Potpourri

Lecture 20

Norwegian tanker Wilstar, damaged by very large wave in Agulhas current - 1974

Potpourri

Last lecture:

A. Near shore processes

- Wave shoaling
- Rip currents
- How waves break

B. Rogue waves

C. Other (please specify)

Wave shoaling in shallow water

Q: Why do waves crests in shallow water often line up parallel to the beach?

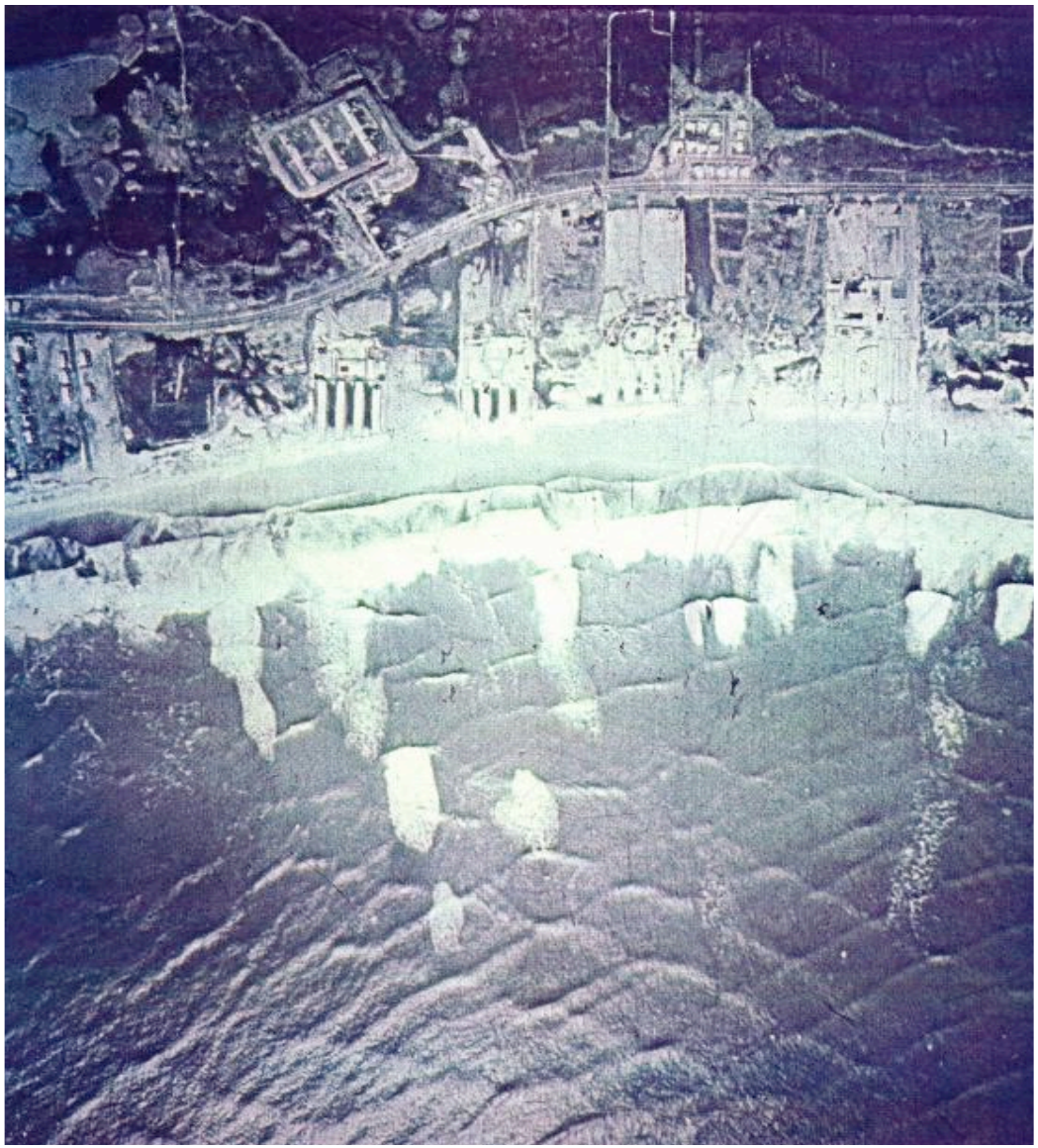
Lima, Peru 2004

Duck, NC 1991

Wave shoaling in shallow water

Q: Why do waves crests in shallow water often line up parallel to the beach?

