MODU Mooring Design and Inspection Practice

Presented by Tom Kwan

David Tein Consulting Engineers, Ltd
OFFSHORE AND MARINE TECHNOLOGY

MODU Mooring Environmental Criteria

(1) **US – American Petroleum Institute**

API RP 2P – MODU (1984, 1987)
- Design Environment: 1-year

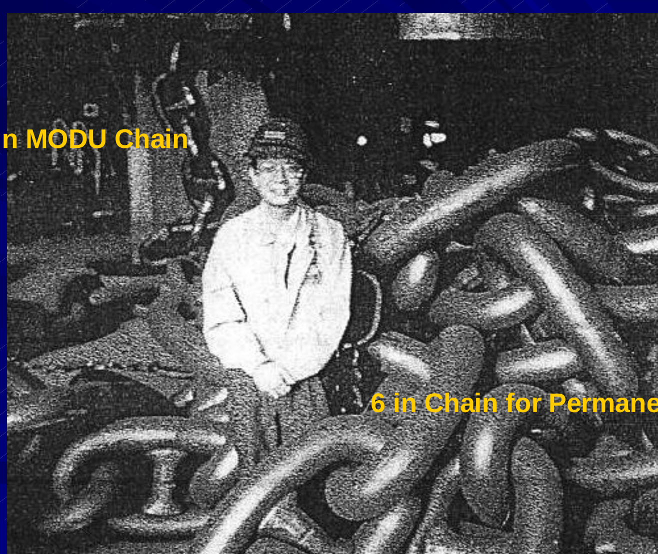
API RP 2SK – MODU and FPS (1997, 2005)
- Design Environment: 5-year (away from other structures)
  10-year (close to other structures)
- The 1997 Revision was Based on Mooring Code Calibration JIP (1995)

(2) **International Standard Organization (ISO 19901-7)**
- API criteria adopted
- Norwegian annex: 10-year design environment

Tension Limits and Safety Factors

	Analysis Method	Tension Limit (Percent of MBS)	Equivalent Factor of Safety
Intact	Quasi-static	50	2.0
Intact	Dynamic	60	1.67
Damaged	Quasi-static	70	1.43
Damaged	Dynamic	80	1.25

Chain for MODU and Permanent Moorings



Overview of Recent 2SK Revision

- Revision Began in 2002 and Completed in 2004
- To be Issued in 2005
- Major Revisions

  MODU and Permanent Mooring
  - Add Pile and Plate Anchor FOS and Design Guide
  - Allow Higher Uplift Angle for Drag Anchors
  - Add Clearance Criteria
  - Revise Mooring Proof Load
  - Add Mooring Hardware Section
  - Revise Dynamic Positioning Section
  - No Change in Environmental Criteria

  Permanent Mooring
  - Revise Chain Fatigue Design Curves
  - Add Global Analysis Guidelines
  - Add Spar VIM Design Guide
  - Add Discussion on Mooring Strength Reliability
  - Provide NPD and API Wind Spectrum

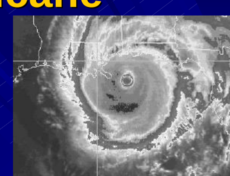
Comparison of MODU Mooring Practice

- Gulf of Mexico
  - Evacuate Drilling and Production Facilities
  - Recent Total Failures: Andrew 2 (1992), Lili 1 (2002), Ivan 4 (2004)
  - There were also Partial Failures
  - Primary Cause: Overloading
- North Sea and Other Areas
  - Manned Facilities
  - Partial Failures
  - Primary Cause: Overloading, Fatigue, Faulty Components

DeepStar 4404 (2001) - Mooring Reliability Study for Permanent Moorings

	GOM	North Sea	W. Africa
H_s (100 yr/10 yr)	1.5	1.15	1.18
V_w (100 yr/10 yr)	1.5	1.14	1.18
Operation Procedure	Evacuate	Manned	Manned

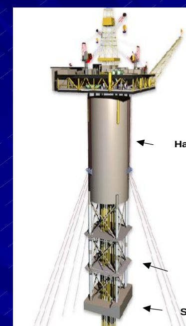
Comparison of GOM Hurricane Environments

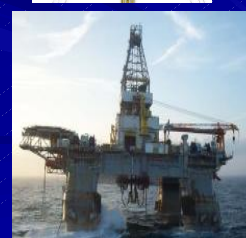


	10-year, MODU Mooring Design	100-year, Permanent Mooring Design	Ivan
Sig. Hs (ft)	26	40	45 - 52
Wind Speed (1 minute, knot)	70	95	95 - 105
Current Speed (knot)	1.8	3.0	4

GOM Operations
Changes in the Last 10-15 Years

- More Floating and Subsea Installations
- More Permanent Deepwater Operations with Higher Production Rates
- More Deepwater MODUs with Taut Leg/Pile Mooring Versus Catenary/Drag Anchor Mooring Years ago
- Some MODUs Stay on One Location for Much Longer Period
- Bigger MODUs
- More Metocean Information





Some Fundamental Questions

- Have the Changes in GOM Operations Increased the Risk Sufficiently to Warrant Another Change of 2SK MODU Mooring Criteria?
- If the Answer is Yes:
  - What Level Of Change is Appropriate?
  - What is the impact of the Change on the Industry?

Long Term Plan for API RP 2SK

- Reactivate the 2SK WG to address GOM MODU mooring issue
- 2SK WG will work with OOC/industry to initiate a JIP to study the MODU mooring reliability and provide a first draft commentary
- The 2SK WG will finalize the commentary and seek API approval and publication (2006/2007)
- After 3-5 years industry practice, the commentary will be incorporated in the 4^{th} edition of 2SK (2010)

Commentary on GOM MODU Mooring Practice Potential Topics

- Basic considerations
- Current design and operation practice
- Historical GOM operation experience
- Risk assessment of current and future operations
- Comments on the use of 2SK environmental criteria for GOM MODU mooring
- Strategy to minimize mooring failure and damage to surrounding structures
- Indicative GOM extreme environments

Revision of API RP 2I
Mooring Inspection

Current API RP 2I

- Developed about 15 years ago
- Address inspection of mooring chain, wire rope, and connecting hardware mainly for MODUs

On-Going Revision

- Add Fiber Rope Inspection Guidelines
- Add Permanent Steel Mooring Inspection Guidelines
- Revise MODU Mooring Inspection Guidelines
- Schedule for Completion: Mid 2006

Design & Installation Improvements to Improve Reliability

Evan H. Zimmerman, JD

Delmar Systems, Inc.

Preface

- Every location is different.
- Every rig is different.
- Evaluate each situation.

- Available technology
- Maturing technology
- Evolving practices
- Risk management
- Impact management

State of the Industry

- API RP-2SK
  - Mooring line tension FOS
  - Anchor guidelines
  - Analysis methods
- 10-Year Hurricane
- >10-Year Survivability

Field Choices

- My Field:
  - Time of year?
  - Pipelines / umbilicals?
  - Other structures?
  - Seafloor conditions?
  - Well program?
  - Shallow hazards?

