Application of Oceanographic Drift Models

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Acknowledgements

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Pawsey Supercomputing Centre
Tracking parcels of water

**Advection**

1. Initial state
2. After advection
3. Final state

**Advection + Diffusion**

1. Initial state
2. After advection
3. After diffusion
4. Final state
Surface Drift Dynamics

Environmental Forcing:
- Winds
- Tides
- River inflow
- Surface Heat Flux

Ocean Response:
- Wind Waves
- Vertical Mixing
- Depth Dependent Currents
- Density Stratification

Drift Response:
- Stokes Drift
- Direct Windage/Leeway
- Adveected by near-surface currents
Drift Modelling

Atmospheric Model
Wind, temperature, precipitation, air-sea fluxes

Wave model
Stokes drift
Wave momentum

Ocean circulation model
Currents, temperature, salinity, turbulence

Particle tracking model
Water mass, debris, sediment, larvae, turtles, wrack, oil/chemical spills, search & rescue

Gnome
response.restoration.noaa.gov

Ichthyop
www.ichthyop.org
Drift Modelling: wind effects

- Wind
- Ocean Surface

Low wind vs storm

Depth

Graph showing:
- $u_w(z=0) = 2.73\%$
- $u_s(z=0) = 0.27\%$
Drift Modelling: Stokes drift

Mass transport due to waves

\[ u = U_s \]
Drift Modelling: wind effects

- Surface drift due to the wind: 2 - 3% of $U_{10}$
- The Ekman currents at the surface strongly depend on the vertical mixing $K_z$: 0.5 to 4% of $U_{10}$
- Stokes drift of waves of same magnitude order: 3% of $U_{10}$
Windage

Wind

Low windage, object sitting deep in water
Medium windage, object sitting half in water
High windage, object sitting high on water

For example 5% windage means an object is moving with the current + 5% wind speed
Leeway divergence

- Leeway divergence transports objects at an angle relative to downwind.
- Symmetry allows stable drift left and right of downwind (little jibing is observed).

→ Diverging search areas with time.
Demo: initial conditions
Demo: advection by currents
Demo: advection by wind
Demo: advection by wind/currents
Demo: advection by wind/currents
Demo: advection by wind/currents
Demo: advection by wind/currents
Shark Bay: 2000

[Map showing distributions with symbols for years 1997, 1998, 1999, and 2000, and a graph with 500 random particles released at t=0.]

Model Run bc4 - bottom tracking

Hour no. 1

20 40 60 80

160 140 120 100 80 60 40 20
Particle Tracking (‘Age’)
Peddies: 3 August 2011

Petite eddies (diameter < 25km)
Peddie – 3 August 2010

Southern Surveyor Voyage
Peddie – 3 August 2010

Temperature

ADCP currents
Northern Indian Ocean

30-Aug-2011
Port Geographe

Location & Concept Plan
Location & Concept Plan

Sand transport

Sand trap

Bypass
Location & Concept Plan
The Problem
The Problem

Oldham et al., 2010
Seagrass Wrack

Oldham et al., 2010
No detailed information available on wrack dynamics

Observations: Wrack present on beaches from May to October
Naturally ‘disappear’ in October/November

Hydrodynamics: Mode of transport (suspended/bedload ?)
Settling velocity ?
Critical shear stress ?

Stage 1 Study:
Wrack ‘life-cycle’

‘Summer’ - quiescent period.
Wrack accumulates offshore in meadows and adjacent un-vegetated areas.

‘Winter’ - storm period.
Wrack is moved into surf-zone & beach. Whilst in the surf-zone, subject to long-shore transport.

Late Winter/Spring.
Wrack is removed from naturally from the beaches.
Particle conceptual model

Resuspension

Transport (Currents, Stokes drift, Diffusion)

Deposition (when $z_p \leq z_o$)

- Beach accumulation ($\tau_c$ increase and $w_s = 0$)
- Resuspension from the beach ($w_s$ decrease back to initial)
Bathymetry: existing/proposed
Wrack transport

Port Geographe

19-May-2009 00:30:00

Northing (m)

Easting (m)
Post construction

Construction completed in June 2014: ~ $27 million
Search for MH370

Disappeared on 8 March 2014
MH370: initial search areas
Search for MH370
Predictions: August 2014
Predictions: August 2014

Debris simulation (months)
- 0-6
- 6-12
- 12-18
- 18-24

Search area

8 March 2014:
MH370 departs Kuala Lumpur

Source: Professor of Coastal Oceanography, Charitha Pattiaratchi
School of Civil, Environmental and Mining Engineering & UWA Oceans Institute
MH370: simulations

Pawsey Supercomputing Centre
MH370: simulations

Loc01

- 08 March 2014 to 01 Sep 2014
- 01 Sep 2014 to 01 April 2015
- 01 April 2015 to 28 July 2015
MH370: simulations

Loc18

- 08 March 2014 to 01 Sep 2014
- 01 Sep 2014 to 01 April 2015
- 01 April 2015 to 28 July 2015
MH370: simulations

Loc25

- 08 March 2014 to 01 Sep 2014
- 01 Sep 2014 to 01 April 2015
- 01 April 2015 to 28 July 2015
Drifter positions 18 Mar 2014