

Accident Analysis for the New Millennium

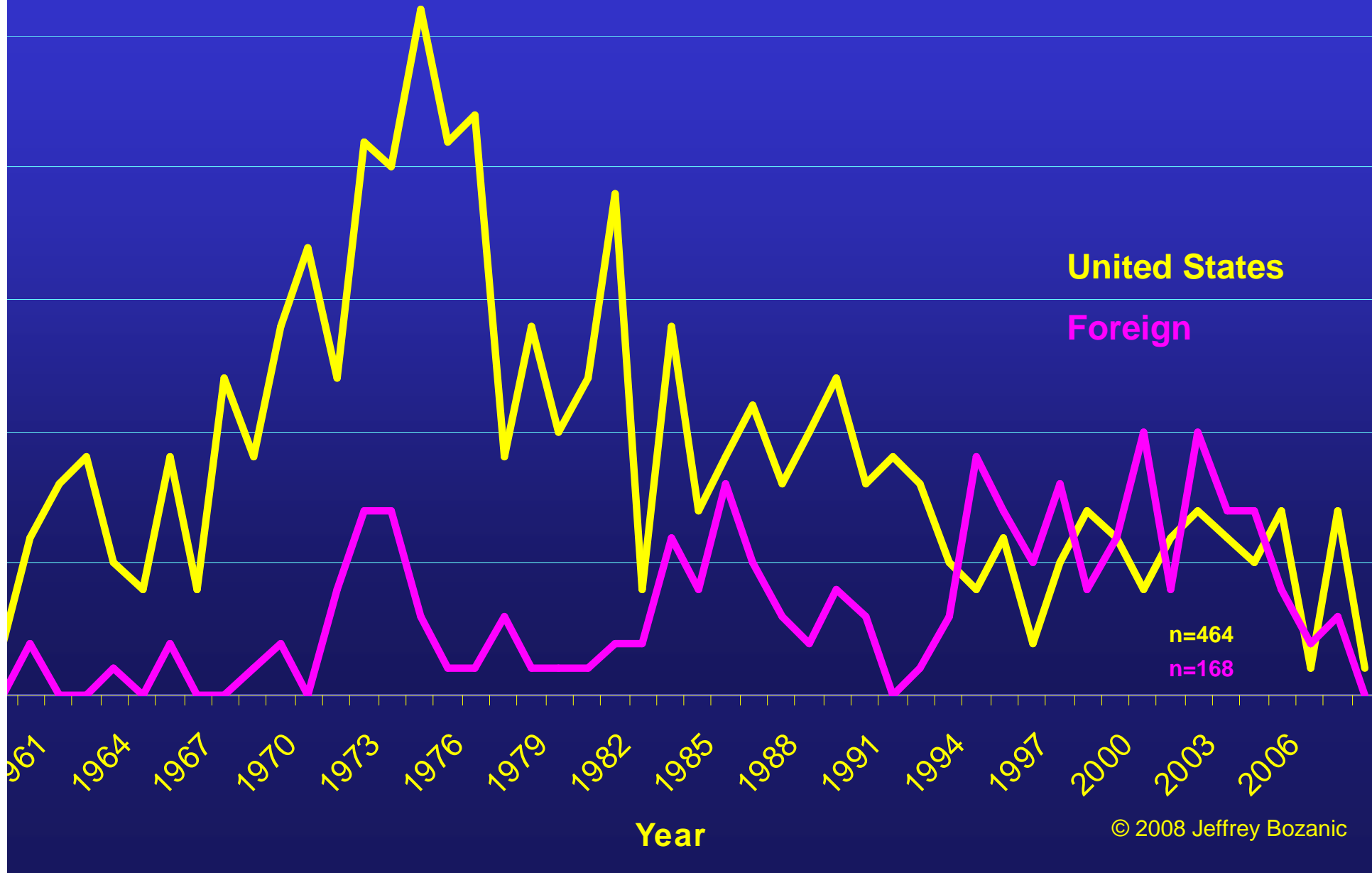
Jeffrey Bozanic

Annual Fatalities

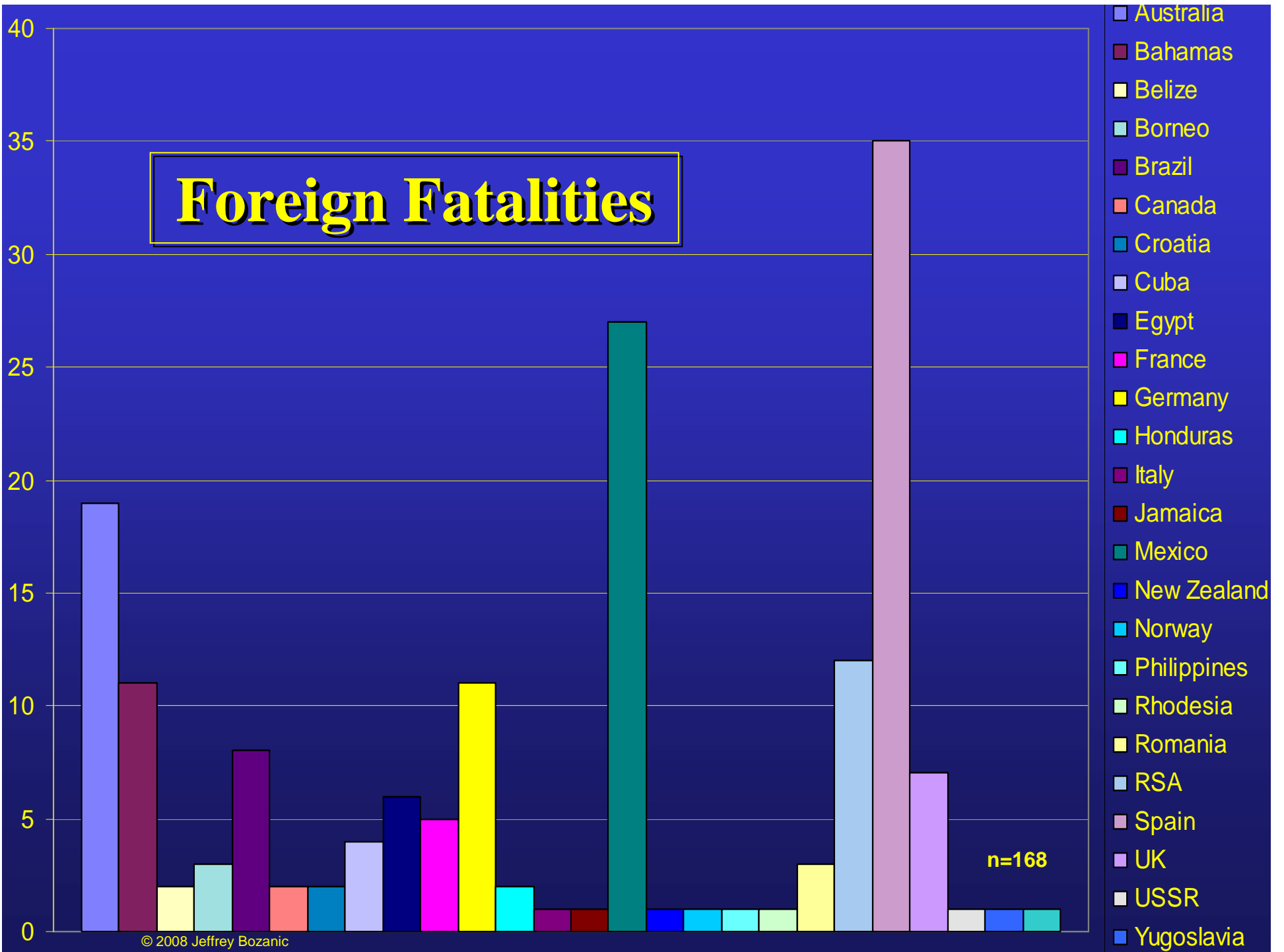


n=635