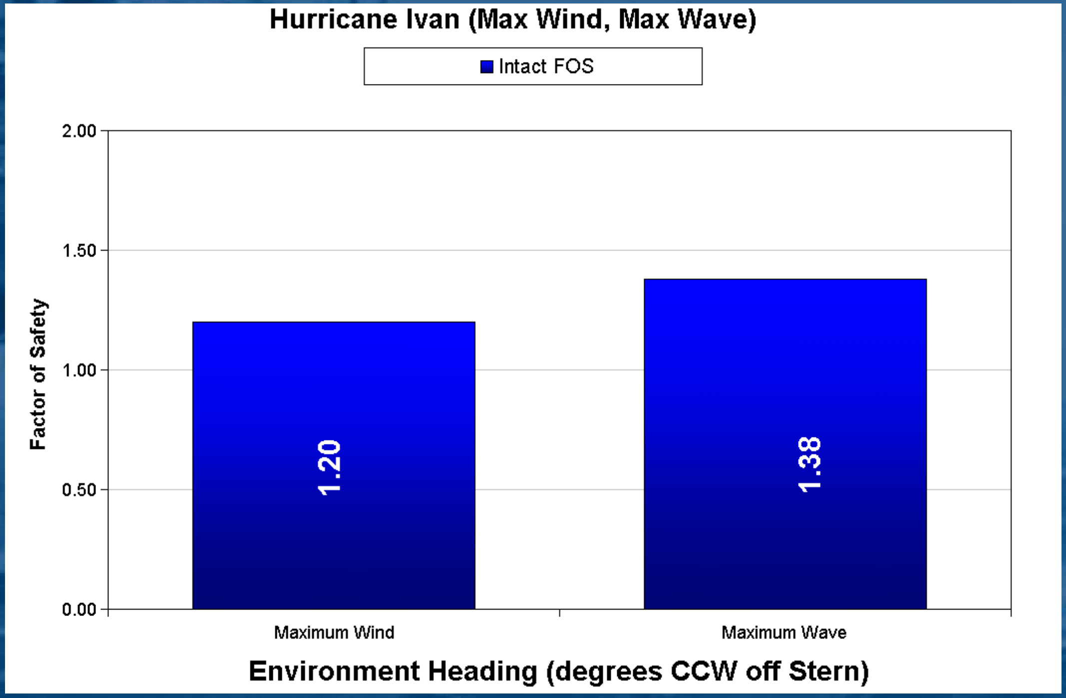
- My MODU Mooring
  - Conventional system?
  - Anchor change?
  - Preset mooring(s)?
  - Buoyed lines?
  - Synthetic inserts?
  - Probable break point?

MODU Mooring Failure

- Fairlead Break
  - Components fall to the seafloor
  - Vessel yaw influences leeward line failure
  - Rig floats free, limited seafloor impact
- Anchor Failure
  - Anchor drags in soil
  - Limited vessel yaw
  - Excess loading leads to anchor failure with continuous drag
  - Rig drifts free trailing anchor lines with anchors on the seafloor

Survivability by Design?

- Can MODU Moorings Survive Hurricane Ivan Events?



MODU Risk Assessment

- Understand failure
- Quantify probability
- Prudently minimize impact of probable failure method

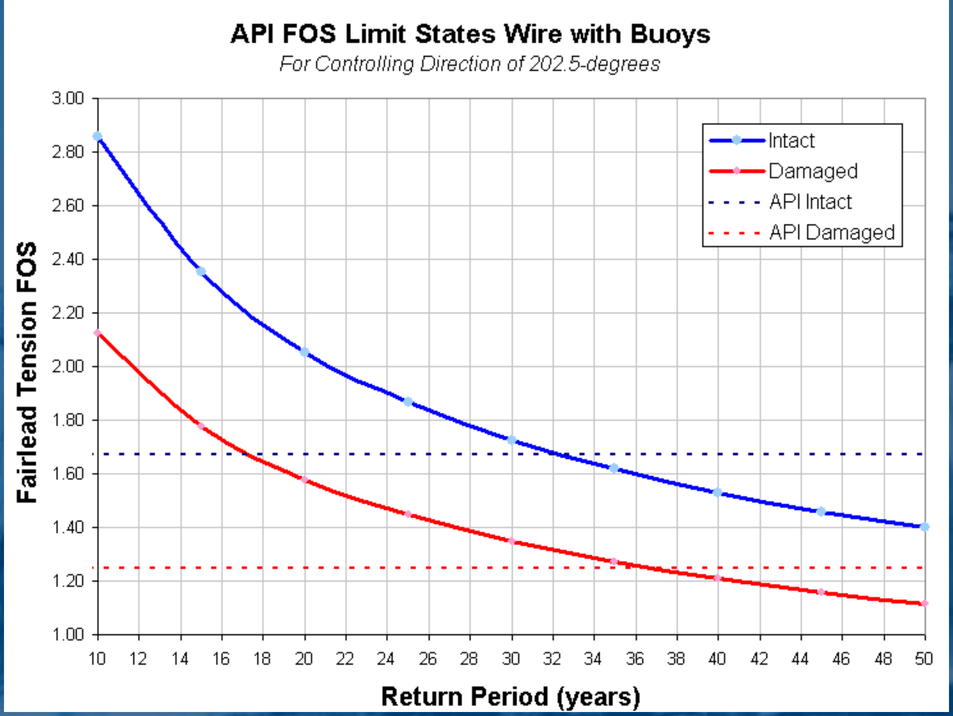
Pipeline Risk

- Moorings over pipelines?
  - As-is configuration
  - Buoyancy
  - Synthetics
  - Anchor selection
  - Catastrophic failure
- Moorings short of pipelines?
  - Anchor selection
  - Catastrophic failure

Facility Risk

- Proximity?
- Relative direction?
- Biased mooring system?
- Anchor selection?
- Hold-back systems?

"Limit State" Analysis



- Quantify system robustness
- Utilize results to determine risk level
- Comparative study with alternate systems / configurations

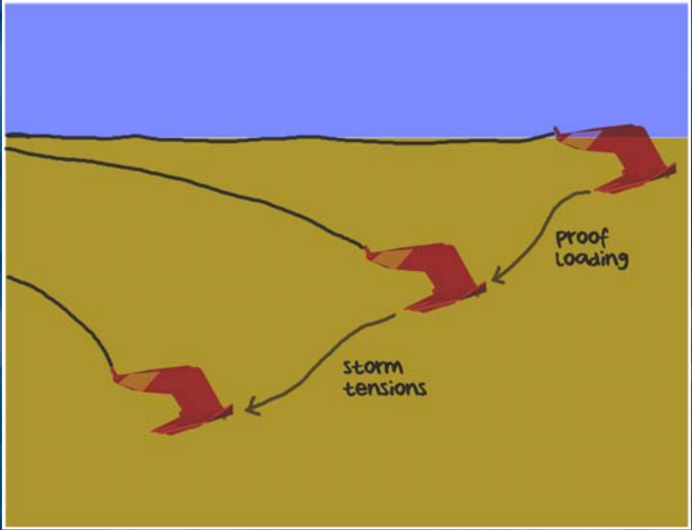
Anchor Selection

A pivotal choice

Conventional Anchors

- 100-year old technology
- Performance well understood
- Capacity limited with size
- Failure with anchor uplift
  - Some residual capacity upon failure
  - Enables load sharing among adjacent mooring lines

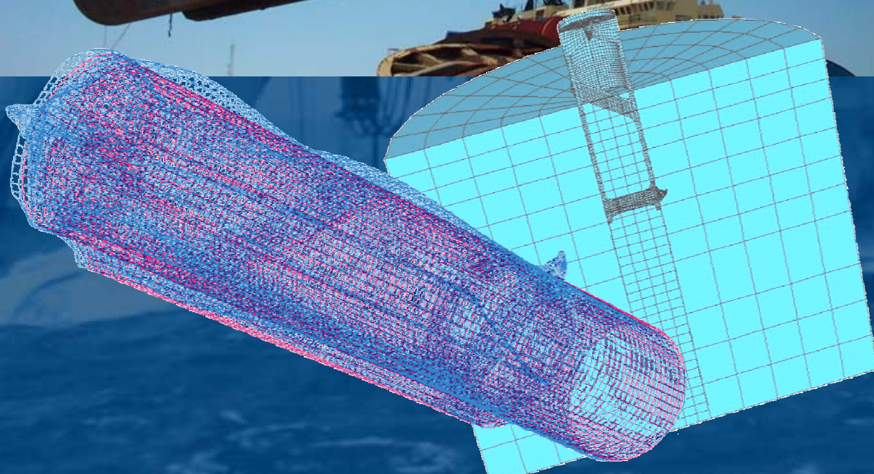
HHC Drag Anchors



- ~20-year old technology
- Performance well understood
- Large capacity versus size
- Failure with anchor uplift beyond 20-degrees
  - Residual capacity upon failure
  - Enables load sharing among adjacent mooring lines

