Movement of pollutants in the vicinity of bivalve molluscs production areas.

"determine the characteristics of the circulation of pollution, appreciating current patterns, bathymetry and the tidal cycle."

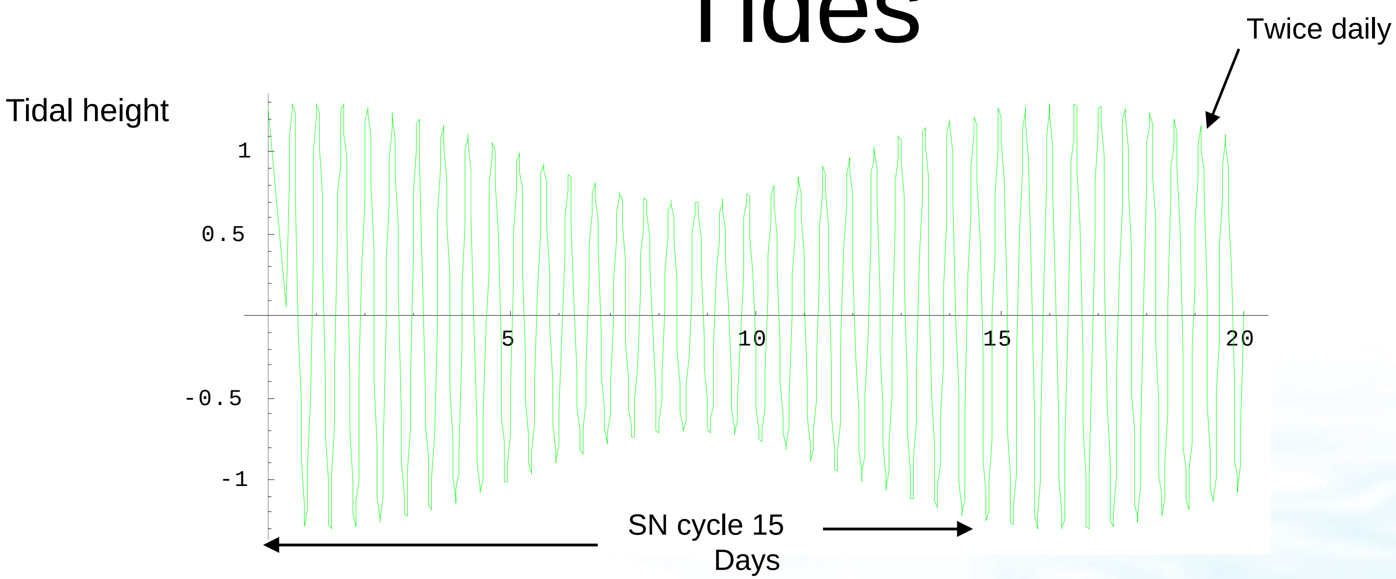
Cefas

Topics covered

- Driving forces and processes
  - Tides
  - Winds
  - Density
- Estuaries
  - Well mixed verses two layer
  - River plumes
  - Salinity
  - Turbidity
- Bathymetry/Charts
- Models
  - Types of model
  - Limitations
  - Resources and Requirements
  - Typical outputs
- Examples

Cefas

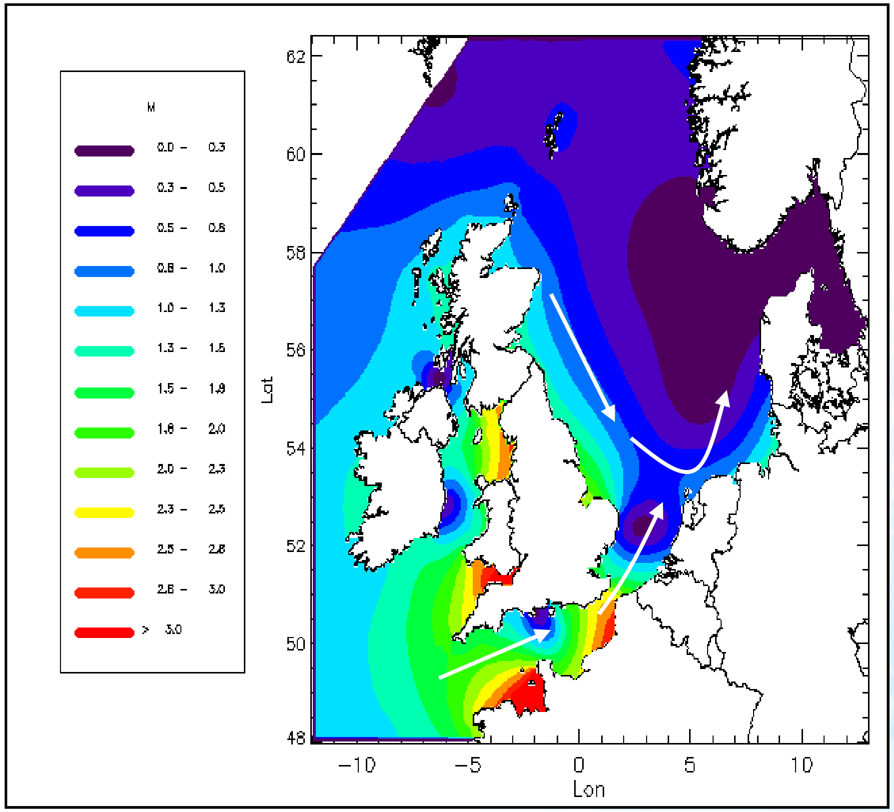
Tides



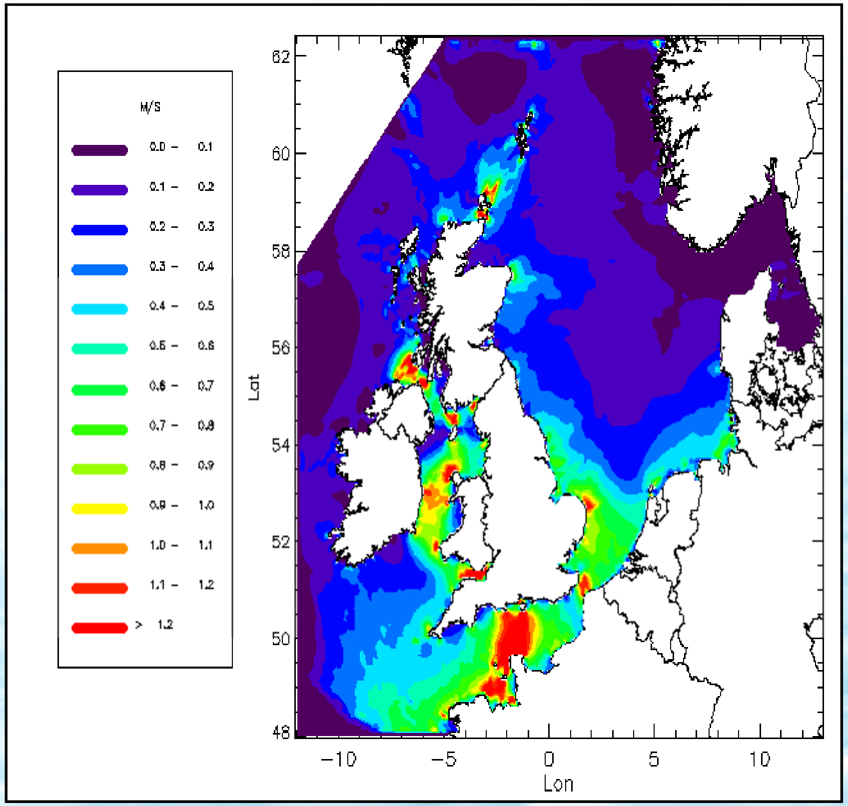
- Cause changes in water level and generate currents (“streams”)
- Main lunar tide (M2) repeats every 12.42 hours.
  - Generally two high/low waters per day.
- Combined with solar diurnal tide (S2)
  - gives 15 day Spring-Neap cycle.
- Other constituents as well, giving rise to various phenomena:
  - diurnal inequality, equinoctial tides, overtides.
  - In some places the diurnal (once daily tides) dominate.

