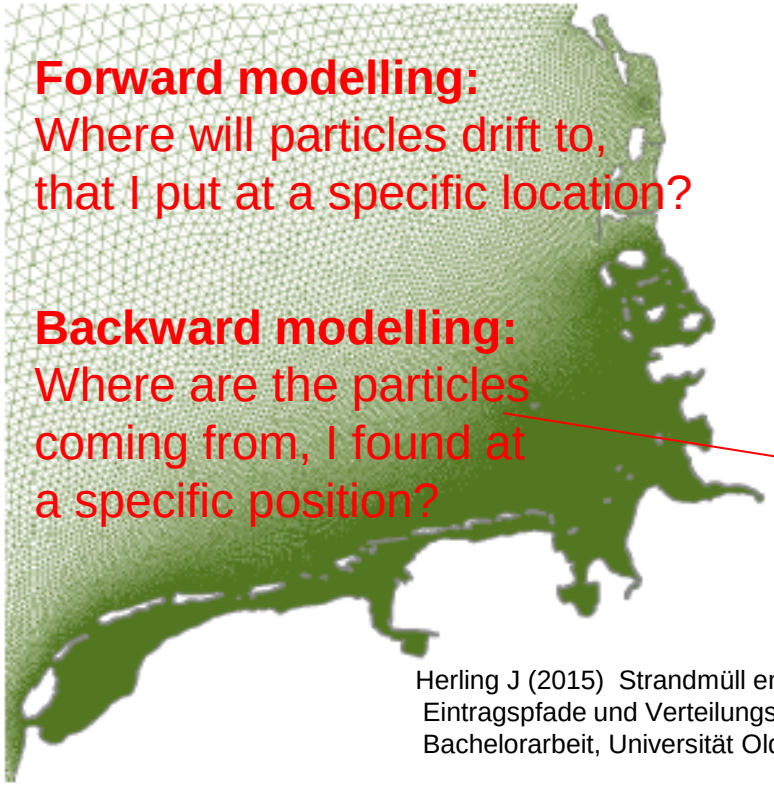
- **Expert Interviews and Workshops** with Stakeholders from economy, society and government, e.g.
  - How can / should actor-orientated abatement strategies be designed and how to implement these strategies ?
  - Are legislative measures reasonable to solve the problems?



Investigation of the role of rivers:

Using hydrodynamic modelling of drifters

Pilot studies:
Master thesis by Vanessa Schakau (2014),
Bachelor thesis by Julia Herling (2015),
University of Oldenburg



Forward modelling:
Where will particles drift to, that I put at a specific location?

Backward modelling:
Where are the particles coming from, I found at a specific position?

Litter monitoring stations in German Bight: Where is litter coming from?