HHC Drag Anchors

Suction Pile Anchors



- ~10-year old technology
- Performance understood
- Failure with excess loading
  - No residual capacity upon failure
  - Stationary foundation (no load sharing)
  - Probable failure method is local padeye structural failure

Suction Pile Failure



Vertically Loaded Anchors

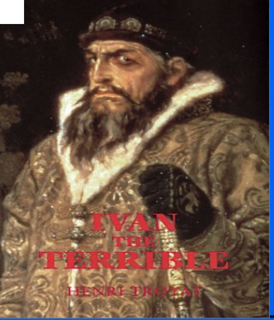
- Maturing technology
- Performance understood
- Failure with excess loading
  - Increasing capacity with load
  - Enables load sharing among adjacent mooring lines
  - Probable failure method is with excessive rotational loading

Vertically Loaded Anchor

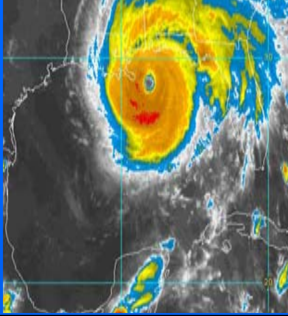
New Anchors

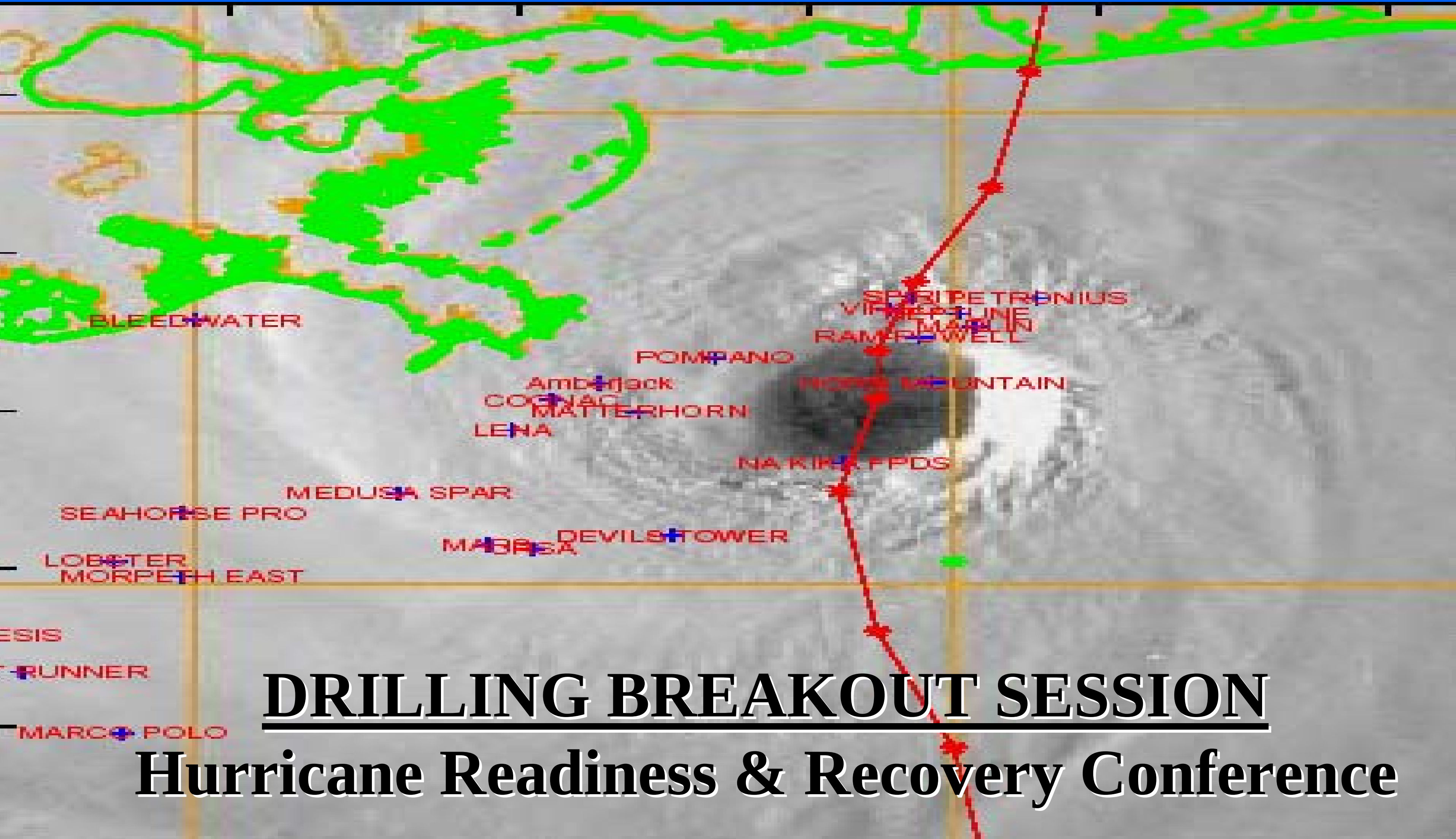
- Maturing technology
- Performance under evaluation
- Failure with mooring component
  - Increasing capacity with load
  - Enables load sharing among adjacent mooring lines
  - Load arm follows mooring line spread angle