Jones Beach
Long Island, NY

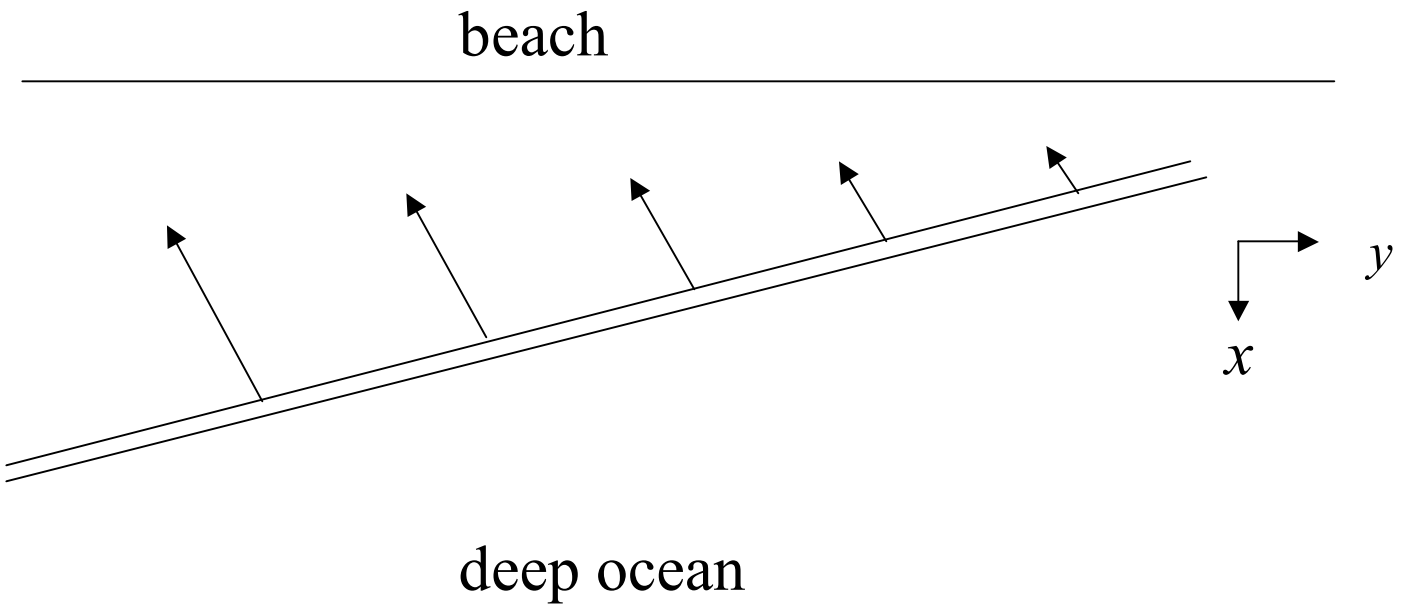


Wave shoaling in shallow water

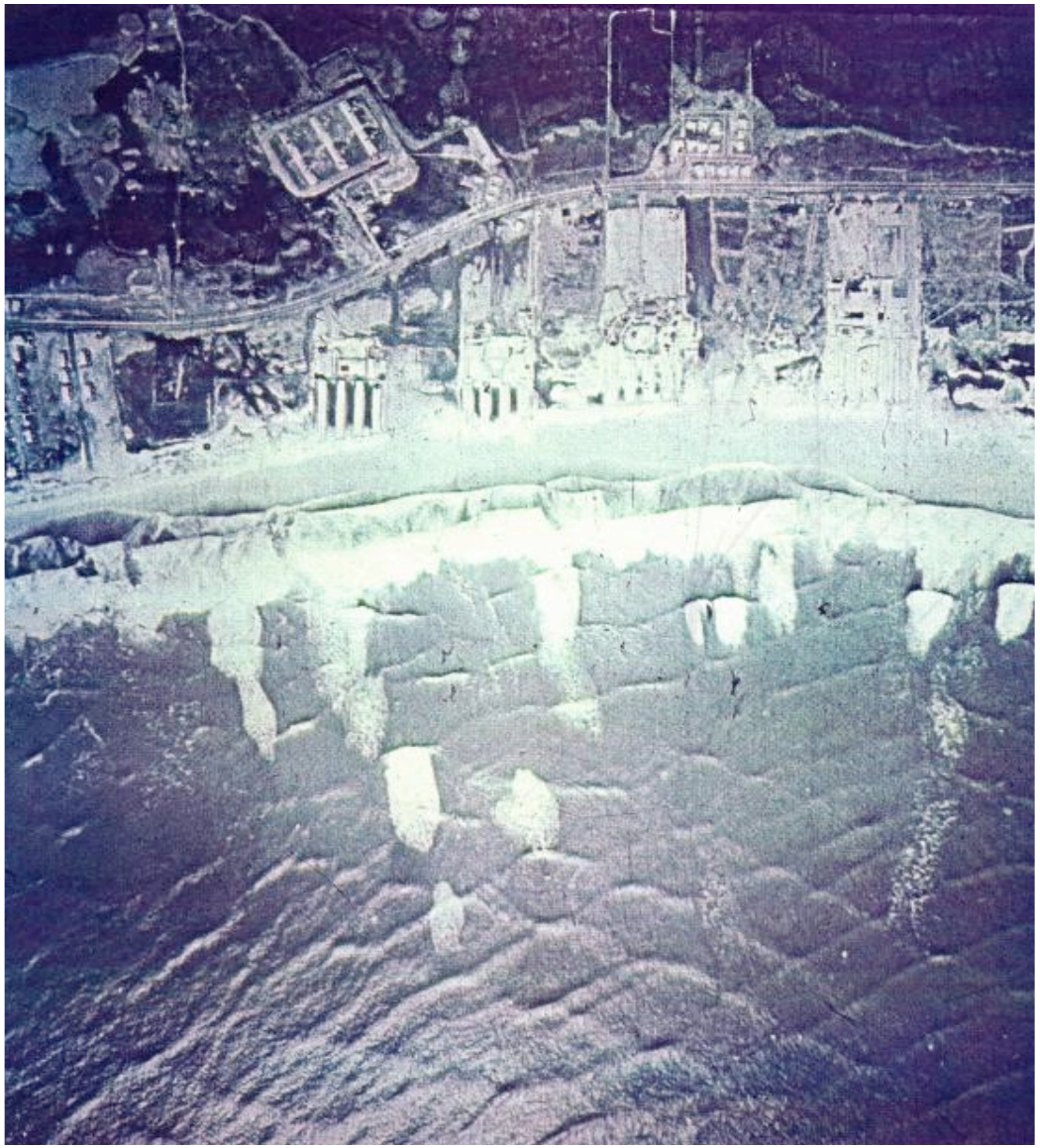
2-D wave equation, with x-dependent speed:

$$\partial_t^2 \eta = \nabla \cdot \{ gh(x) \nabla \eta \}$$

$$c(x) = \sqrt{gh(x)}$$



Wave shoaling in shallow water



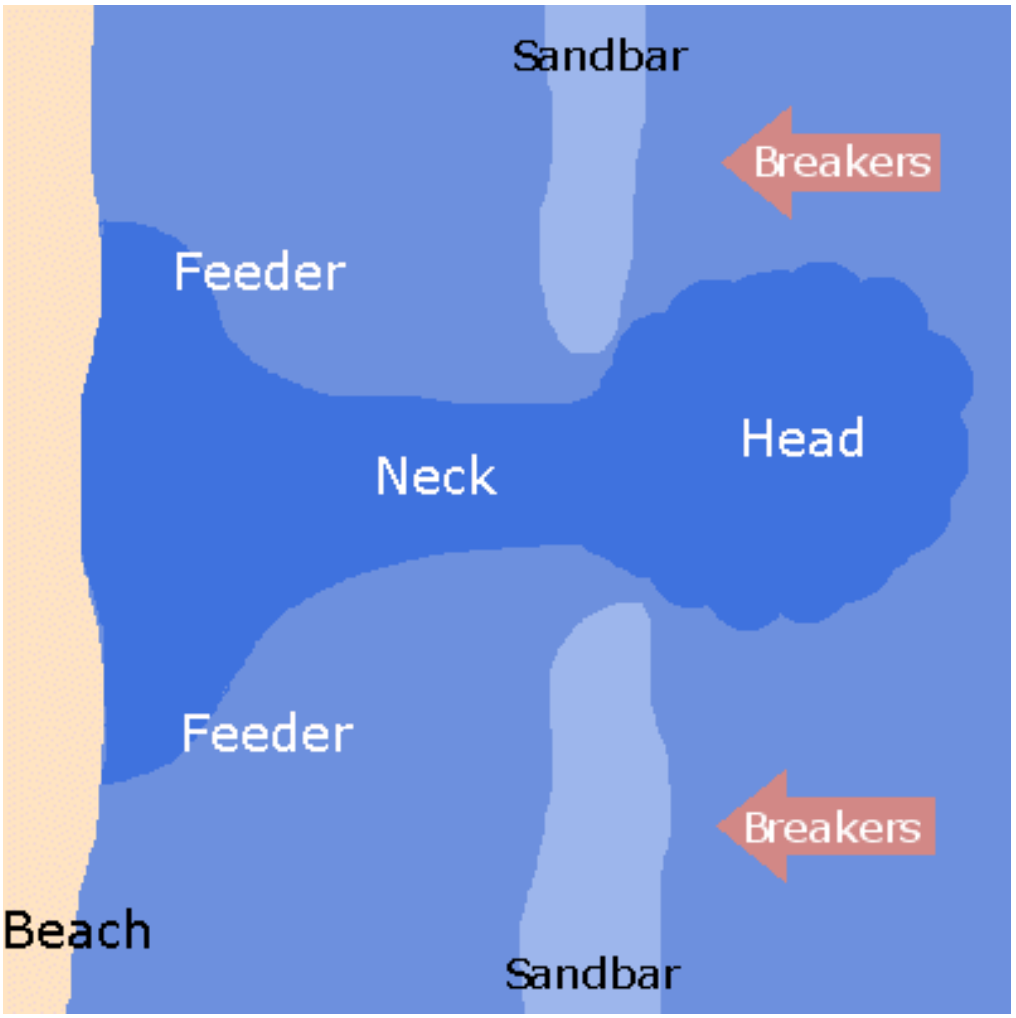
A2. Rip currents

Rosarita beach,
Baja California

A rip current is a narrow jet that carries water away from shore. They form in the region of breaking waves, and extend somewhat beyond the breaking region.

Rip currents

Standard Explanation



from http://www.ripcurrents.noaa.gov/science.shtml

Rip currents

Rosarita Beach, Baja Ca

Sand City, CA

Sometimes rip currents form in an approximately periodic array. What creates a periodic sandbar?

Rip currents

Another problem with the sandbar mechanism:

- Rip Current Duration