Annual Fatalities--Geography



Foreign Fatalities



Accident Analysis (1977)

Sheck Exley

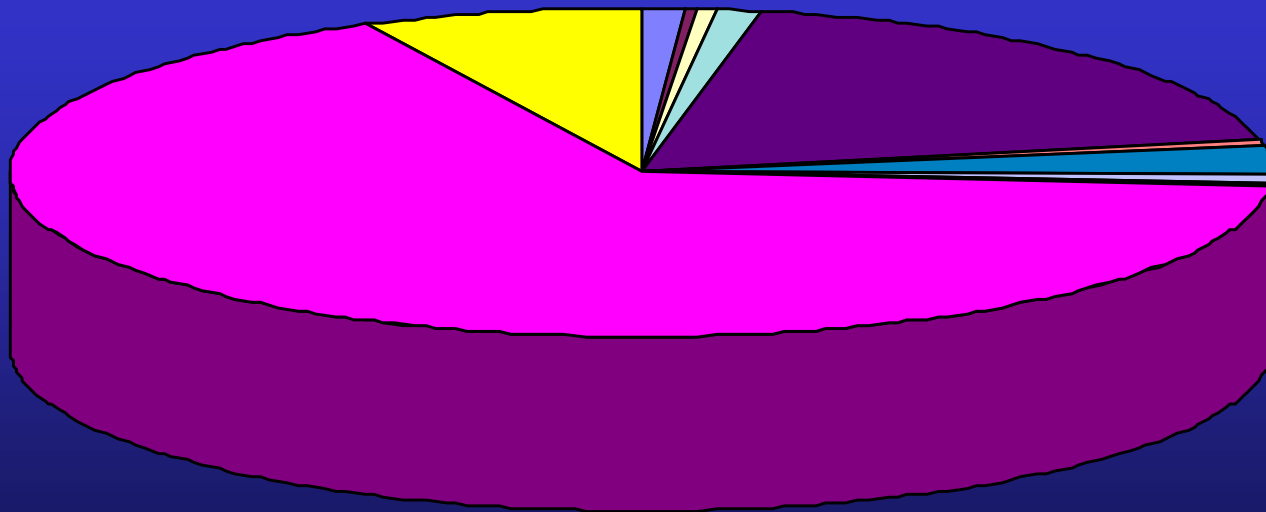
- **Guideline**
- **Air Rule**
- **Depth**