New Anchors



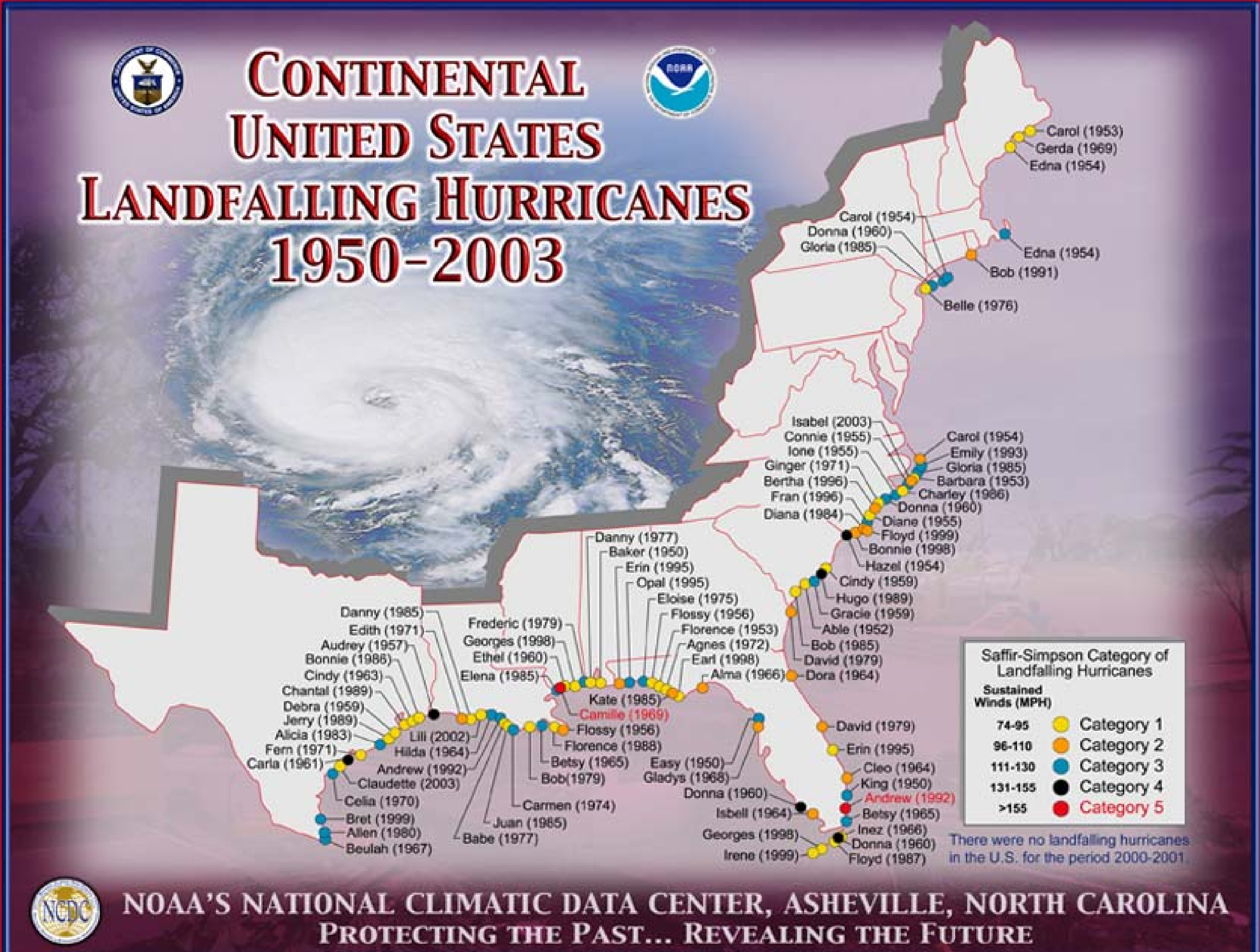
WELCOME



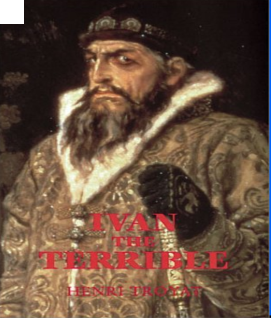


DRILLING BREAKOUT SESSION

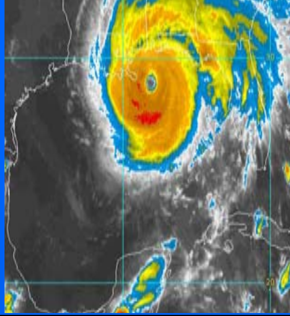
Hurricane Readiness & Recovery Conference



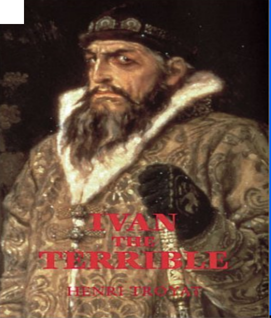
CONTINENTAL
UNITED STATES
LANDFALLING HURRICANES
1950-2003
Carol (1953)
Gerda (1969)
Edna (1954)
Carol (1954)
Donna (1960)
Gloria (1985)
Edna (1954)
Bob (1991)
Belle (1976)
Isabel (2003)
Connie (1955)
Ione (1955)
Ginger (1971)
Bertha (1996)
Fran (1996)
Diana (1984)
Carol (1954)
Emily (1993)
Gloria (1985)
Barbara (1953)
Charley (1986)
Donna (1960)
Diane (1955)
Floyd (1999)
Bonnie (1998)
Hazel (1954)
Cindy (1959)
Hugo (1989)
Gracie (1959)
Able (1952)
Bob (1985)
David (1979)
Dora (1964)
Danny (1977)
Baker (1950)
Erin (1995)
Opal (1995)
Eloise (1975)
Flossy (1956)
Florence (1953)
Agnes (1972)
Earl (1998)
Alma (1966)
Frederic (1979)
Georges (1998)
Ethel (1960)
Elena (1985)
Kate (1985)
Camille (1969)
Danny (1985)
Edith (1971)
Audrey (1957)
Bonnie (1986)
Cindy (1963)
Chantal (1989)
Debra (1959)
Jerry (1989)
Alicia (1983)
Fern (1971)
Carla (1961)
Lili (2002)
Hilda (1964)
Andrew (1992)
Claudette (2003)
Celia (1970)
Bret (1999)
Allen (1980)
Beulah (1967)
Flossy (1956)
Florence (1988)
Betsy (1965)
Bob(1979)
Carmen (1974)
Juan (1985)
Babe (1977)
Easy (1950)
Gladys (1968)
Donna (1960)
Isbell (1964)
Georges (1998)
Irene (1999)
David (1979)
Erin (1995)
Cleo (1964)
King (1950)
Andrew (1992)
Betsy (1965)
Inez (1966)
Donna (1960)
Floyd (1987)
Saffir-Simpson Category of Landfalling Hurricanes
Sustained Winds (MPH)
74-95 Category 1
96-110 Category 2
111-130 Category 3
131-155 Category 4
>155 Category 5
There were no landfalling hurricanes in the U.S. for the period 2000-2001.
NCDC
NOAA'S NATIONAL CLIMATIC DATA CENTER, ASHEVILLE, NORTH CAROLINA
PROTECTING THE PAST... REVEALING THE FUTURE



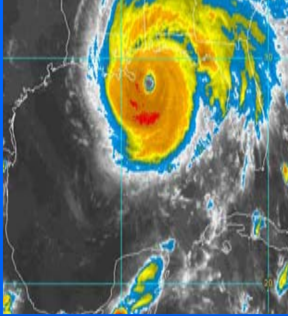
Ivan Facts

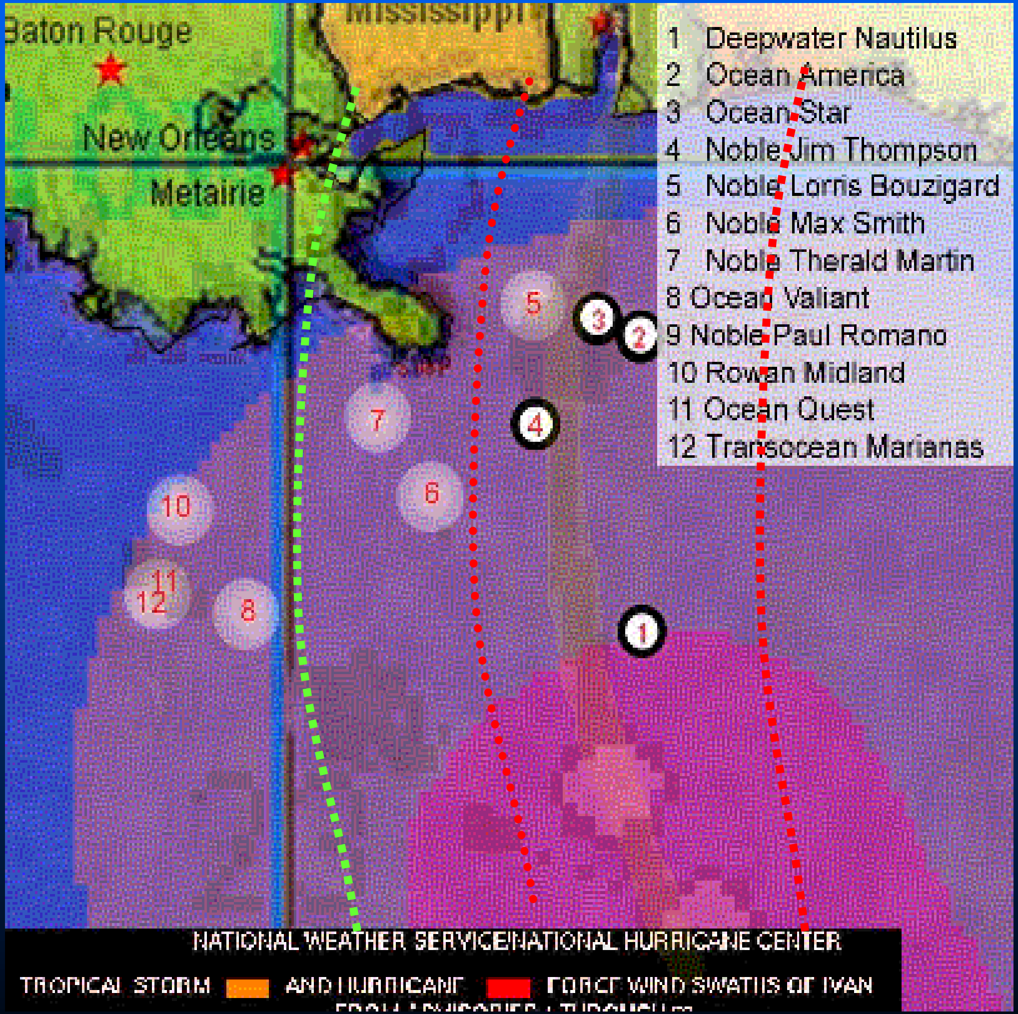


- **Wave loads exceeded Design Criteria.**
  - 10 Yr Return Period Criteria Exceeded; (Hs ~26 ft)
    - » ~100 Miles West (90.25^{o}W)
    - » ~150 Miles East (84.5^{o}W)
  - 100 Yr Return Period Criteria Exceeded; (Hs ~40 ft)
    - » ~30 Miles West (88.8^{o}W)
    - » ~110 Miles East (86^{o}W)
- **5 MODUs Incurred Damage to Moorings**
  - 4 MODU Moorings Failed & Rigs Drifted.
    - » All failures due to overload
    - » 100 Yr Storm Event exceeded in all cases.
    - » 0.86 mile to 70 mile excursions reported.
- **2 MODUs survived > 10 Yr Return Period Event.**
  - Both rigs on West Side of Storm.