- Some shorelines are characterized by permanent rip currents which may be found in a fixed location such as a break in a reef or other hard structure. Some rip currents are persistent, lasting for many days or months in one location. Rip currents may also migrate along a stretch of coastline. Rip currents may also be ephemeral, forming quickly and lingering for a few hours or days before dissipating and disappearing.

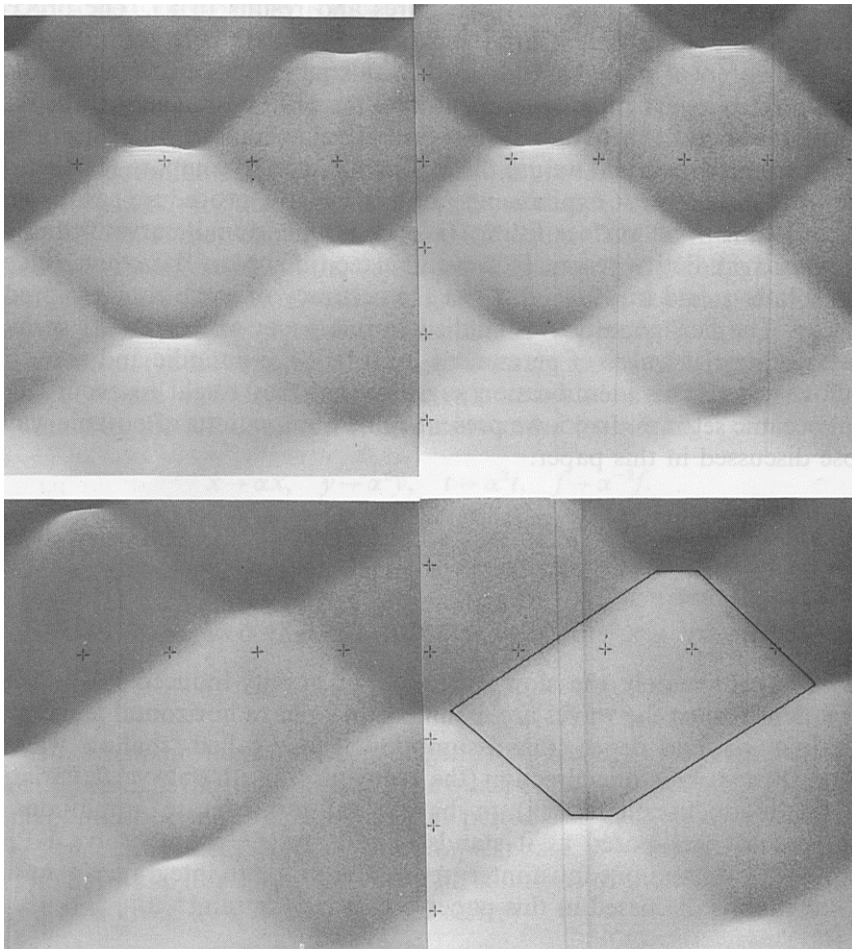
  – http://www.ripcurrents.noaa.gov/science.shtml

Rip currents

an alternative explanation

Recall KP solutions of genus 2, in water of uniform depth.

How would such wave patterns behave as they approach shore?