Accident Analysis (1984)

Wes Skiles

- **Guideline**
- **Air Rule**
- **Depth**
- **Training**
- **Lights**

Cave Dive Training Level

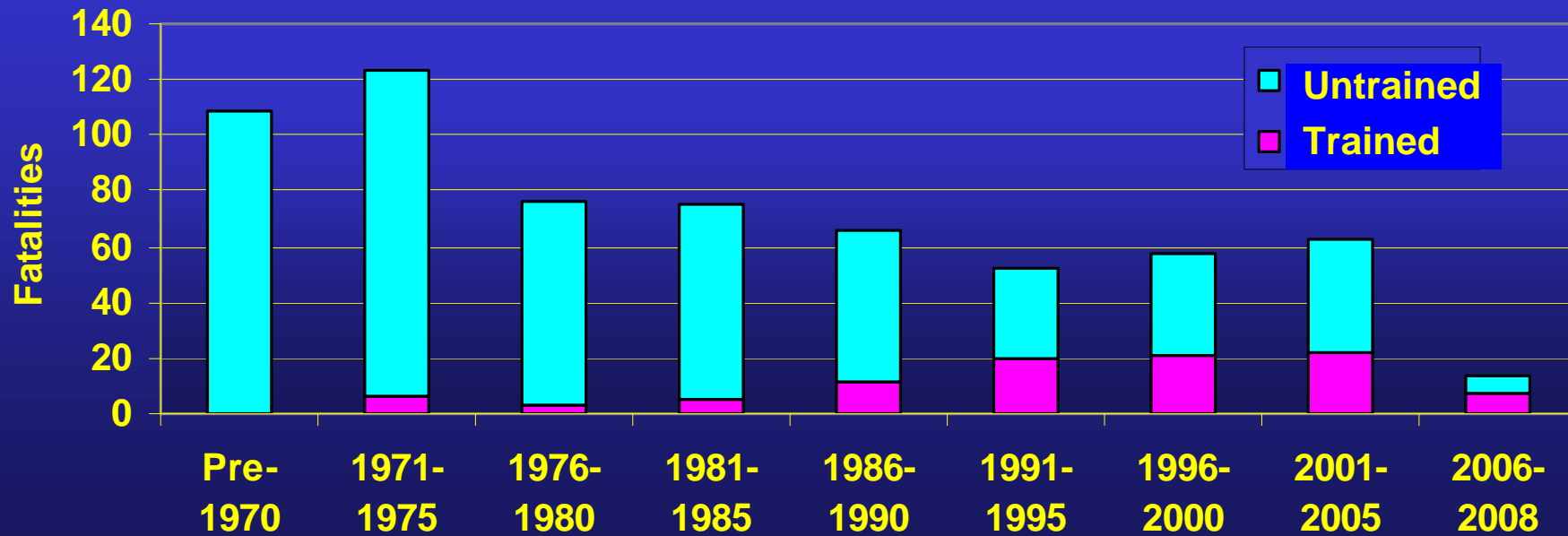


- Basic
- Cat 2
- Cave
- Cavern
- Full
- In training
- Inst
- Intro
- Intro to Cave Instr
- No
- Yes