Close Proximity Needed

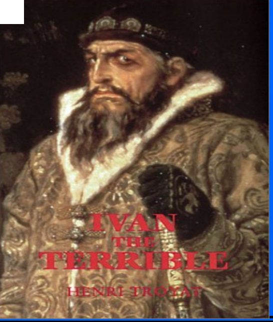




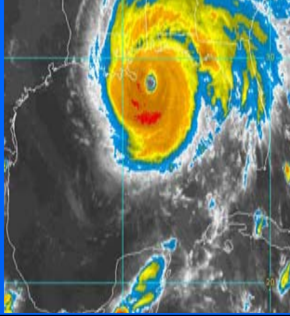
- 7 MODUs in Direct Path of Ivan
- Two undamaged.
- One damaged.
  - Still held in place.
- Four failures and free to drift.
  - ≥ 100 Yr Wave & Wind.

Boundary > 10 Yr RP Wave Event

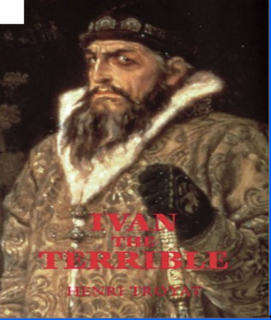
Boundary > 100 Yr RP Wave Event



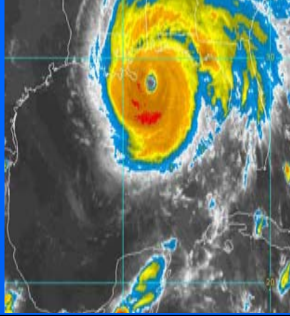
Summary of Moored Rig Incidents
Transocean & Diamond



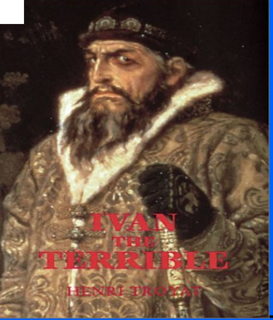
Rig	Mooring Type
Transocean Nautilus RB8-8M	Taut Mooring System – Synthetic Rope 9.55’ x 70’ SP Anchor 3,500’ 3-3/4” HS Wire 500’ 3-3/4” HS Wire
Lorris Bouzigard Pentagone 85	10 pt Conventional Mooring System. 2.75” IWRC EEEIPS Wire & 3” QRC Chain 9 & 12 MT Stevipris Anchors
Jim Thompson EVA – 4000	Semi-Taut System 9 Point 30 – 60 Deg Suction Pile & Wire



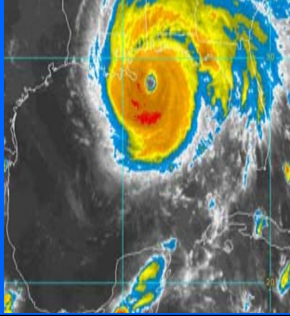
Summary of Moored Rig Incidents
Noble Drilling



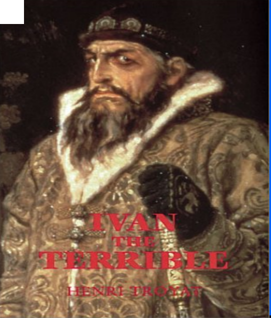
Rig	Mooring Type
Ocean America **Odyssey Class**	**Conventional 8 Pt – 45º** **10MT Bruce MK-4 Anchors** **3-1/4” Chain & 3-1/2” Wire**
Ocean Star **Enhanced Victory Class**	**Conventional 8 Pt – 45º** **10MT Bruce Anchors** **3-1/4” Chain & 3-1/2” Wire**



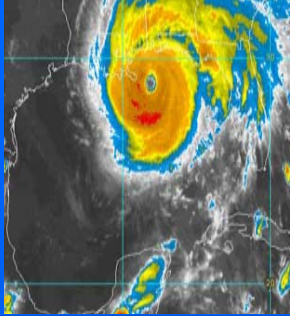
PURPOSE OF SESSION



- Provide insight into mooring incidents.
- Disseminate knowledge across Industry.
  - Equipment & Methods.
  - Industry initiatives.
  - Risk management.
- Discuss
  - Additional industry needs & path forward.
  - New Technology & Applications.



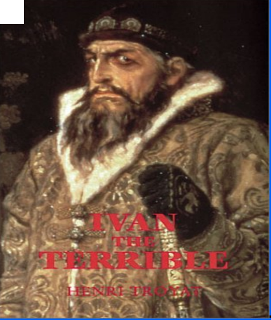
Morning Agenda



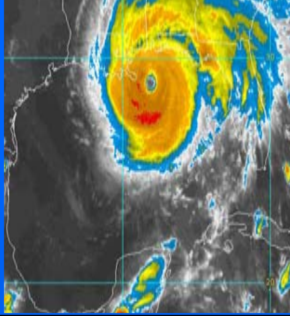
- API RP2SK Standards Review & Update
- Deepwater Nautilus Mooring Incident
- Jim Thompson Mooring Incident
- Facilitated Panel Discussion

BREAK

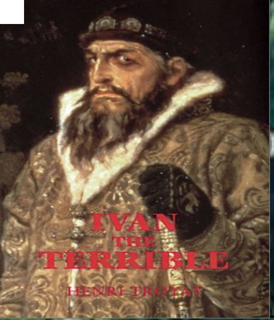
- Proposed JIP on Reliability and Risk Assessment.
- Riser Management in Severe Environments
- Designs & Installation to Improve Reliability & Reduce Risk.
- Station Keeping Capabilities of the Development Driller



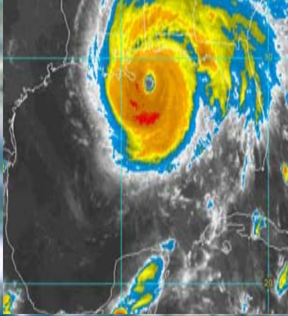
Afternoon Agenda



- Facilitated Panel Discussion & Open Forum
- Summarize Breakout Session
  - Panel Members
- Plenary Session
  - Reconvene All Breakout Sessions for Recap

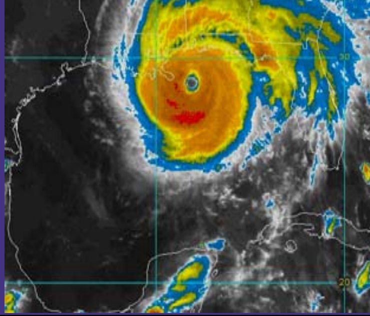


IVAN PERSPECTIVE



- **"Despite the fury of Ivan, there were no reports of injury, fatalities or significant pollution associated with offshore facilities – a significant tribute to the programs in place for safeguarding life, property and the environment."**

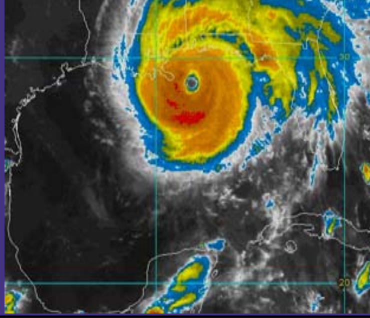
MMS Ocean Science Newsletter; Volume 1 Issue 6, Nov/Dec-04