Spatial distribution

Tidal elevation

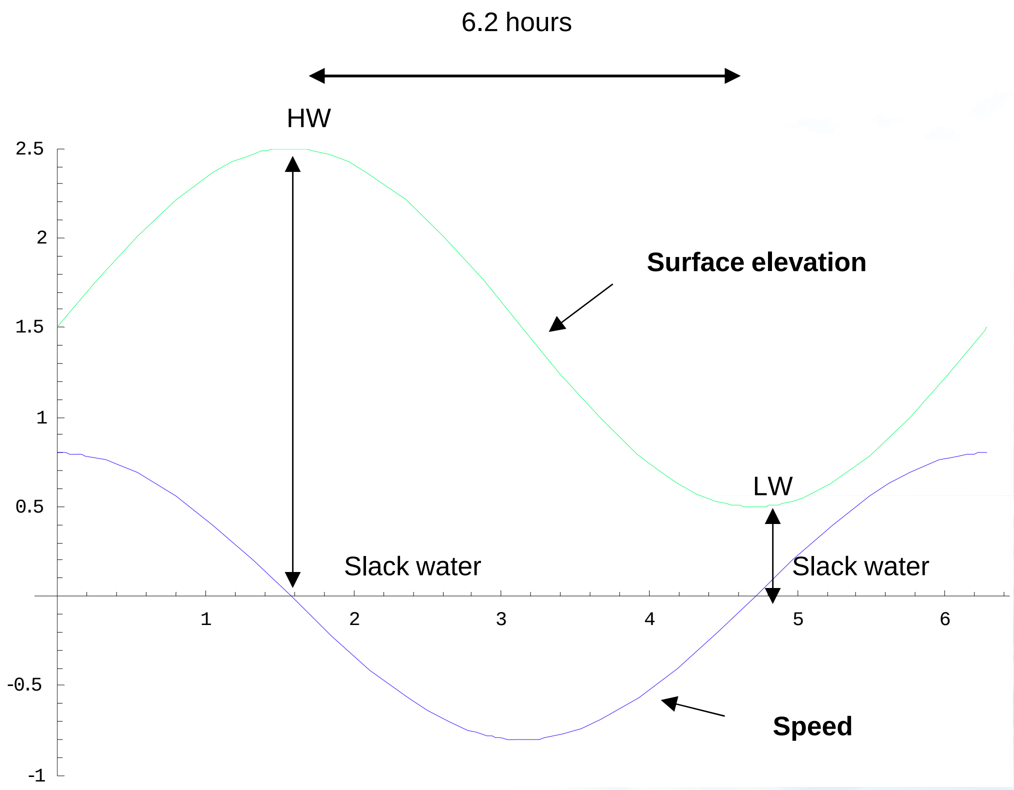


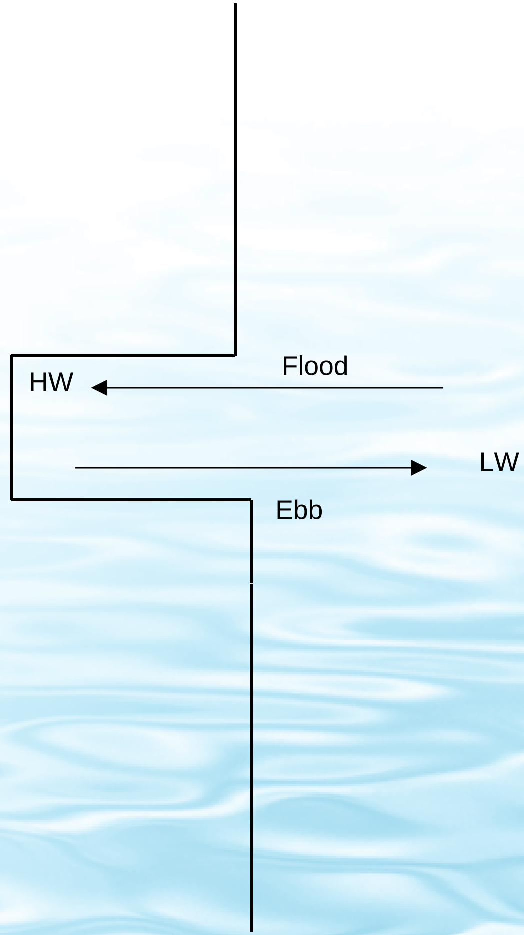
Tidal currents



Cefas

Typical estuary relationships between tidal rise & fall and tidal currents.