15.12% of fatalities have overhead training

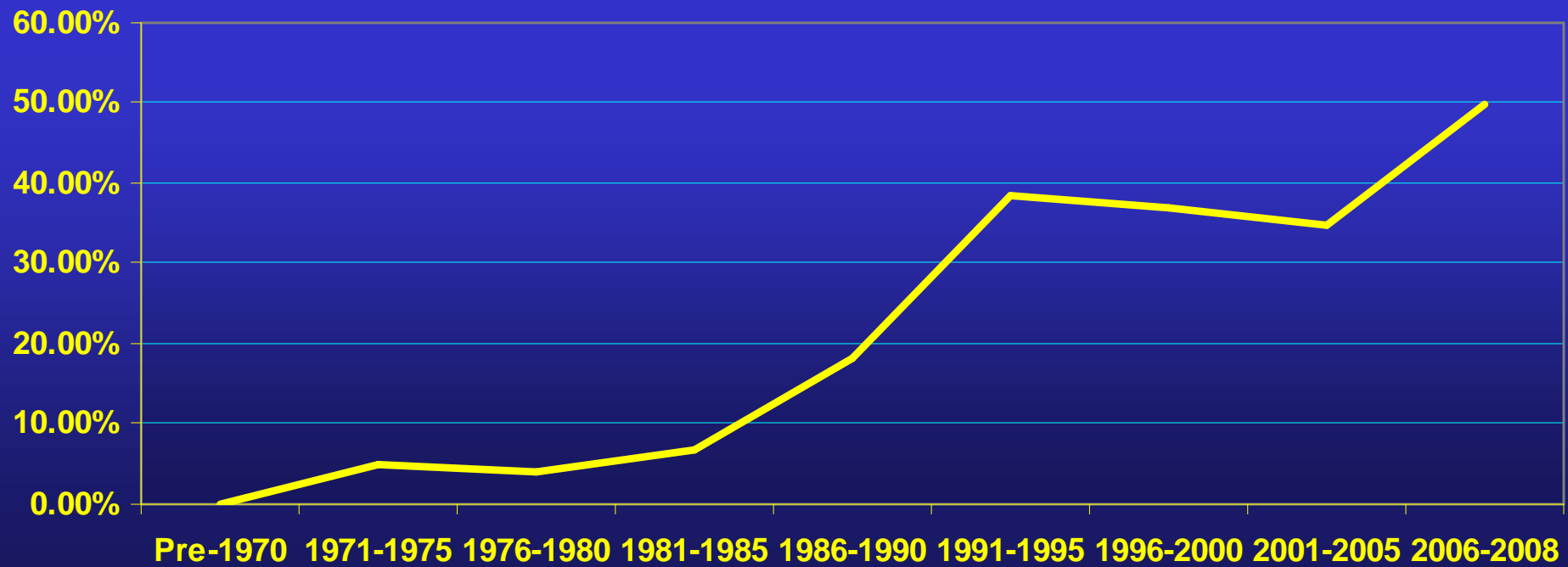
n = 96

Fatalities and Training



n = 635

Trained Overhead Divers as Percentage of All Fatalities



n = 635

Why??

- **Training is now more available**
- **Access control at popular locations**
- **Effectiveness of past educational campaigns**
- **New contributory causes**

Accident Analysis (2008)

- **Guideline**
- **Air Rule**
- **Depth**
- **Training**
- **Lights**
- **Inappropriate gas mixtures**

Case History #1

- **A diver exploring a cave system was using stage bottles to extend penetration distances.**
- **At the start of the dive, he dropped his decompression bottle near the entrance for later use.**
- **During the exit phase of the dive, he picked up and switched to his stage bottle.**

Case History #1

- **Fighting the inflowing current, he was observed to convulse, and drowned.**
- **It was later determined that he had left the wrong bottle at his decompression stop, and was breathing his high oxygen mix (EAN50) at depth (140 ffw).**

Improper Gas Mixes ^{JEB1}

- **Wrong gas at depth**
- **Mislabeled cylinders**
 - **Increased task loading**
 - **Improper mixing procedures**
 - **Poorly analyzed or unanalyzed mixes**
- **Cave divers progressing to stage bottles too rapidly**

Slide 14

JEB1

p

Jeffrey Bozanic; 23/05/2008

Accident Analysis (2008)

- **Guideline**
- **Air Rule**
- **Depth**
- **Training**
- **Lights**
- **Inappropriate gas mixtures**
- **New technology**

Case History #2

- **A cave diving team is using trimix and scooters to explore the far reaches of a cave system.**
- **The divers are working to depths of over 250 ffw.**
- **During the exit phase of the dive, one diver apparently fouls the line in the DPV, silting the cave.**
- **Both divers die before being able to solve the problems.**

New Technology

JEB2

- **Nitrox & Trimix**
- **Diver propulsion vehicles (DPVs)**
 - **Rebreathers**
 - **Combinations of above**
 - **Increased task loading**
- **Cave divers progressing to new technology too rapidly**
- **Cave divers over-extending themselves on new technology**

Slide 17

JEB2

p

Jeffrey Bozanic; 23/05/2008

Accident Analysis (2008)

- **Guideline**
- **Air Rule**
- **Depth**
- **Training**
- **Lights**
- **Inappropriate gas mixtures**
- **New technology**
- **Medical problems**
- **Equipment maintenance**

Case History #3

- **A 51 year old full cave certified diver is exploring a cave with a cave certified buddy.**
- **The depth is about 30 ffw.**
- **During the dive the regulator second stage parts from the regulator hose.**
- **In the process of changing regulators, the diver drifts up a few feet and embolizes.**
- **The buddy is unable to tow the victim to safety in time to preserve life.**

Case History #3

- **The few feet that the victim drifted up should not have been sufficient to cause an embolism in a healthy individual**
- **During autopsy, it was found that the victim had undiagnosed lung cancer**
- **It is likely that the cancer mass had blocked a portion of the airway, causing the embolism**

Medical Problems

JEB3

- **Aging cave diver population**
 - “Old timers” still active
 - Many new cave divers are older
- **Undiagnosed medical issues**
- **Chronic health problems**
 - Blood pressure
 - Arteriosclerosis
 - Others
- **Poor physical condition**
 - Heart attacks