Proposed MODU Mooring JIP

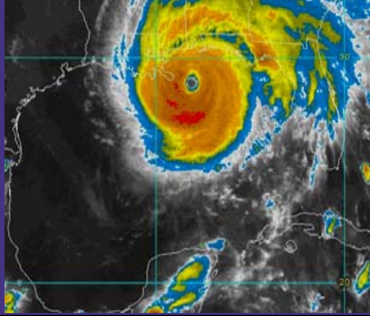
Hurricane Readiness & Recovery Conference

AGENDA



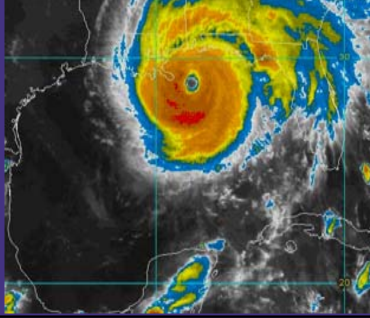
- Operating Philosophy & Historical Performance in GOM
- Genesis of the Proposed JIP
- Scope of Work Developed by Planning Committee
- Path Forward

GOM Historical
MODU Performance



- During 13 years of operations, only 3 storms have caused mooring failures.
- Storms since 1992 resulting in MODU mooring failures.
  - Andrew (1992); Category 4 Offshore & 3 at Landfall.
    - » 2 Rigs Broke Loose
  - Lili (2002); Category 4 Offshore and 2 at Landfall.
    - » 1 Rig Broke Loose
  - Ivan (2004); Category 4 Offshore and 3 at Landfall.
    - » 4 Rigs Broke Loose

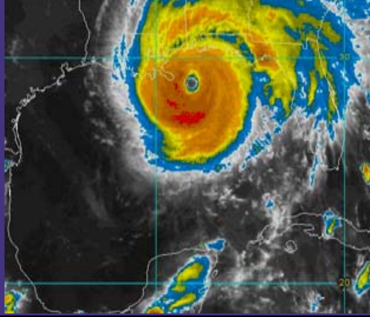
GOM Operating Philosophy



- ***Safety Procedures during Hurricane Season:***
  - Protect human life:
    - » Evacuate Drilling and Production Facilities.
  - Minimize Pollution Risks:
    - » Secure wells on drilling rigs and shut wells in below mudline on production facilities.
    - » Pipelines shut in where necessary.
- ***Minimize Business Interruption:***
  - Design moorings to meet or exceed API 2SK criteria.
  - Perform risk analysis when mooring near infrastructure.
  - Common techniques used to minimize risk.
    - » High hold anchors utilized when mooring near pipelines.
    - » Utilization of suction piles.
    - » Utilization of synthetic mooring systems.

GOM .vs. North Sea

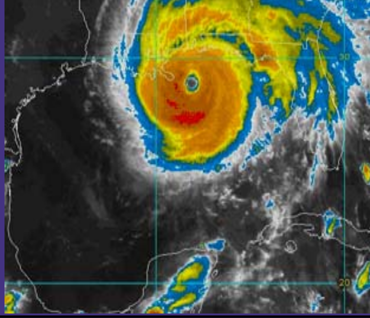
Operational Considerations



- **GOM Philosophy:**
  - Evacuate Drilling & Production Facilities.
    - Protect Human Life.
  - Secure wells.
    - Reduce pollution risk.
- Hurricane intensity has high variability.
- Aerial distribution of maximum wind & wave is more localized.
- Storm track and resulting direction of environmental forces are less predictable than North Sea.

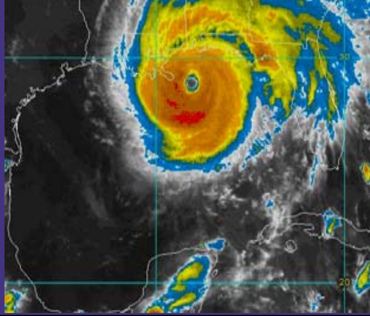
- **North Sea Philosophy:**
  - Facilities not evacuated.
  - Active winching if possible.
  - Thruster assist.
- Storm intensity is more predictable.
- Storm patterns are less random.
- Extreme Winter Storm < Extreme Hurricane

Conclusion



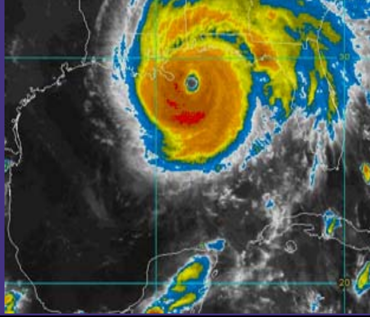
- **Current practice & industry standard code has produced an acceptable level of risk.**
  - Few mooring failures in the GOM.
  - The industry has had years of successful operations in the GOM.
- **Industry has been innovative in developing new methods which provide adequate moorings in deeper waters.**
  - As deeper water opportunities challenge mooring limits, it will be necessary to quantify risk using scientific methods.
- **Expansion of GOM deepwater infrastructure will require additional risk management tools.**

Genesis of Proposed JIP



OOC presents – Ivan findings to MMS	10-March-05
Industry JIP Kick Off Meeting; -MMS Attended	06-April-05
JIP Planning Committee Meeting	26-April-05
Update OOC Membership on Proposed JIP	01-June-05
Final JIP Planning Committee Meeting	02-June-05
JIP – RFP Introduced to Contractors	13-June-05
Proposals Received by Planning Committee	13-July-05

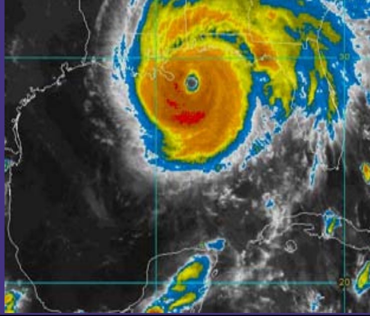
JIP Planning Committee



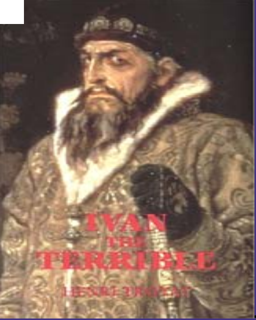
Craig Castille	Dominion (OOC)
Dave Loeb	Shell
Greg Walz	BP
David Smith, Nelson Tears & John Heideman	ExxonMobil
Charlie Theriot	Marathon
Jenifer Tule	Kerr McGee
David Wisch & Kai Tung Ma	Chevron
Darrel Pelley & Riddle Steddum	Transocean
Scott Marks & Jitendra Prasad	Noble Drilling
Karl Sellers & Rodney Eads	Diamond Offshore
Momen Wishahy	Global SantaFe
Alan Quintero	Atwood Oceanics
Fred Hefren & Glen Woltam	MMS

Tom Kwan (DTCEL/API) & Evan Zimmerman (Delmar) participated in Planning Committee activities until work scope established.