Video: 2-phase waves of permanent form in shallow water

– Hammack & Scheffner

Experiments on rip currents

(Hammack, Scheffner & Segur, 1991)

Rip currents

Open questions:

1. Create a suitable mathematical model that describes these rip currents. The model needs:

- Variable depth (uniform slope will do)
- Wave breaking and return flows
- 3-D motion

Rip currents

Open questions

1. Create a suitable mathematical model that describes these rip currents. The model needs:

- Variable depth (uniform slope will do)
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- 3-D motion

2. Once a good mathematical model exists, Harry Yeh's tank (at OSU) would be a suitable place to test the theory

Rip currents

Open questions

3. The KP solutions (of genus 2) used in the rip-current experiment were “symmetric”, so they propagated normal to the sloping beach. More general KP solutions (of genus 2) are not symmetric, so they would not propagate normal to the beach.

- Would such waves generate slowly migrating rip currents?
- How far can the incoming waves deviate from being symmetric before the rip currents disappear?

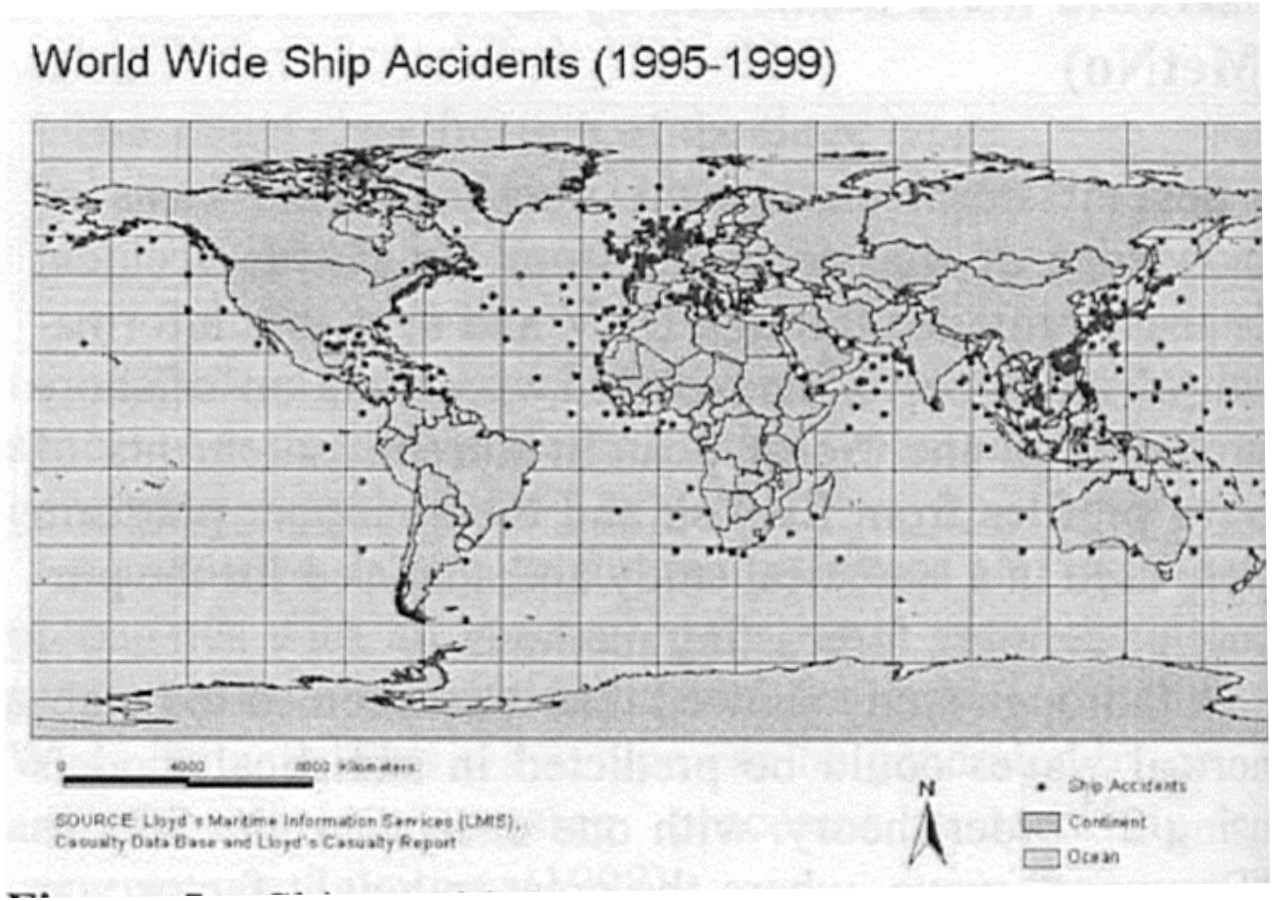
B. Rogue waves

Norwegian tanker Wilstar, damaged by very large wave in Agulhas current - 1974

Q: What are “rogue waves”?