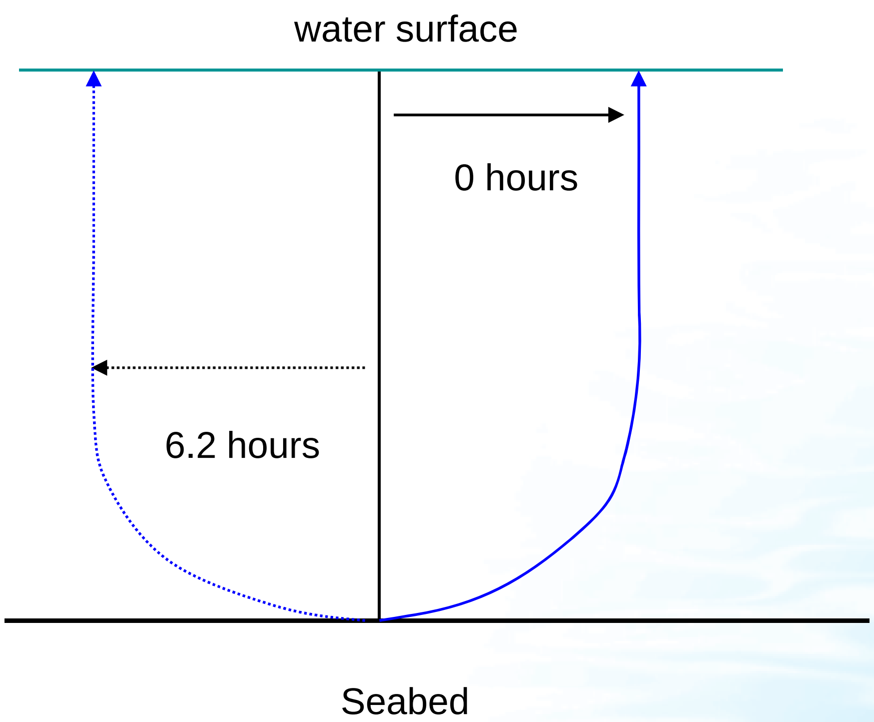


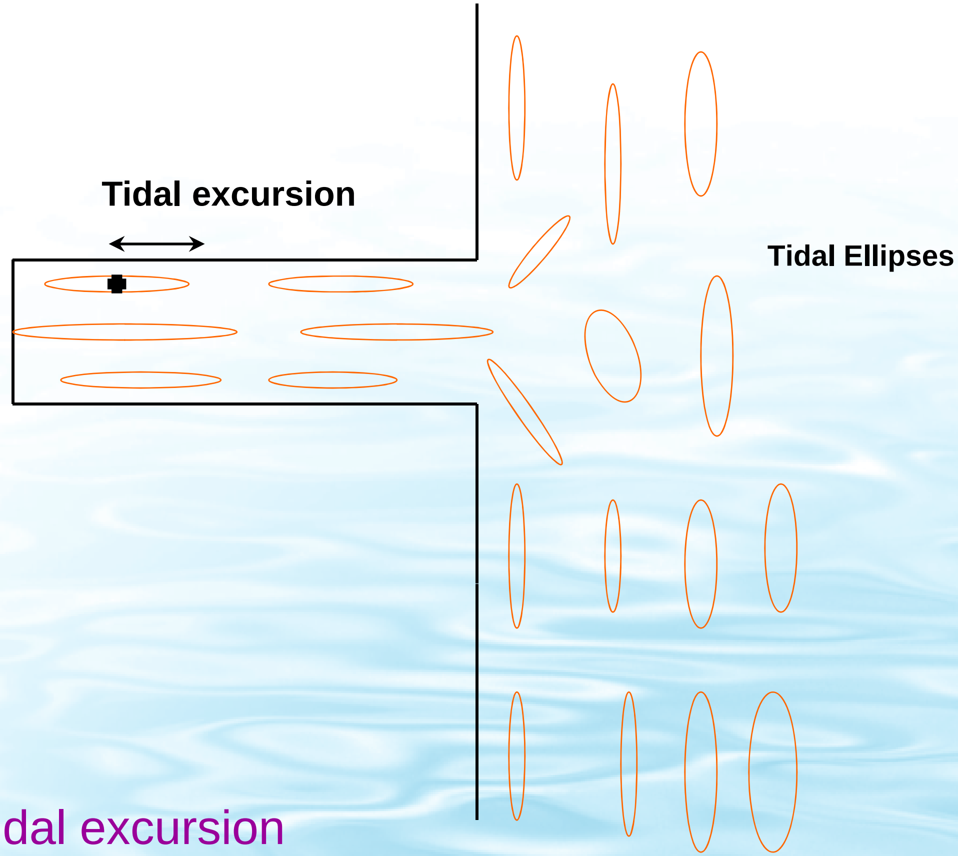


(short reflective estuary)

Cefas

Tidal currents (“streams”)





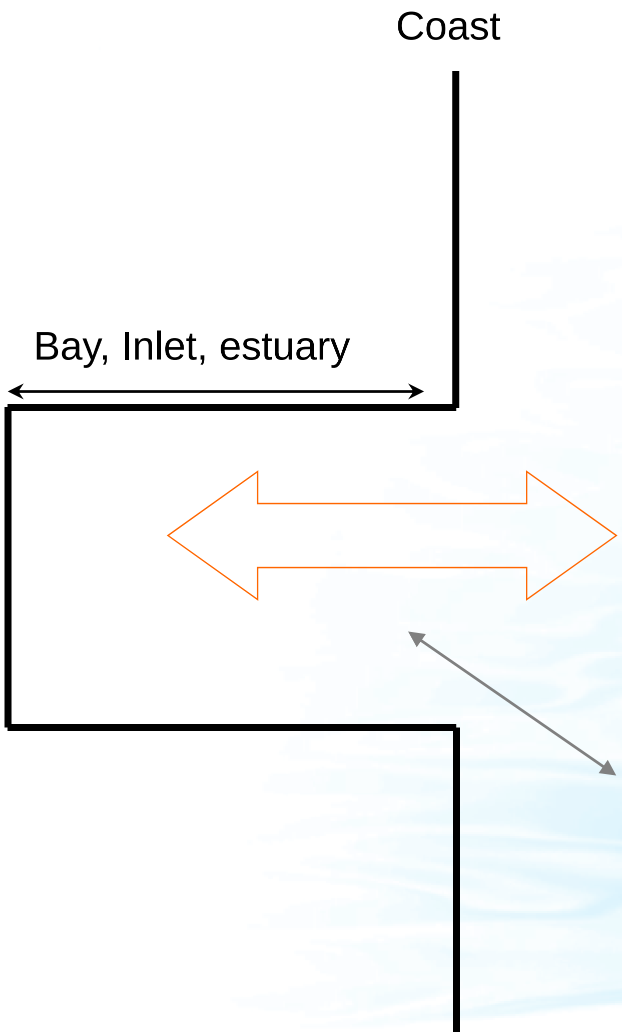
Tidal excursion

50 cm/s for 6.2 hours ~ 10 km

Small net movement

Cefas

Tidal prism



Tidal Prism: Volume of water entering and leaving on a given tide

= (Volume at HW) – (Volume at LW)

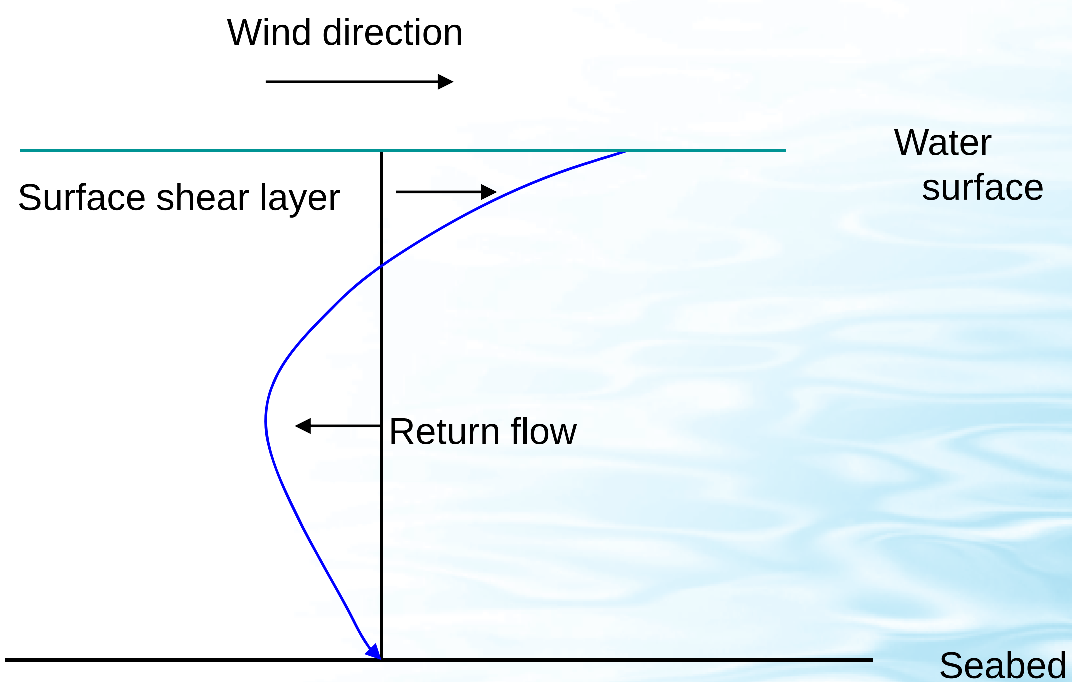
Flushing time: Time for significant proportion of water of estuary to be renewed

~ hours ~days ~ weeks

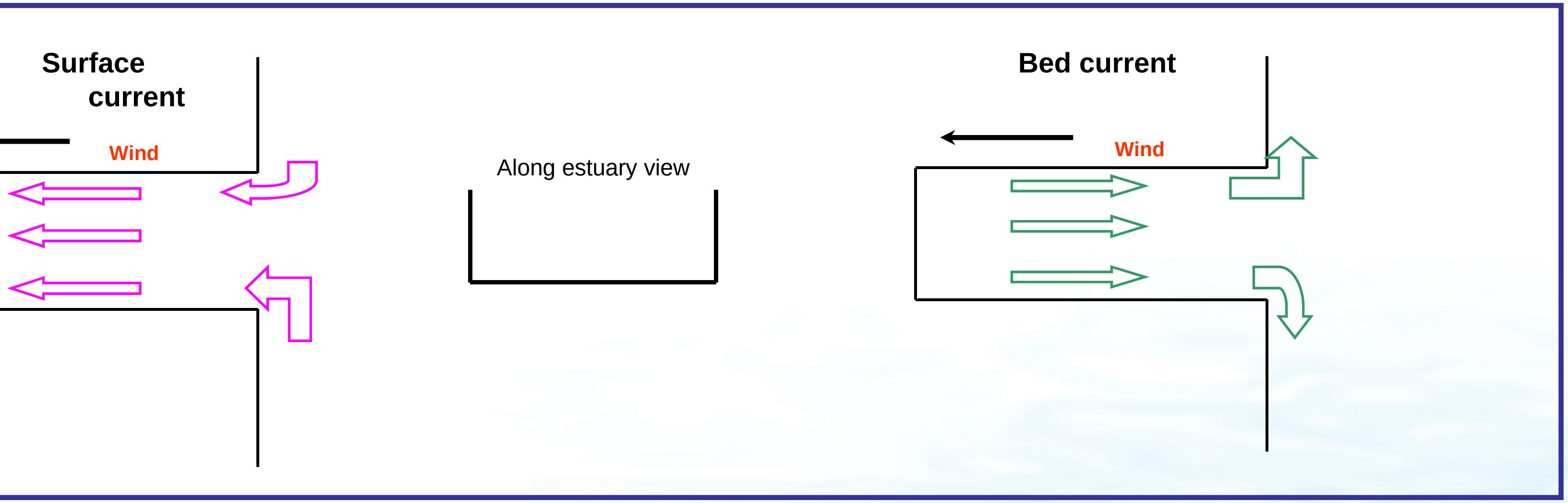
Wind driven currents

Generally weaker than tides (~ 1 to 10 cm/s ?)