Slide 21

JEB3

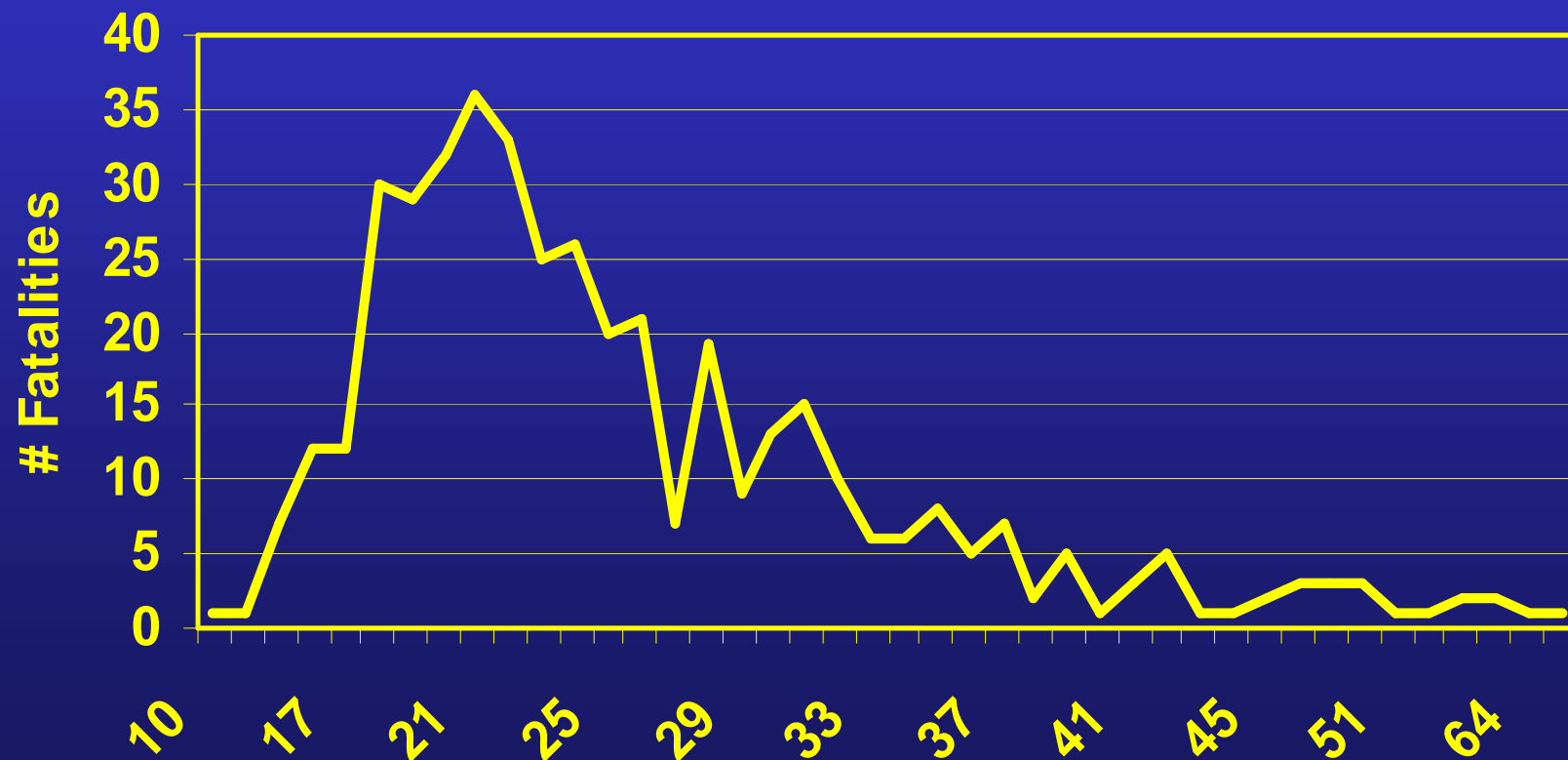
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Jeffrey Bozanic; 23/05/2008