Rogue wave breaking over supertanker in storm off Durban, S.A. in 1980. The mast seen starboard stands 25 m above mean sea level. Mean wave height at time was 5-10 m. Photo due to Phillipe Lijour, first mate.

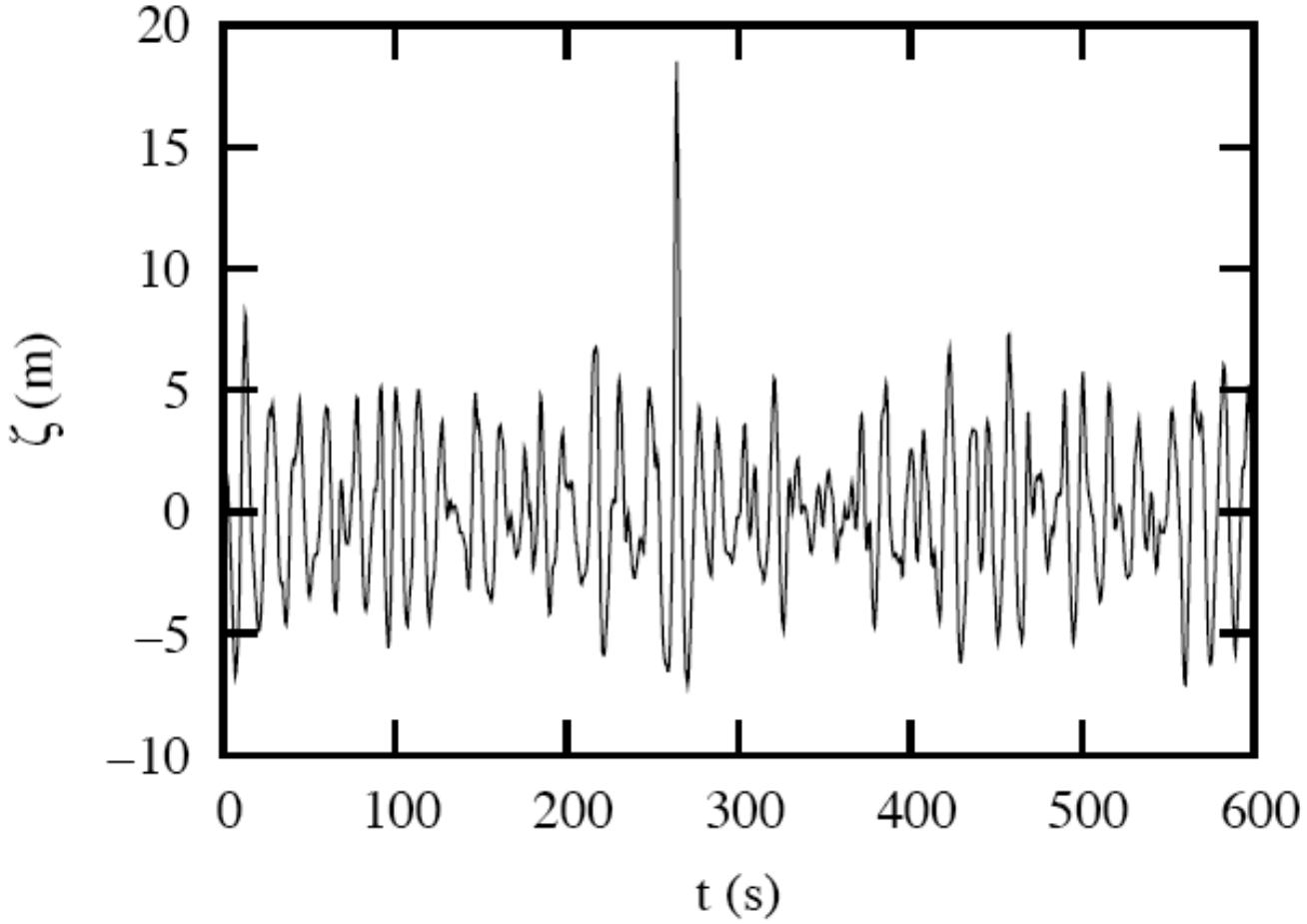
Q: What are “rogue waves”?



Based on a database from Lloyd’s Marine Information Service (LMIS), 2 ships/week are lost at sea due to heavy weather.

– Guedes Soares et al (2001)

Q: What are “rogue waves”?



Waves measured at Draupner oil platform in the North Sea, Jan. 1, 1995.
Peak wave height, 18.5 m. Standard deviation of wave record, about 3 m.

Rogue wave - an extreme event

- A rogue wave has an amplitude much larger than nearby waves, for no obvious reason.