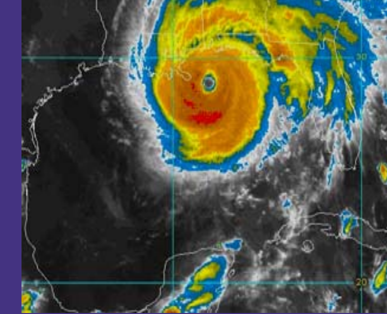
Proposed JIP
Study Objectives



- **Task 1; Metocean**
  - **Establish baseline USGOM Deepwater Metocean Criteria.**
    - **> 600’ WD**
    - **For Hurricanes (Tropical Revolving Storms)**
      - **5, 10, 25, 50 & 100 Year Return Periods**
    - **Empirical relationships for wind, wave and current.**
      - **Joint Directional Probabilities.**
    - **Will utilize GOM ISO Draft as Starting Point**

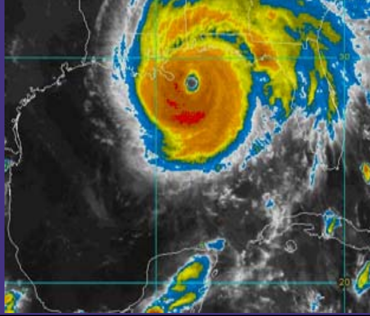


Proposed JIP Study Objectives



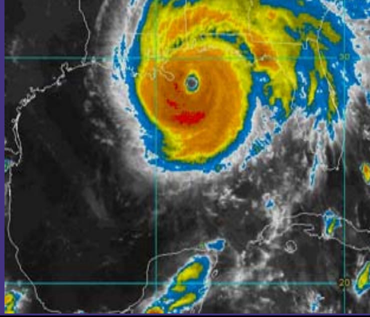
- **Task 2; Historical Reliability**
  - Assess MODU Mooring Failures from 1985 - 2004.
    - » Categorize causes of failure.
    - » Categorize resulting damage to surrounding equipment.
  - Determine FOS on mooring components using Hindcast Environments.
  - Determine mooring reliability for study period.
    - » All moored MODUs in operation.
    - » MODUs impacted by 5, 10, 25, 50 & 100 RP Storms.

Proposed JIP
Study Objectives



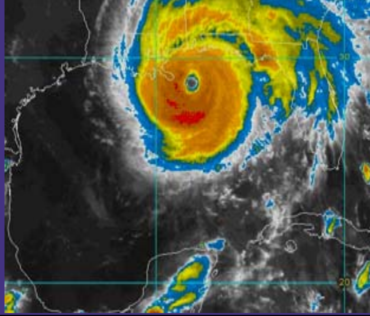
- Task 3; Calibration Study
  - **Deterministic FOS Study for Fleet Cross Section of Semi-submersibles.**
    - » **Water Depth and Spread Type Matrix**
    - » **Intact and 1-Line Damage with Collinear Environment.**
  - **Evaluate the reliability of existing code of practice using directional environmental data.**
    - » **Based upon deterministic study above and various Return Period Storms defined in Task 1.**

Proposed JIP
Study Objectives



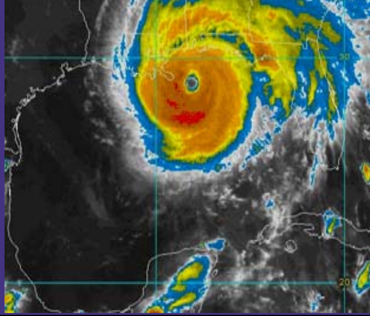
- Task 4; Comprehensive Risk Assessment
  - **Conditional Probabilities of Mooring Failure and Surface and/or Subsea Damage.**
  - **Develop a risk ranking method or matrix to summarize results.**
  - **Outline workflow for risk assessment so it can be updated as GOM infrastructure changes.**
  - **Assess consequential damages caused by collisions between typical MODUs and GOM Deepwater Production Facilities.**

Proposed JIP Study Objectives



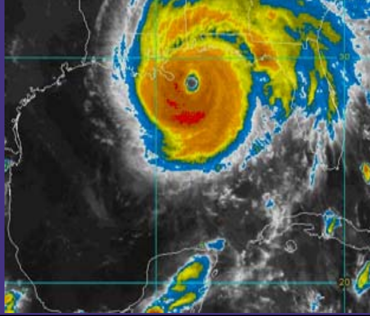
- <u>Task 5; Recommendation to API Committee 2</u>
  - **Appropriate recommendations to API-RP-2SK Subcommittee.**

Proposals Tendered



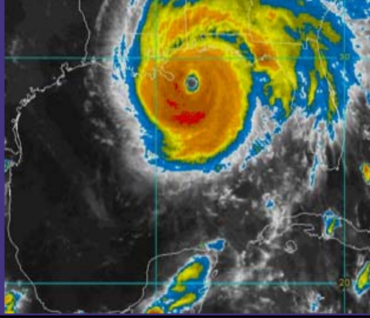
- ABS – Joint Proposal — John Stiff
  - Energo Engineering, Inc.
  - ORTC; (Offshore Risk & Technology Consulting)
  - MCOT; (Metocean, Coastal & Offshore Technologies)
  - Delmar Systems
  - OceanWeather
- DNV — Craig Colby
  - OceanWeather, Inc.
- DTCEL – Joint Proposal — Tom Kwan
  - Energo Engineering, Inc.
  - ORTC; (Offshore Risk & Technology Consulting)
  - MCOT; (Metocean, Coastal & Offshore Technologies)

Proposals Tendered



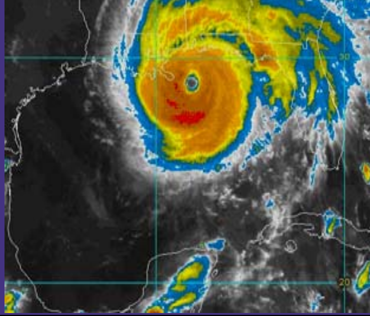
- **Granherne** (A Halliburton Company) — Richard D'Souza
  - ORTC – Malcolm Sharples
  - University of Texas Austin
  - OceanWeather, Inc.
  - MCOT
- **Noble Denton** — Dr. Bader Diab
  - OceanWeather, Inc
- **Sea Engineering** — Dr. Pieter Wybro
  - Ken Schaudt – Metocean via OceanWeather
  - ORTC – Malcolm Sharples
  - Energo, Engineering Inc.

Path Forward for JIP



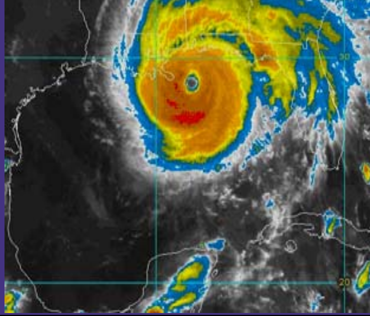
Proposal Review by JIP Planning Committee	August, 2005
Select JIP General Contractor	August, 2005
Secure Funding	3^{rd} Qtr, 2005
Begin Work on JIP	4^{th} Qtr, 2005
Conclude Work on JIP	3^{rd} Qtr - 2006
Present Findings to API 2SK Work Group	4^{th} Qtr - 2006

JIP Funding

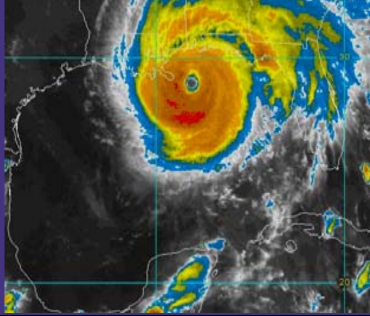


- Funding will be from;
  - Drilling Contractors.
  - Operating Companies.
  - Service & Supply Sector.
- OOC – Has & will support efforts, however will not contribute to funding.
- MMS – Is supportive of efforts and has funded ORTC to review incidents.
  - MMS will participate, but will not fund beyond white paper awarded to ORTC.

Funding Model



- Companies funding JIP will form the;
  - "JIP Steering Committee".
- Will have three levels of participation in Steering Committee;
  - Tier 1: Funding with Voting Rights
  - Tier 2: Funding with No Voting Rights
  - Tier 3: No funding or voting rights.
    - » Participation encouraged by Industry; MMS & USCG
- Currently have information on JIP at OOC Website;
  - www.offshoreoperators.com
- Planning Committee RFP (Scope of Work) is available along with funding structure.
- If interested, contact myself or log into OOC Website.



THANK YOU!

Questions?