Age of Decedents

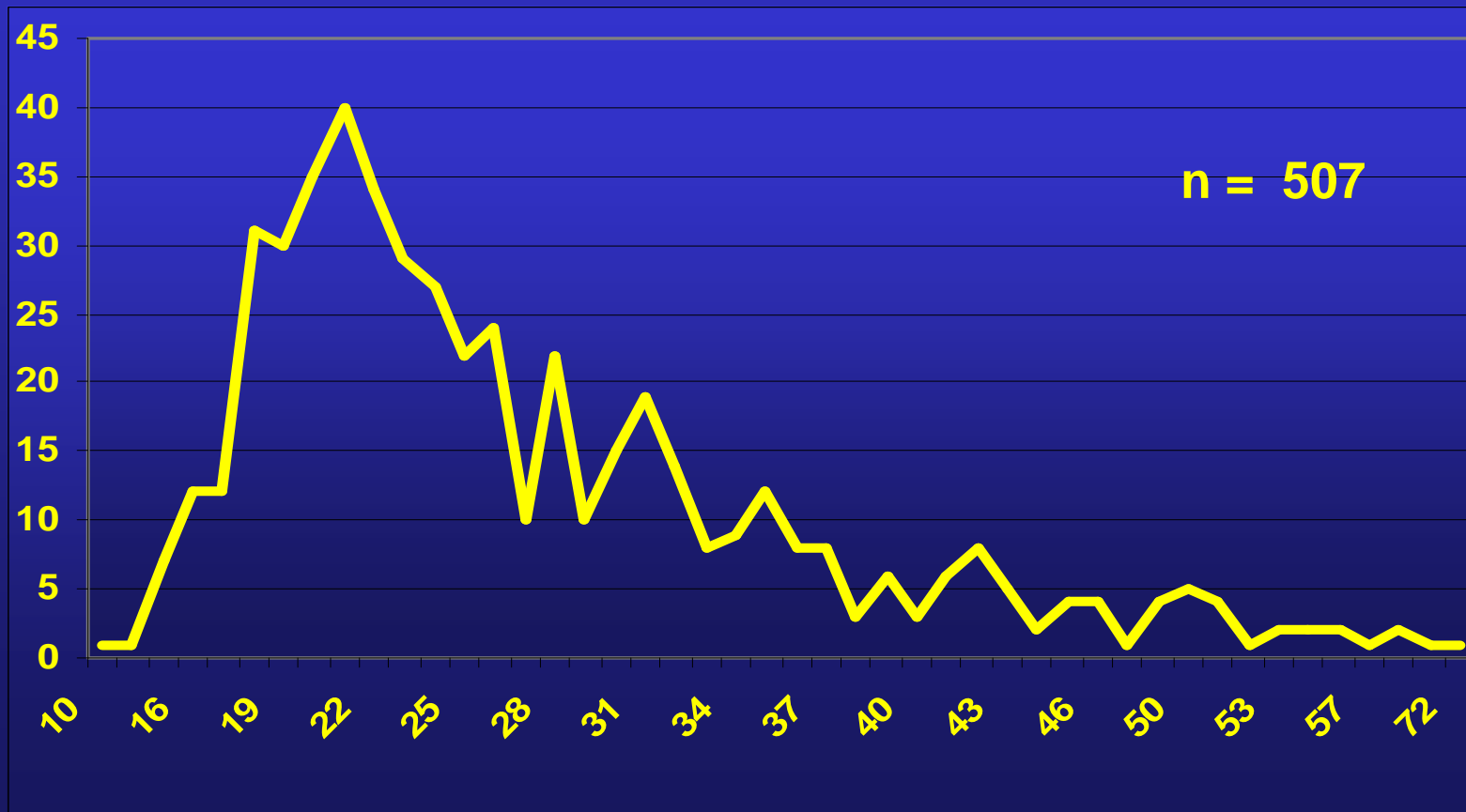
1950-1999

n=427

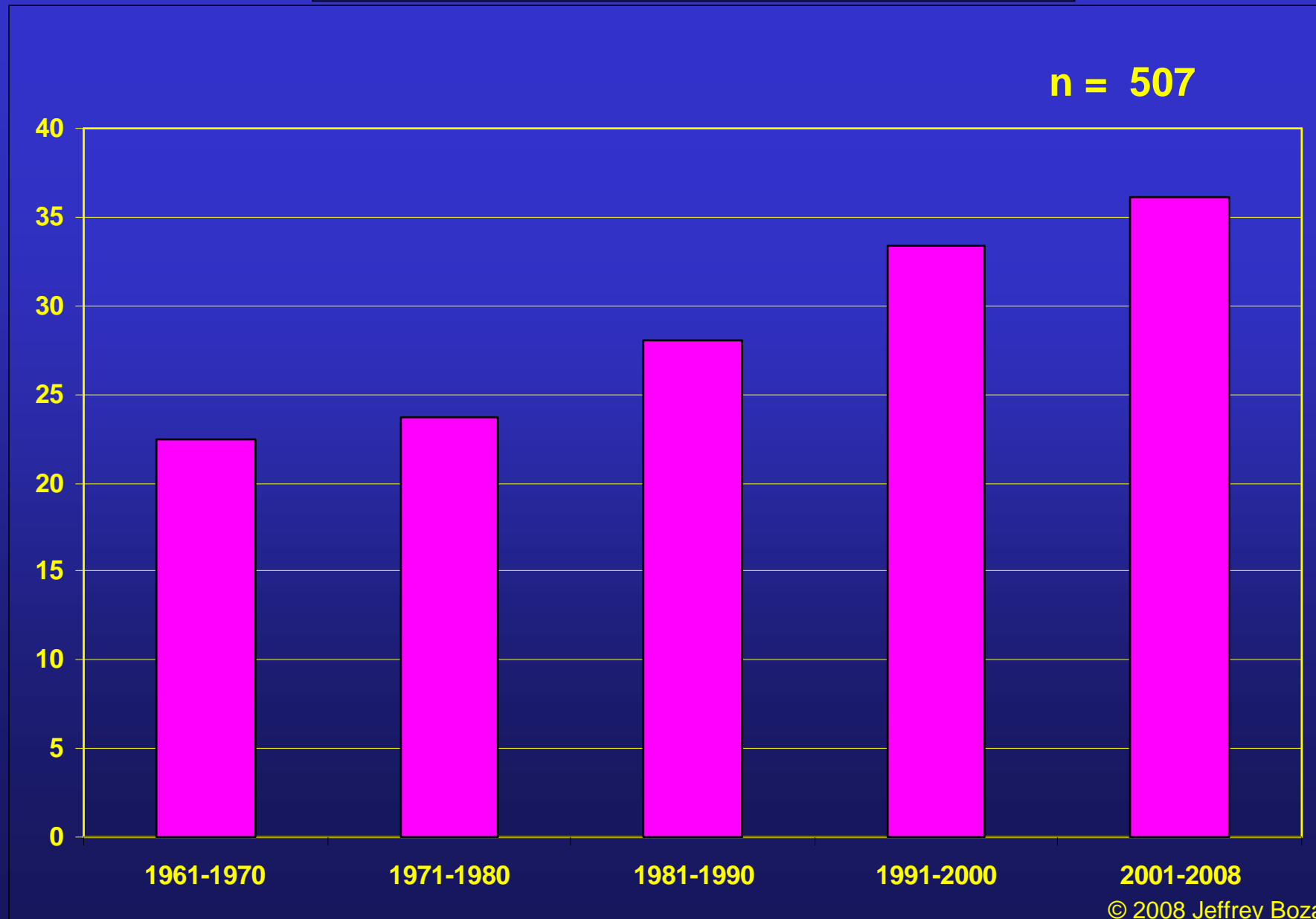


Age of Decedents

1950-2008



Mean Age of Decedents



Equipment Maintenance

JEB4

- **Complacency**
- **Poor regulator servicing**
- **Exposure suit issues**
- **Rebreather issues**
 - **Failure to change sensors**
 - **Over-using absorbent**
- **Configuration issues**
 - **Roll off on isolation manifolds**
 - **Too much redundant equipment**

Accident Analysis (2008)

- **Guideline**
- **Air Rule**
- **Depth**
- **Training**
- **Lights**
- **Inappropriate gas mixtures**
- **New technology**
- **Medical problems**
- **Equipment maintenance**
- **Solo diving**

Case History #4

- **Two cave divers conducted an exploration dive in a long lava tube cave.**
- **During the exit they stop to explore a side passage.**
- **Upon returning to the main line, the lead diver, a very experienced (>1,000 cave dives) individual, begins to swim in the wrong direction**
- **During the ensuing discussion, the divers decide to swim in the other direction**
- **Both divers exit safely**

Solo Diving

- **Has been associated with at least 72 fatalities**
- **51% of the trained cave divers who died in caves were on solo dives**
- **Just because you are diving with someone does not mean you have a “buddy”**

Solo Diving

- **Much exploratory cave diving done solo**
- **Lack of qualified dive partners**
 - **Reduces some environmental risks**
- **Lacking the most important piece of redundancy: the human brain!**