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  - Is a rogue wave a rare event from a known population?
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Rogue wave - an extreme event

- A rogue wave has an amplitude much larger than nearby waves, for no obvious reason.
- Conceptual question
  - Is a rogue wave a rare event from a known population?
  - Or an element of an entirely different population?
- Other problems
  - Inadequate theoretical models (in what way?)
  - Are we measuring the important variables?

Rogue wave - an extreme event

Possible mechanisms:

- Wave-current interactions

  Smith (1976), White & Fornberg (1998), Baschek (2005)

Rogue wave - an extreme event

Possible mechanisms:

- Wave-current interactions
- Wave breaking

  MAXWAVE - identifies extreme waves from satellite radar measurements of breaking waves - Rosenthal (2005)

Rogue wave - an extreme event

Possible mechanisms:

- Wave-current interactions
- Wave breaking
- Geometric focussing of wave energy
- Frequency-focussing of wave energy

*NLS as approximate model of self-focussing in 2-D:

Henderson, Peregrine & Dold (1999), Kharif *et al*. (2001), Oronato *et al*. (2001), Calini & Schober (2002), Dysthe *et al*. (2003)

* NLS with 4-wave mixing: Janssen (2003)

Rogue wave - an extreme event

Possible mechanisms:

- Wave-current interactions
- Wave breaking
- Geometric focussing of wave energy
- Frequency-focussing of wave energy
- Strongly nonlinear wave dynamics

  Bateman, Swan & Taylor (2003)

Rogue wave - an extreme event

Possible mechanisms:

- Wave-current interactions
- Wave breaking
- Geometric focussing of wave energy
- Frequency-focussing of wave energy
- Strongly nonlinear wave dynamics
- Other (please specify)

Rogue waves - summary

We know very little about rogue waves.

- What data should we gather to learn more?
- Is there one kind of rogue wave or several?
- Should we try to learn more about the tails of our known distribution of ocean waves?
- Should we be looking for a new kind of mechanism?

Current score: Ignorance 1, Us 0

How do waves break in shallow water?

Choice 1: A “plunging breaker” - dissipative

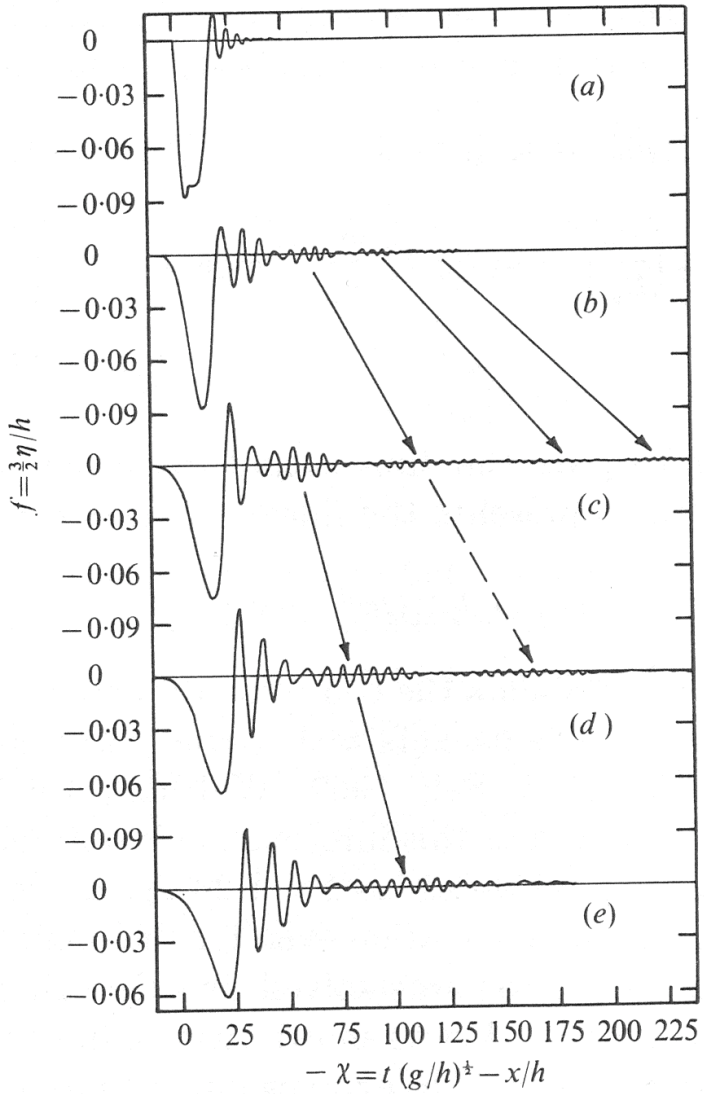
(CLAWPACK probably uses this)

How do waves break in shallow water?