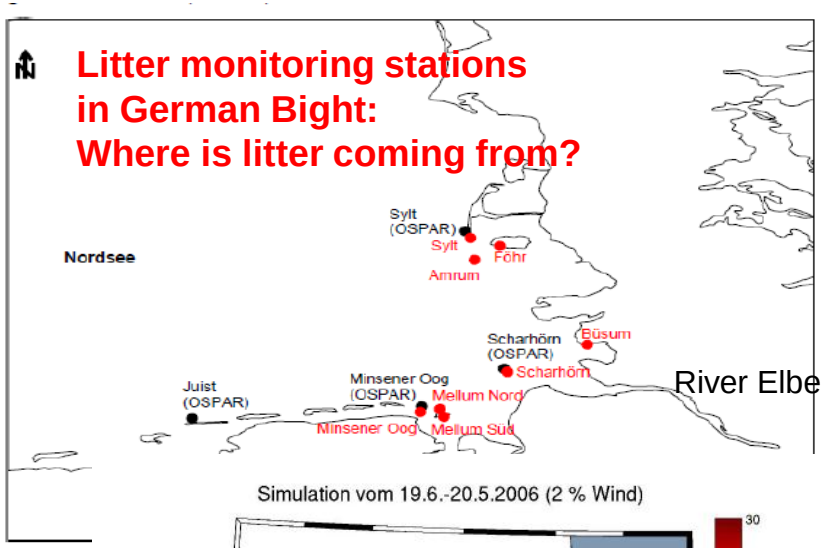
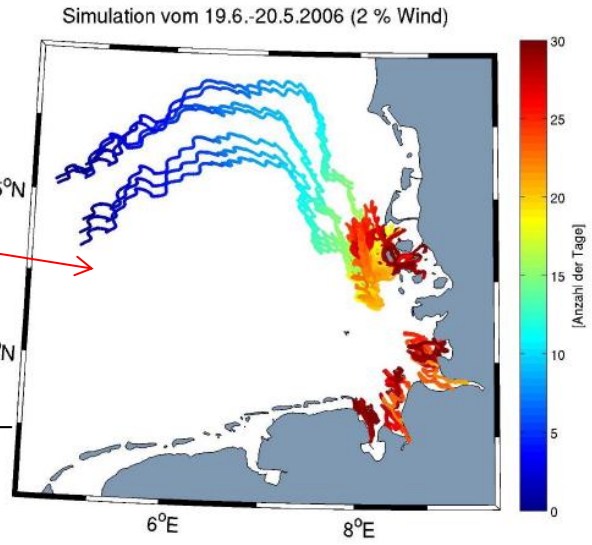
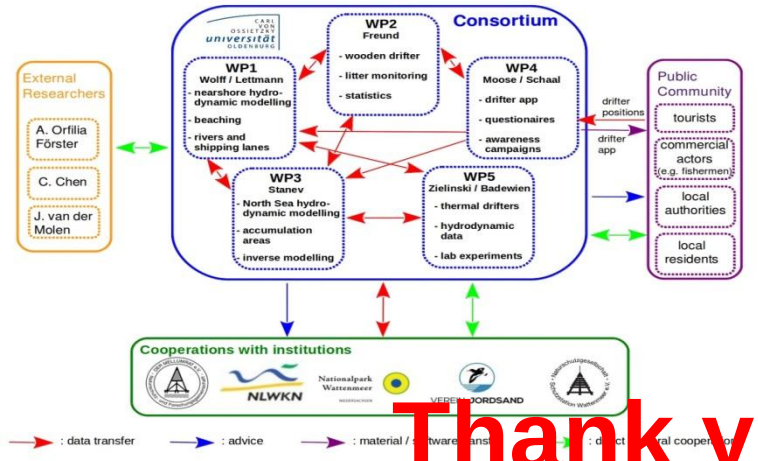


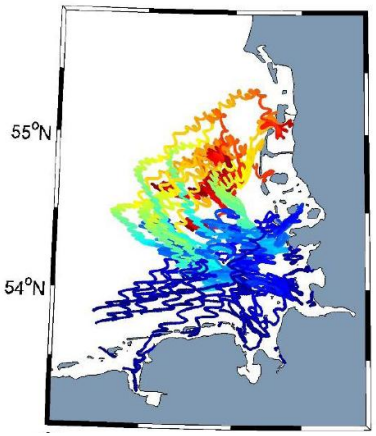
Abbildung 6:
Jordsand e.V
(Quelle: Schulz

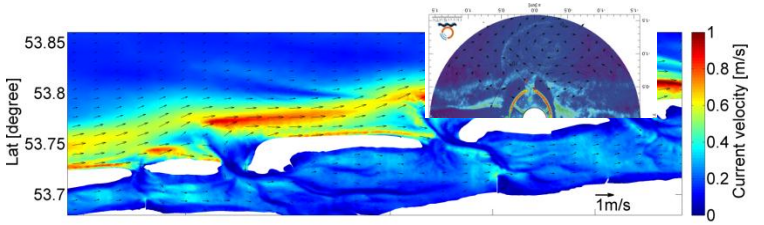


Herling J (2015) Strandmüll entlang der Deutschen Bucht – Eintragspfade und Verteilungsmuster von 1995-2013. Bachelorarbeit, Universität Oldenburg



Thank you for your attention !





Contact: Prof. Dr. Jörg-Olaf Wolff (wolff@icbm.de)
Web Page: www.macroplastics.de