Accident Analysis (2008)

- **Guideline**
- **Air Rule**
- **Depth**
- **Training**
- **Lights**
- **Inappropriate gas mixtures**
- **New technology**
- **Medical problems**
- **Equipment maintenance**
- **Solo diving**
- **Skill maintenance**

Case History #5

- **A pair of divers are cave diving in a system along permanent lines.**
- **Both are full cave certified (3 years), but have not recently been cave diving.**
- **As part of the dive plan, they cross to a secondary line (leaving a gap reel).**
- **During the exit they miss the jump, swimming 1400 feet in the wrong direction.**
- **Recovery divers find the bodies about 250 feet from the entrance.**

Skill Maintenance

- **In the past, “Cave divers were cave divers!”**
- **Many people now only cave dive on vacations**
- **People return to dives they were once capable of, but arguably now are beyond their skill level**

Related Projects

- **Divers Alert Network (DAN)**
- **Incident Reporting & Investigative System (IRIS)**
- **Deeplife**
- **Incident Reporting & Analysis Project (IRAP)** http://www.cavediver.net/irap/irap_frm.htm

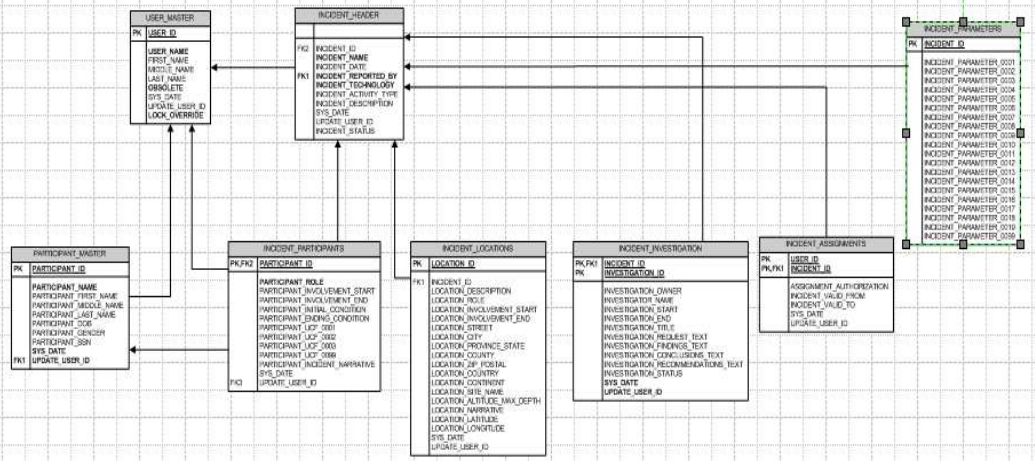
Incidence Rates

After Denoble & Bozanic

Population	Denominator	Time Period	/100K Divers	/100K Dives
CDG, GB	Recorded	1957-1979		138 (65-300)
CDG, GB	Recorded	1980-2006		24.6 (12-50)
Orkney, Scotland	Recorded	1999-2000		4 (1-11)
Australia	Estimated	1989	34	1.7-3.4
BC, Canada	Tank Count	1999-2000		2.04 (0.8-6)
Japan	Tank Count (est)			1-2.4
U.S.	Estimated	1960-1994	160-1400	
U.S.	Estimated	1989	16.7	0.8-1.6

