Internal Waves and Solitons Offshore Nigeria

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By

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Outline

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- Data & Methodology
- Results & Discussion
- Conclusion & Recommendations
Introduction

- Internal waves?

=> Solitons?
- high amplitude
- nonlinear
- non-dispersive
- Propagate large space without dissipation
... introduction:

**Formation/Generation Modes**

- **current**
- **Tidal Mode:**
  - topography
  - stratification
- **Lee wave formation mode**
- **Fission Process – B-O**

**theoretically:**

KdV: nonlinear effect=dispersive effect

*Internal Waves & Solitons Offshore Nigeria*
... introduction:

Description

- Propagation along the thermocline

2-layered model

- Very sharp increase in current speed

Current profiles

Internal Waves & Solitons Offshore Nigeria
Objectives of the study:

- identify internal waves/solitons as they propagates around the vicinity of Odudu TOTAL oil platform, offshore Nigeria;

- quantify the physical characteristics of the waves (amplitude, scale length, propagation speed etc.) at the study location;

- analyse the correlation between the current events and the temperature (thermocline) of the study location;

- examine the predictability and variability of the internal waves/solitons activities using the available set of data;

- examine the potential risks posed by internal waves/solitons;

- interpret the observations in relation to nonlinear internal tide generation;
**Study Area**

Nigerian continental shelf: (between long 2° 42’ E & 8° 35’ E)

- South-westerly waves
- Temperature: 27-28°C
  - 24-25°C
- Low salinity
- River discharge: 302 km³/year
Data and Methodology

ADCP
- Current speed
- Current direction

Thermistor
- Temperature

Conductivity Sensor
- Salinity

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2 m depth interval
2 m & 29 m

19 Feb 2008
21 March 2008

FSO Unity Log
Results and Discussion

Current Speed (m/s): 10 March 2008

depth BMSL
Results and Discussion

► Soliton activities are a characteristic of the Odudu environment

► Soliton events occur approximately twice in a day with an average period of 12 hours 19 minutes between them

► their period of occurrence links them to tidal generation which also occurs twice in a day (semi-diurnal tide)

► each event comes in a packet of individual waves with the largest (having highest speed) in the lead and the smallest (having the least speed) in the rear
…Results and Discussion

The strongest event identified on 8th May 2008 at 00:42 UTC:

Current Speed (m/s)

Temperature Signature (deg)

Internal Waves & Solitons Offshore Nigeria
...Results and Discussion

► the strongest event identified on 8th May 2008 at 00:42 UTC

- 3.5m (Bin 12)
- 11.5m (Bin 8)
- 17.5m (Bin 5)
Results and Discussion

7 individual solitons in the packet

\[ c = c_0 \left(1 - \frac{\alpha \eta_0}{3c_0}\right) \text{ (1)} \]

\[ E = \frac{4}{3} g \Delta \rho \eta^2 L \text{ (2)} \]

\[ \Rightarrow \text{ speed: } 0.53 \text{m/s} \quad 0.76 \text{m/s} \]

\[ \Rightarrow \text{ amplitude: } 8 \text{m} \]

\[ \Rightarrow \text{ scale length: } 120.50 \text{m} \]

\[ \Rightarrow \text{ wavelength: } 50 \text{km} \]

\[ \Rightarrow \text{ Energy: } 1.75 \times 10^2 \text{ kJ} \]

Propagation: northward (towards the coast)

Correlation: varies slightly differently from what is generally expected but with overall range between 0.3 and 0.5
Results and Discussion

- Semi-diurnal occurrence of solitons suggests they are a product of tidal forcing when tidal currents flow over the ocean bathymetry.

- The Nigerian continental shelf provides a favourable condition but the actual source site of these solitons is unclear.

- The estimated physical characteristics of the Odudu soliton events are identical to those of an established New York Bight.
  
  ……probability of linkage.
Conclusion & Recommendations

- Odudu oil platform vicinity and, indeed, the Niger delta region of the Nigerian continental shelf experience solitary wave activities.

- The waves are rank-ordered in packets with the largest always wave in the lead and the smallest behind, all propagating in the northern direction towards the shore.

- The dataset showed the strongest event occurring on 8th May 2008.

- Even though weak, correlation still shows thermocline depth linearly varying with soliton depth which is in line with theoretical believe.

- The period of occurrence of solitons is observed to be in the same trend with tidal occurrences (≈ 12hrs 20mins - semi-diurnal & 2 weeks peak cycle - spring tides).
 Conclusion & Recommendations

- because they show periodic linkage with tidal occurrence, they can be fairly predicted to occur around the time of tidal events

- and going by the above observation, probability of being generated by tides is thus high

- impacting 175000 J of energy on the platform and other equipments in the area poses a great threat. If not well checked, continual impact could affect operations in the future.

- the surface rips associated with solitons could affect transportation (oil spillage, etc) and fishing systems (especially artisanal fishing)

- there is possibility for coastal consequences
the probability of soliton occurrence has been estimated as a function of tidal range which can be used to predict likely soliton activity at any time in the future and in combination with the soliton cycle of 12 hours plus, this could be used to appropriately schedule current sensitive operations at this location.

to understand the full extent of soliton activities, an extension of the depth of *in-situ* measurement is necessary such that the whole ocean depth can be captured.

due to its importance in modern oceanographic systems, a partnership through which satellite images of soliton activities in this study area can be acquired is likewise recommended.
“I am you; you are ME. You are the waves; I am the ocean. Know this and be free, be divine.”

(Sri Sathya Sai Baba, 1926)