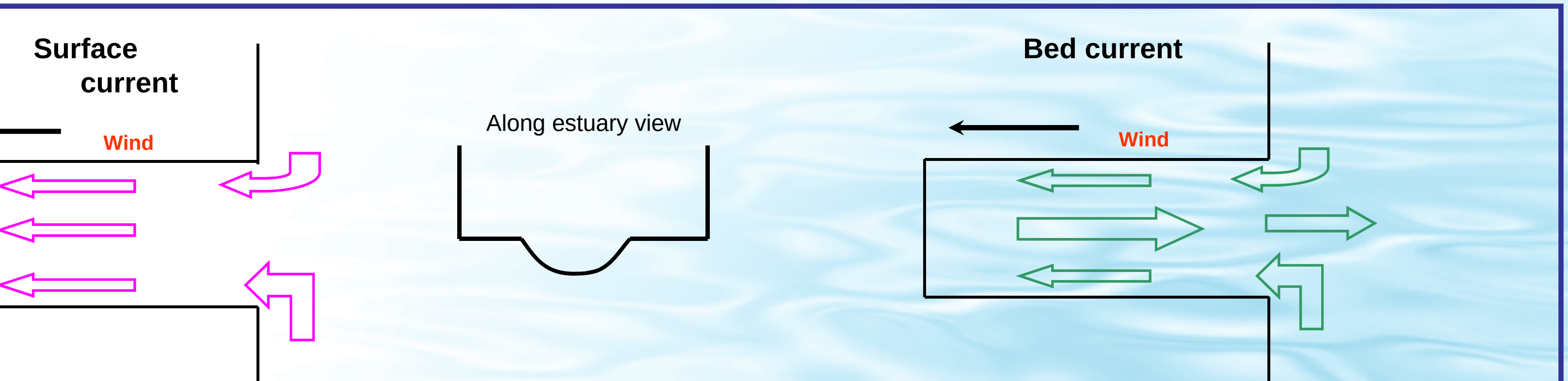
Surface current ~ 3% of wind speed.



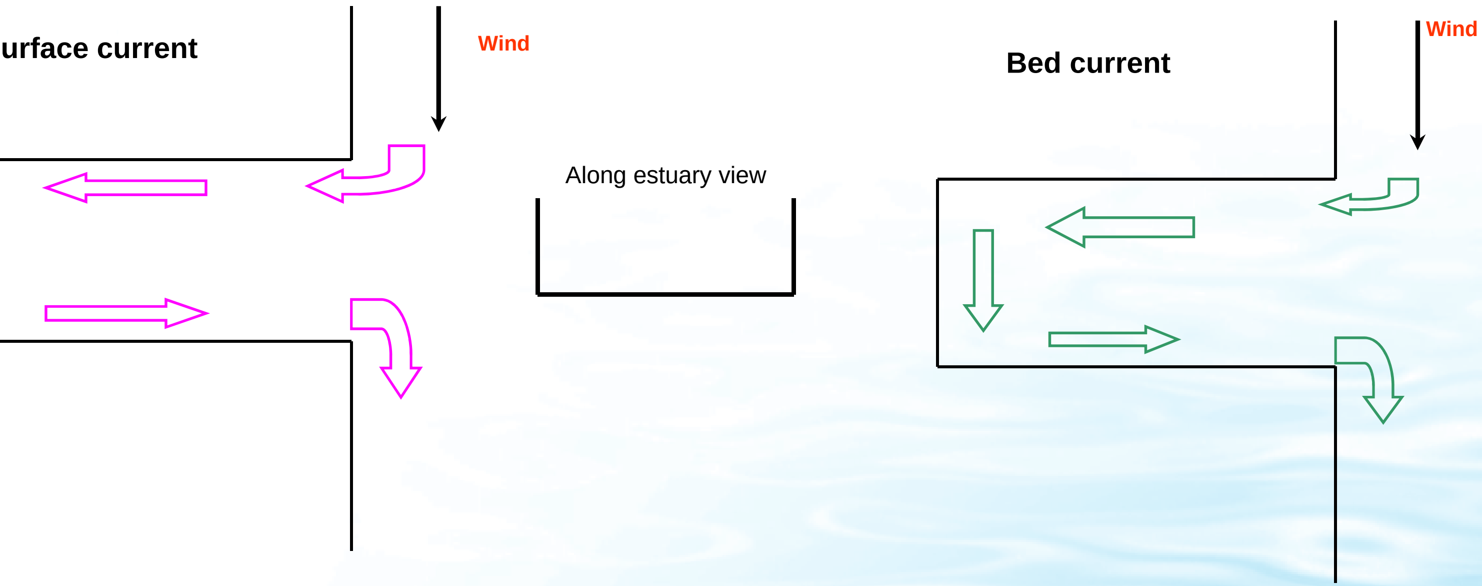
Up estuary wind



ymetric modification.