- Tables and Views**
- INCIDENT_ASSIGNMENTS
 - INCIDENT_HEADER
 - INCIDENT_INVESTIGATION
 - INCIDENT_LOCATIONS
 - INCIDENT_PARAMETERS
 - INCIDENT_PARTICIPANTS
 - PARTICIPANT_MASTER
 - USER_MASTER

INCIDENT REPORTING & INVESTIGATION SYSTEM (IRIS)



Page-1

- Database Properties**
- Definition
 - Columns
 - Primary ID
 - Indexes
 - Triggers
 - Check
 - Extended
 - Notes

Physical Name	Data Type	Req'd	PK	Notes
INCIDENT_ID	CHAR(10)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	INCIDENT_ID identifies the Incident that these definable parameters relate to.
INCIDENT_PARAMETER_0001	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0001 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0002	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0002 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0003	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0003 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0004	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0004 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0005	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0005 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0006	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0006 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0007	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0007 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0008	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0008 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0009	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0009 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0010	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0010 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0011	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0011 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0012	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0012 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0013	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0013 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0014	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0014 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0015	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0015 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0016	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0016 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0017	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0017 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0018	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0018 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0019	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0019 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.
INCIDENT_PARAMETER_0099	CHAR(10)	<input type="checkbox"/>	<input type="checkbox"/>	INCIDENT_PARAMETER_0099 is one of 99 (initial number) definable parameters related to the incident. There are also Location and Participant parameters in other tables.

Show: Portable data type Physical data type (Microsoft Access)

- Add
- Remove
- Edit...
- Move Up
- Move Down

Challenges—Data Collection

- **Do not receive data**
- **Years to get data (2006)**
- **Incomplete**
- **Contradictory information**
 - **Newspapers**
 - **Internet sources**
 - **Personal accounts**
- **Need official sources documents**
 - **Autopsy reports**
 - **Law enforcement incident reports**

Challenges—Foreign Data

- **Do not receive data**
- **Years to get data (2006)**
- **Incomplete**
- **Contradictory information**
- **Need official sources documents**

- **Translations**

Challenges—Data Entry

- **Time**
 - **Research**
 - **Data entry**
 - **Averages one working day per incident to research & enter**
- **Data integrity**
- **Coding**

Challenges—Reports (Individual)

- **Legal Climate**

“Please send me a copy of the accident report as soon as possible... if you need one, I can get you a release from the deceased...”

- **Community too small to maintain confidentiality**

Challenges—Reports (Summary)

- **Time to amass and compile data**
- **Data integrity**
- **Time to analyze and prepare report**
- **Takes several years to add sufficient data to make new report worthwhile**
- **Re-coding for new trends**

Challenges—Reports (Individual Requests)

- **Legal climate**
- **Time to research data**
- **Incomplete information to track particular case**
- **Re-coding for requested information**

How Can You Help?

Individuals

- **Report any information on fatalities (esp foreign)**
- **Participate in IRAP**
- **Provide diving history (log book data)**
- **Provide annual information on diving**
 - # dives (O/W & cave)
 - trimix (O/W & cave)
 - rebreather (O/W & cave)

Recovery Divers

- **Accident reports to IUCRR within days**
- **Provide other source data**

How Can You Help?

Site Managers

- **Accident reporting**
- **Annual activity level reporting**
- **Historical data on activity levels**

Agencies

- **Certification numbers to DAN**
- **Add activity data fields to member renewal applications and report**
- **Award information to DAN (Abe Davis, etc)**

Accident Analysis (2008)

- **Guideline**
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- **Medical problems**
- **Equipment maintenance**
- **Solo diving**
- **Skill maintenance**

Acknowledgements

- **NACD**
- **NSS-CDS**
- **IUCRR**
- **Univ of Rhode Island**
- **DAN**
- **Henry Nicholson**
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- **Ken Hill**
- **Mark Dougherty**
- **Mark Fowler**
- **Gerry Putnam**
- **Igor Beades**
- **Brian Roberts**

Previous Coordinators

- **Dave Desautels**
- **Sheck Exley**
- **John Crea**

Information Compilation

- **Rebekah Halpern**
- **J. Ian Martin**
- **Elaine Jobin**
- **Michel Gadbois**

Case History #6

- **A diver exploring the Blue Hole in New Mexico fails to return from a dive**
- **Recovery divers are unable to find the body**
- **Six years later, the body is recovered...**

Case History #6

- **A diver exploring the Blue Hole in New Mexico fails to return from a dive**
- **Recovery divers are unable to find the body**
- **Six years later, the body is recovered...**

In Lake Michigan!!