2005 Hurricane Readiness and Recovery Conference

InterContinental Houston Hotel
26-27 July 2005

Riser Management in Severe Environments
Managing Risk

Transocean

Riser Management in Severe Environments

- **What is a Severe Environment?**
  - ✓ Tropical Revolving Storm (Hurricane, Cyclone)
  - ✓ Oceanic, Wind-driven or Eddy Currents

- **The severity of the environment is directly related to the operations being performed.**
  - ✓ Drilling
  - ✓ Tripping
  - ✓ Running Casing
  - ✓ Drill Stem testing

- **Some type of operations have more stringent weather limitations.**
  - ✓ Drilling ahead is a good example

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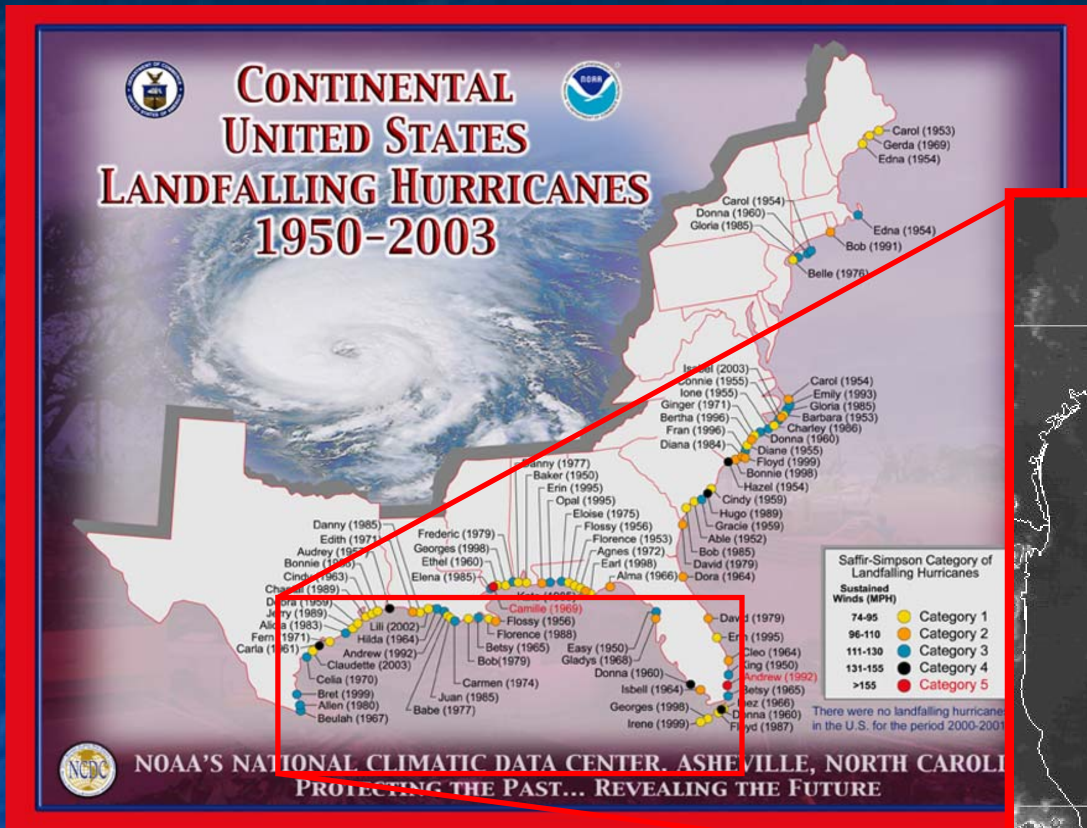
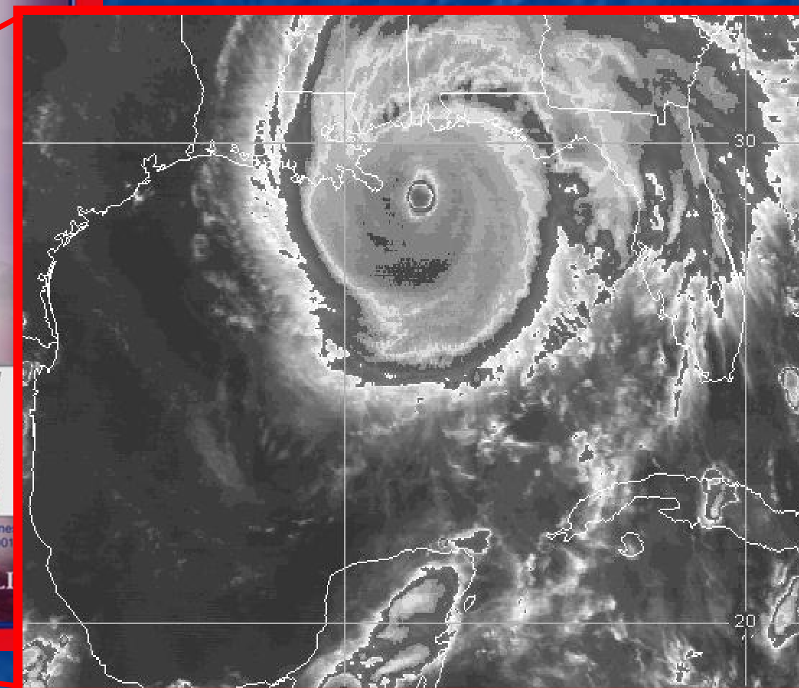


The area affected by the storm is much larger than the path of the eye wall



There are no discernable patterns in the landfall probabilities and intensity of hurricanes affecting the continental United States

Transocean

Riser Management in Severe Environments

The concept of riser management is such that when properly executed, we don't have to manage marine drilling risers in the storm environment.

Purpose of Riser Management (Why)

To Minimize Risk -

- ✓ of pollution from unplanned discharges
- ✓ of equipment damage
- ✓ of infrastructure damage
- ✓ of personal injury

Key Riser Management Issues relating to Storm Preparedness:

- ✓ Understanding equipment and people limitations
- ✓ Proper planning
- ✓ Timely execution

Transocean

Managing Risk in Riser Operations Everyday:

- **DO** - obtain credible site-specific data, including metocean and bathymetry.
- **DO** – have a site-specific riser management plan.
- **DO** –minimize differential riser angles.
- **DO** – have a reliable means for sensing currents throughout the water column and for monitoring riser angles during operations.
- **DO NOT** – unlatch BOP in any environmental conditions under which the riser cannot be retrieved.
- **DO NOT** – attempt to run or retrieve BOPs in high surface currents unless reliable current measurements through the water column indicate that riser angles can be managed within recommended limits

Storm preparedness planning, mitigating risk:

- **DO** – Have a predefined plan for storm preparedness.
- **DO** – Retrieve the LMRP and marine drilling riser prior to encountering tropical storm environments.
- **DO** – Review and update T-time estimates on a routine basis during storm season to reflect changing operating and environmental conditions (such as high currents and well construction operations).
- **DO** – Maintain the ability at all times to manoeuvre a DP installation out of the path of a tropical storm environment to sufficient distance to protect personnel and equipment. This means allotting sufficient time to retrieve and stow the riser system onboard.

Riser Management in Severe Environments

What if a riser cannot be retrieved?

There are situations where well construction operations prevent unlatch and pulling the riser at the best opportunity, resulting in all or part of the riser suspended beneath the unit

While it is always preferable to retrieve and secure the marine riser on deck, riser systems are designed to survive severe storm environments in a suspended state.

This a routine practice in other harsh-environment operating areas

Mitigating Risk while Suspended

- Pull as much as possible. Shorter riser strings have shorter natural periods and less severe dynamic response
- Properly support the marine riser
  - ✓ Gimbaled Spider
  - ✓ Shared Load Path (hook/tensioners or hook/substructure)
- Use of a landing joint (when possible) to increase the annulus around the riser in the diverter housing and prevent damage to buoyancy and peripheral lines.

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Conclusions…

- Riser Management is a methodology that we practice every day. Storm preparedness is one aspect of riser management
- The importance of site-specific data can never be underestimated.
  - As an example, simultaneous occurrence of tropical cyclone and eddy current must be considered.
  - Site-specific bathymetry is crucial for DP rigs which may unlatch and drift while retrieving risers
- Consistent application of riser management strategy minimizes exposure to risk associated with severe storms
  - A plan is only useful if it is executed in a timely manner and an organized fashion

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