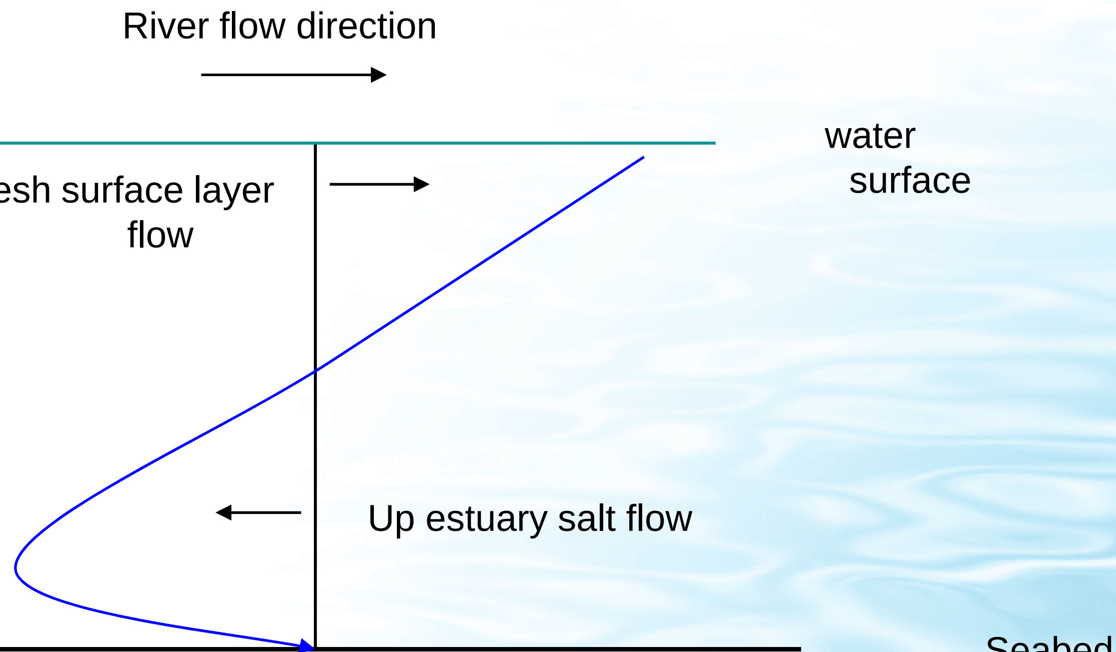
Alongshore wind



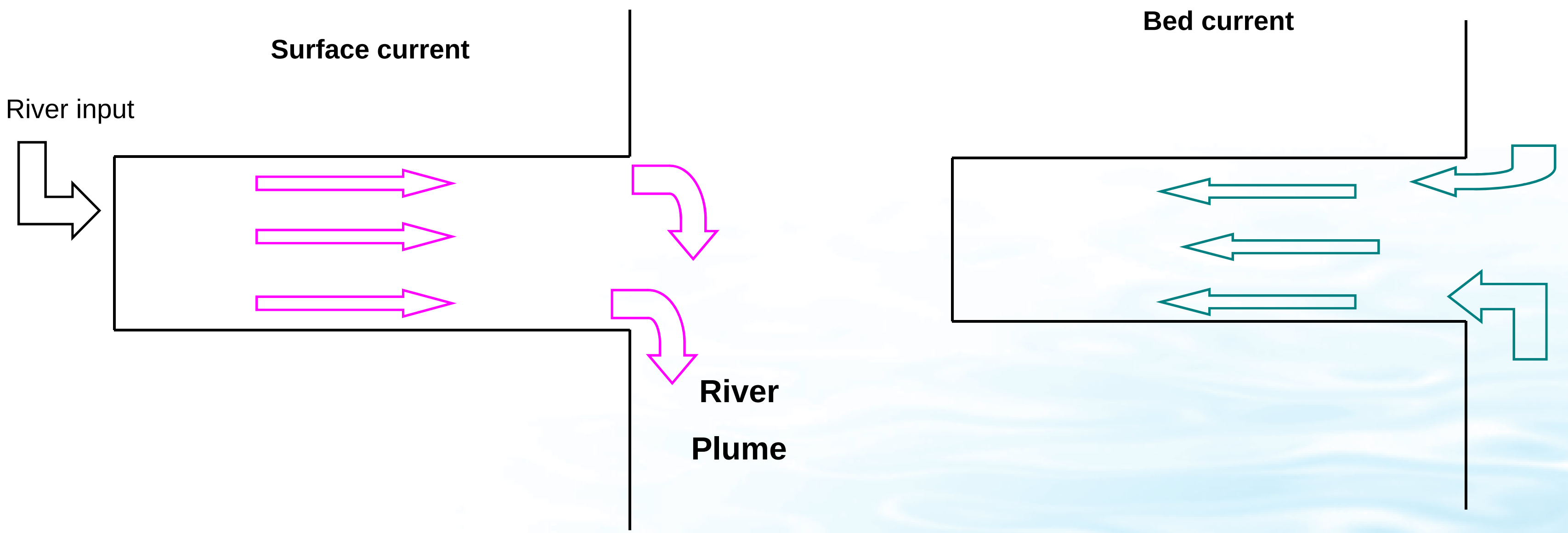
- Wind from south will reversed directions.
- Again bathymetry/shape will modify flows

Density (salinity) driven currents

- Associated with river inputs.
- Surface layer velocity controlled by magnitude of river flow.



Density driven flows



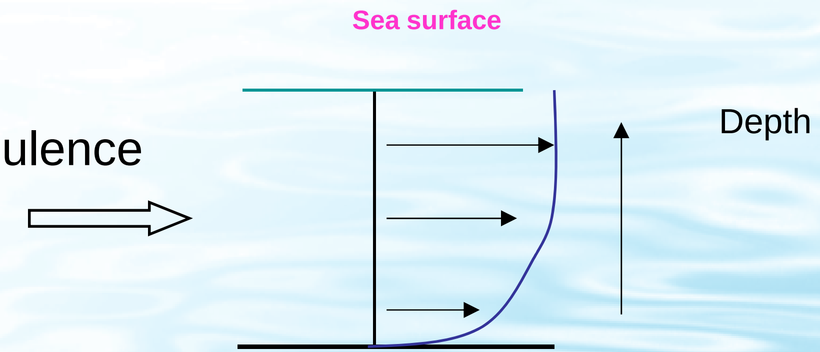
- Density dominated estuaries relatively complex.
  - Behaviour depends on complex considerations of vertical mixing.
- Note the river plume (turns to the right in northern hemisphere).

Cefas

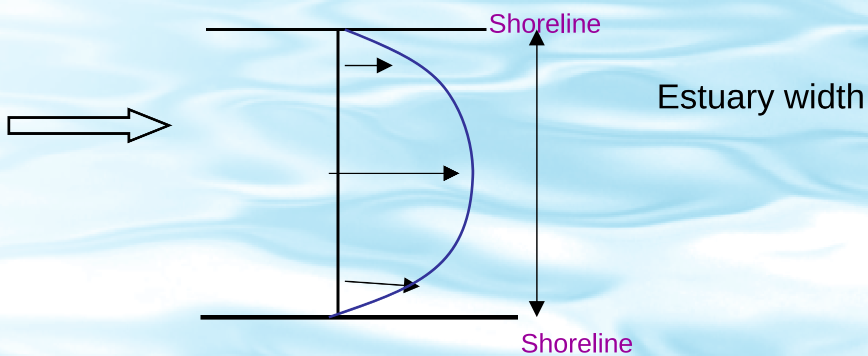
Advection and Dilution of contaminants

- **Advection**
  - Movement by currents without dilution
  - Often draw material into long streams aligned along flow direction.