Recall Hammack's experiments in shallow water

"Undular bore"

- dispersive



How do waves break in shallow water?

Front of 2004 tsunami reaches the shore of Thailand

. The tsunami of 26 December 2004 approaching Hat Ray Leah beach on the Krabi coast, Thailand. (Copyright Scanpix

Note two breaking wave fronts

(photos from Constantin

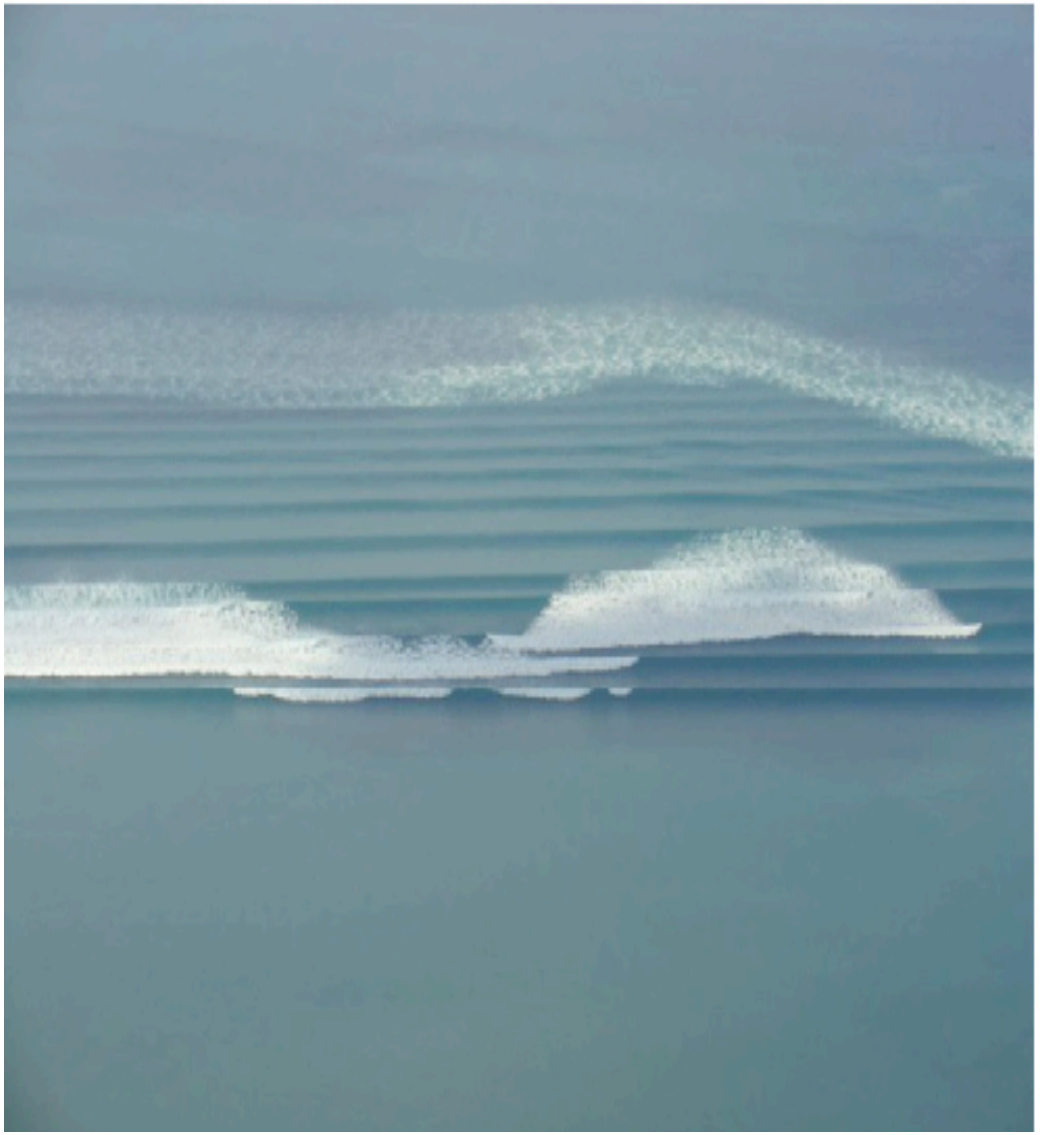
& Johnson, 2008)

How do waves break in shallow water?

Front of 2004 tsunami reaches the shore of Thailand

Train of oscillatory waves behind front

(Constantin & Johnson,2008)



How do waves break in shallow water?

Photo due to
Clark Little, SWNS

Summary:

The “shallow water equations” are similar to the equations of gas dynamics in 2-D. But breaking water waves seem to be more complicated than ordinary shock waves in gas dynamics.

Q: How to model wave breaking properly?

That’s all, folks