- **Dilution**
  - Mixing by small scale turbulence
  - Dispersion

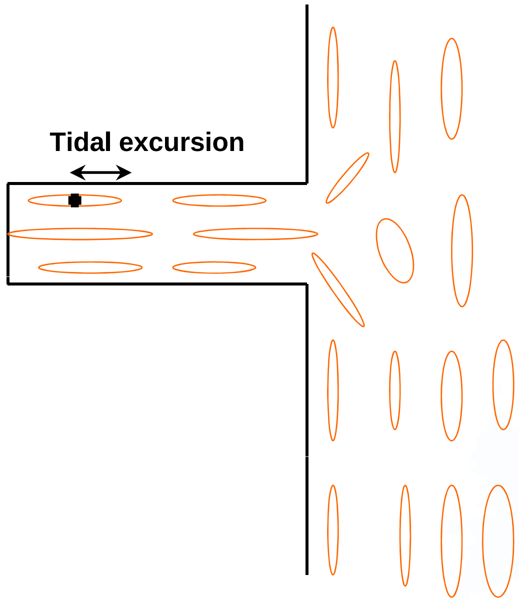


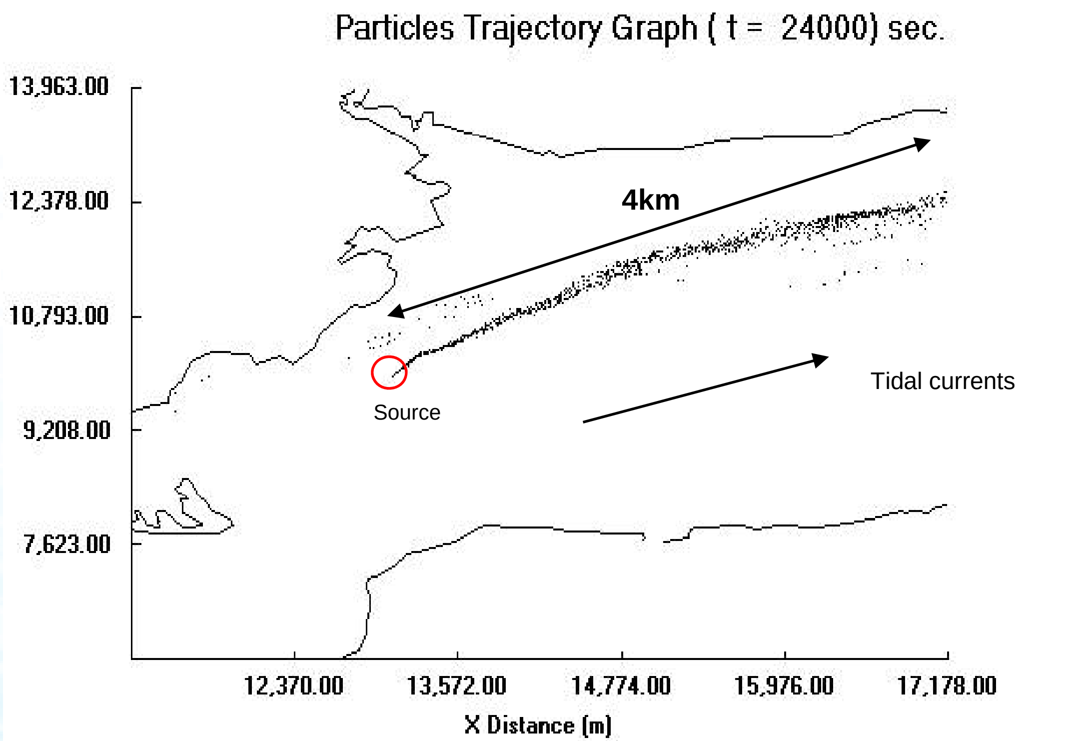
    - Vertical shear dispersion



    - Lateral shear dispersion

Example snapshot of advection and dispersion.





Cefas

Estuary classification

Mixed (single layer constant density).

- Strong mixing (e.g. tides), small river inputs.

Two layer – less dense above more dense water.

- Weak mixing and significant river inputs or strong surface heating (e.g. Mediterranean).

or tidal estuaries, measure of importance of river input is

R = (Volume River Flow) /Tidal Prism

Salinity and Turbidity

Turbidity: Suspended particulate material+CDOM.

- Input from: a) rivers, b) material within estuary, c) marine input.

- Can increase T_{90}.

Salinity

- Acts as a tracer for freshwater.

- Useful if main inputs are associated with freshwater.

- Allows calculation of dilution.

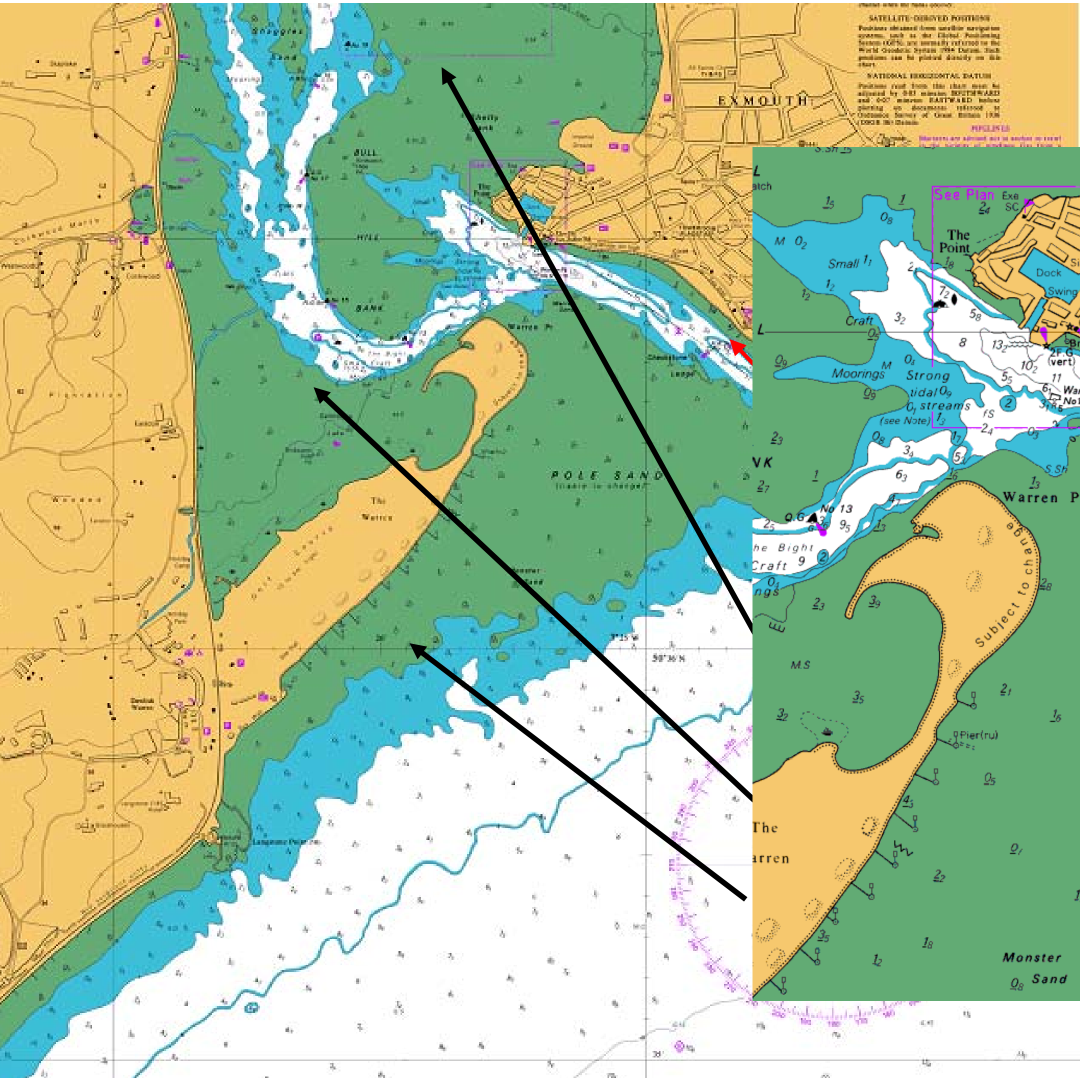
Summary of key points

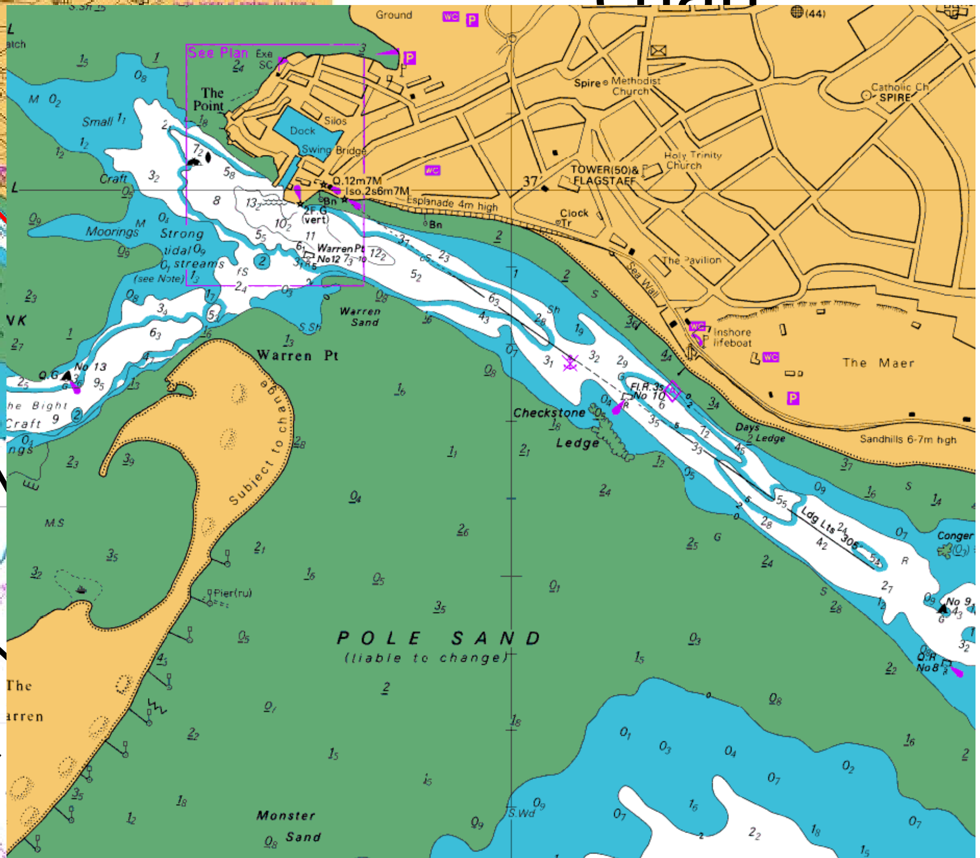
- Currents area generally aligned <u>alongshore</u>
- Material will be drawn out in the direction of current, often forming ‘plumes’.
- Tides can transport material rapidly, with maximum distance given by the tidal excursion.
- Wind and density driven flows generally weaker, but persistent.
- Surface and bottom currents may be in opposite directions.
- Turbidity may be important when considering T_{90}.
- Salinity acts as a tracer for river inputs.

Sources of practical information

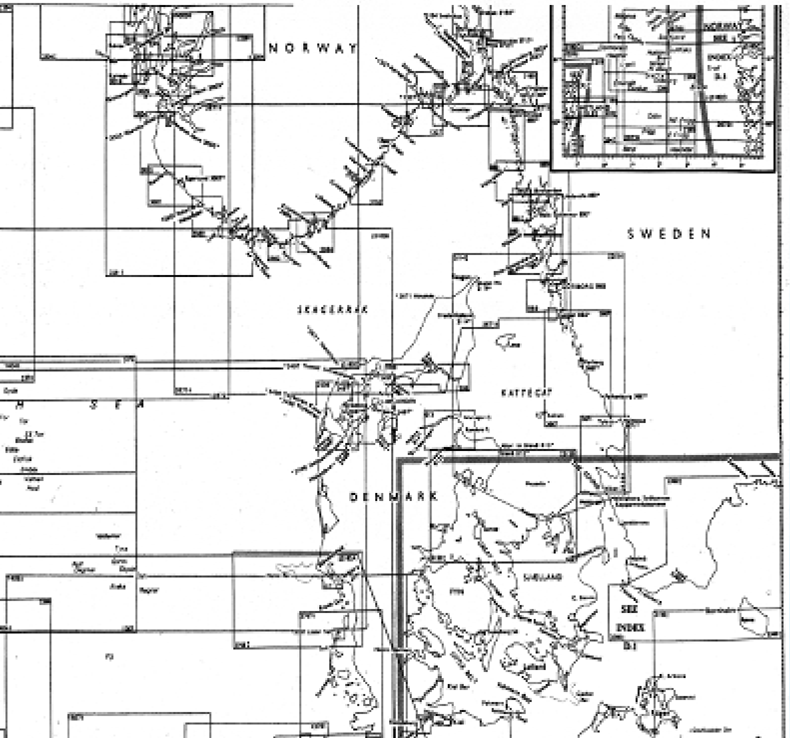
- – Charts
- – Tide tables
- – Tidal software
- – Previous studies
- – Internet
- – Local knowledge
- – Models

UK hydrographic chart





Availability of UKHO charts

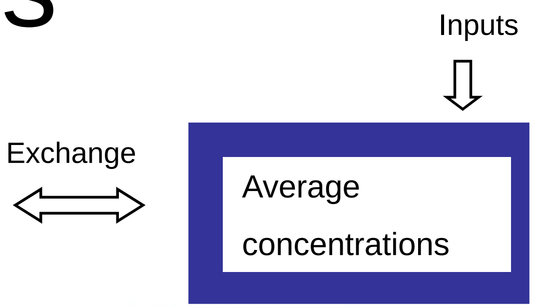


- UK charts available at low resolutions for most European countries
- However, detailed information harbours/estuaries may require local charts?

Models

- Allow
  - For complexity not possible by human assessment.
- Require:
  - Time and expertise to set up;
  - Input data;
  - Interpretation of output;
  - Knowledge of limitations/approximations.
- Results need careful assessment because:
  - Key processes may be missing (e.g. two layer flows);
  - Included processes may not be realistic enough;

Types of Models

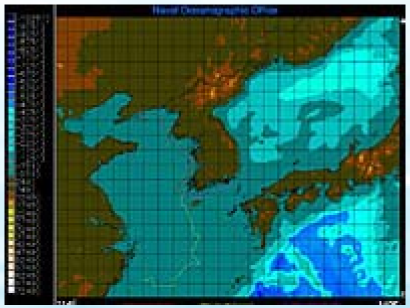


ingle box or 1D

- Idealized geometry.
- Could be set-up in 1 day if data is available.
- Possible to solve without computer.

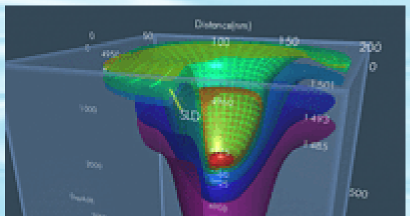
DH Depth integrated (tidal/wind)

- Realistic geometry.
- Computer solution generally fast.
- Could be setup in a few days by expert.
- Widely available e.g. Hydrotrack.



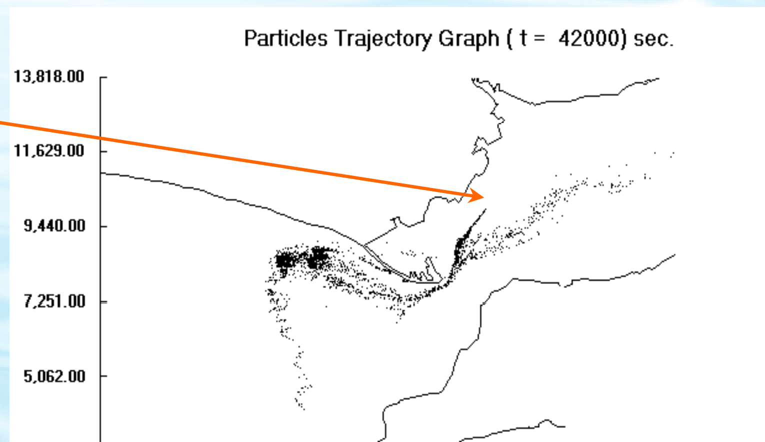
D Baroclinic (density with tides/wind)

- Realistic geometry.
- Computer solution complicated/time consuming.
- Requires weeks to set up.



Animation of model output

- D depth integrated hydrodynamics.
- olent - 50 km along coast from
eymouth.
- un showing several tidal cycles with NW
nd imposed
- ngle contaminant source.
esults do not directly give
ncentrations.



Requirements for setting up

- Estuary shape and depth
  - Charts.
- River flows
  - Usually available in UK.
- Model parameters
  - Typical values available from literature.
- Boundary conditions
  - larger area model, data, expert judgment.

Are the outputs ‘right’?

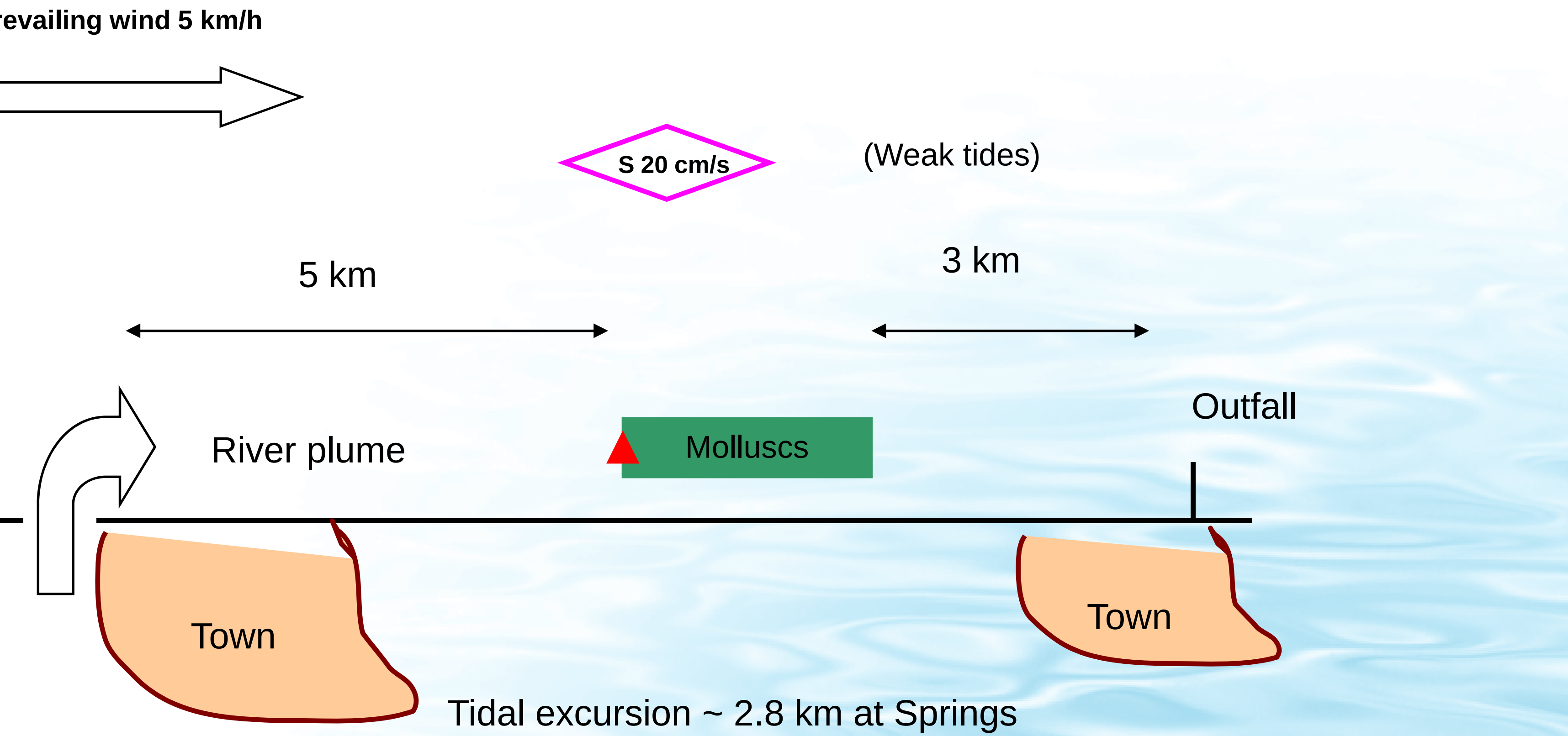
- We have no way of knowing.
  - Validations require expensive field measurements
- Results may be sensitive to
  - uncertain model parameters
  - boundary conditions
- However, models very powerful tool for visualisation and qualitative understanding.
- Can suggest appropriate monitoring
- Only way of dealing rationally with complex systems

Choice of Models

- Depends on question to be answered
  - Average level of contaminants
  - Specific particle paths
- Character of estuary/coast
  - Density plays minor role
  - Density plays significant role
- Resource available
  - Time
  - Money
  - Expertise

Finally Some Examples

Example 1

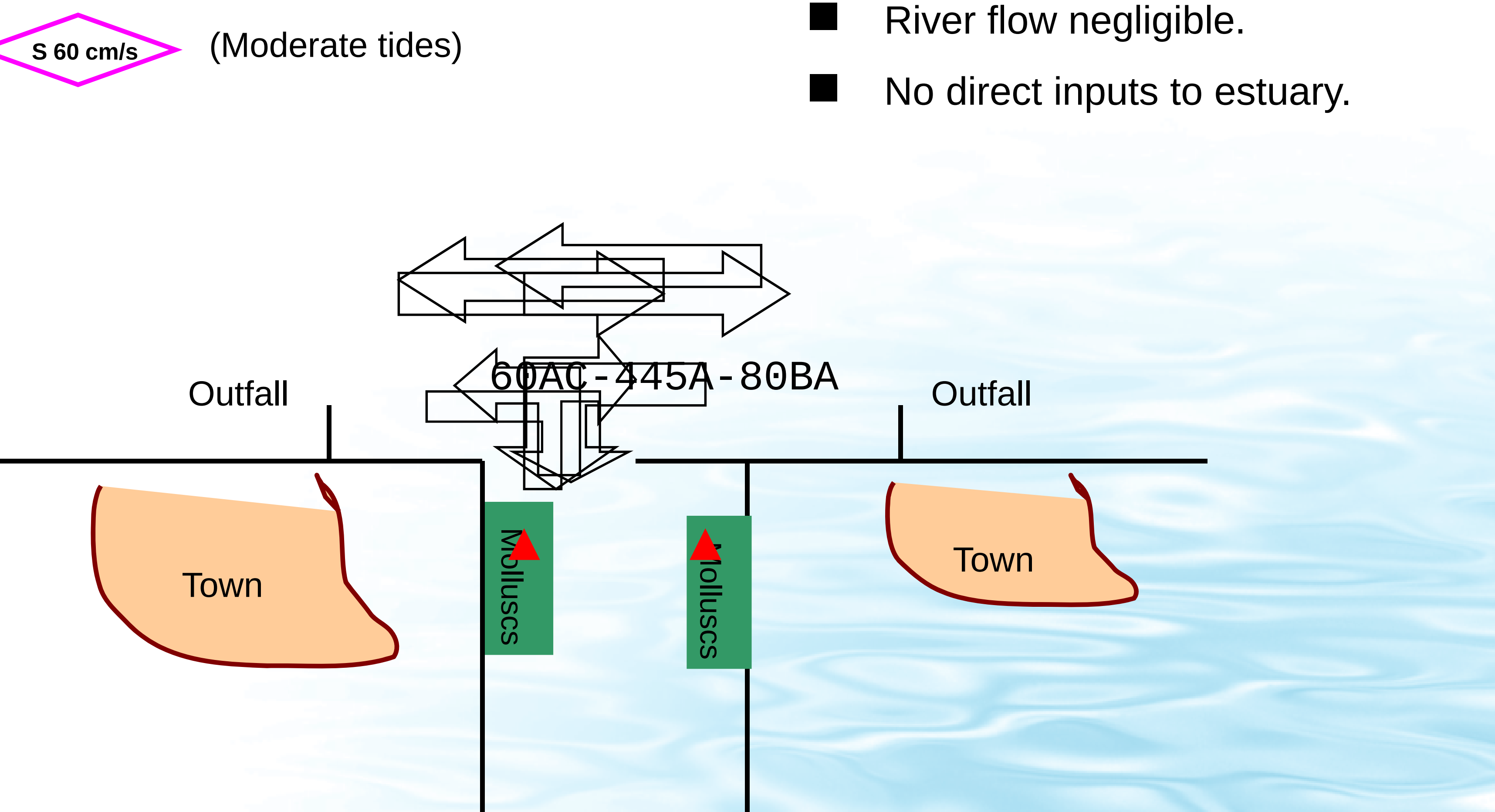


Tidal excursion ~ 2.8 km at Springs

River plume reaches production area in ~20 hours

Example 2

- River flow negligible.
- No direct inputs to estuary.



Summary of presentation

Driving forces

- Tide, wind, density

Transport processes

- Advection, diffusion, dispersion

Estuary types

- Well mixed
- Two layer

Charts

Models

- Box models
- 2D Depth integrated,
- Full 3D baroclinic