



# World Maritime University

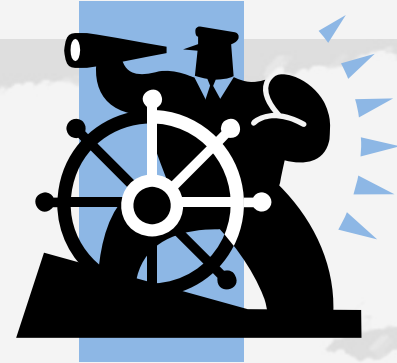
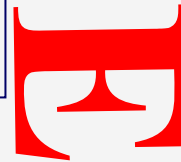
## Seminar on Maritime Casualty Investigations

Human factors

1



FATIGU





## **Integral part of the HUMAN ELEMENT**



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- **This presentation is based on material prepared by**
  - Transportation Safety Board Of Canada (CTSB)
  - US Coast Guard

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Transportation  
Safety Board  
of Canada

Bureau de la sécurité  
des transports  
du Canada

Canada 



Homeland  
Security

United States Coast Guard

Semper Paratus





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## Three Components:

- Intro
- Basic Concepts of Fatigue and Sleep
- Guidelines for Investigating



**“A common myth still exists that fatigue can be prevented by characteristics of personality, intelligence, education, training, skill, compensation, motivation, physical size, strength, attractiveness or professionalism.”**



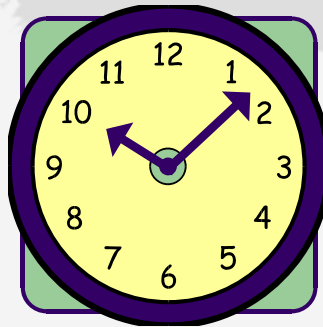
- **Investigators Tool Bag**
- **Background info on physiological bases of Alertness & Fatigue**
- **Understanding of how Fatigue affects performance**
- **Guidance/Procedures on how to investigate Fatigue**





## Investigating for Fatigue

- HOURS OF SERVICE
  - The Myths

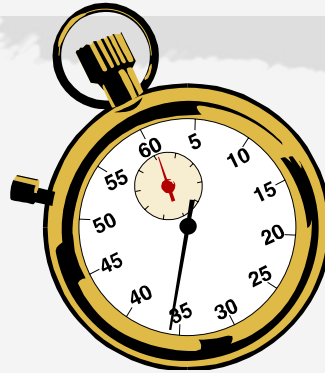


**1. All Hours are equal and interchangeable.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Reality

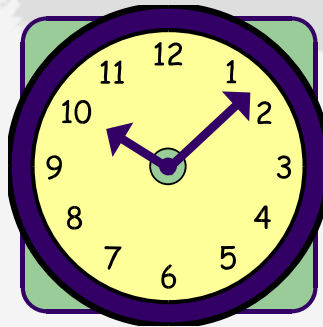


**1. People never fully adjust to unusual schedules.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Myths

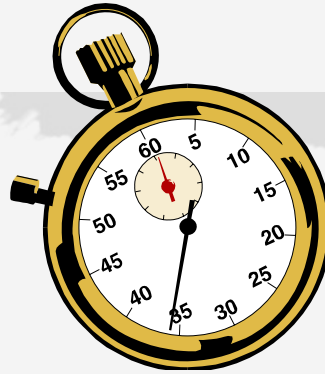


**2. Fatigue is a function of consecutive hours worked.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Reality

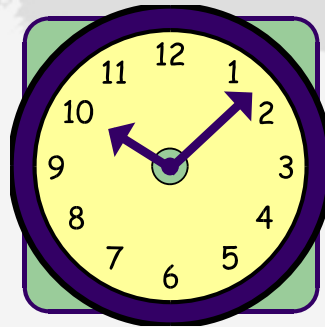


**2. The time of day that one works has a far greater effect on alertness than the number of consecutive hours worked.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Myths



**3. Recovery from fatigue is related to hours just worked.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Reality

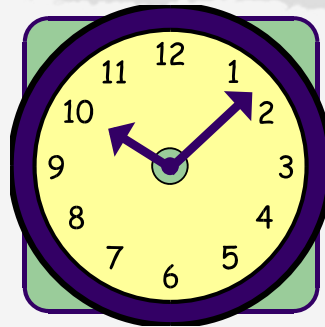


**3. Quality of sleep is as important as quantity.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Myths



**4. Not working = rest.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Reality



**4. Recovery is not simply related to duration of hours off work - restitution theory not viable.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Reality

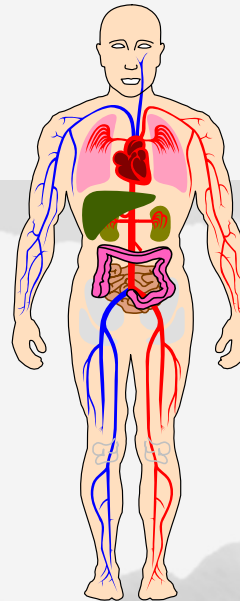


**Length of sleep is not simply correlated with how long one works.**



## Investigating for Fatigue

- HOURS OF SERVICE
  - The Reality



**Humans respond to a circadian clock.**



## Sleep and Fatigue Issues

- Alertness
- Biological Clock
- Sleep/Wake Cycles
- Nature and Function of Sleep
- Quality and Quantity of Sleep



## Sleep and Fatigue Issues

- Sleep Disorders/Disturbances
- Irregular Schedules
- Jet Lag
- Effects of Fatigue on Performance



## Alertness –

- The optimal activated state of the brain
- As fatigue increases the brain appears to fall asleep, involuntarily, against the will of the person
- Noted especially when performance demands involve sustained attention and monotony



## Alertness - influences

- Sense of danger – a near miss!
- Interest or opportunity
- Muscular activity – running, walking, chewing gum
- Sleep bank balance
- Strategic napping



## Alertness – influences

- Environmental light – brightness!
- Temperature & Humidity - cool/dry is best
- Sound – irregular is good, soothing is bad
- Aroma – peppermint helps



## Biological clock



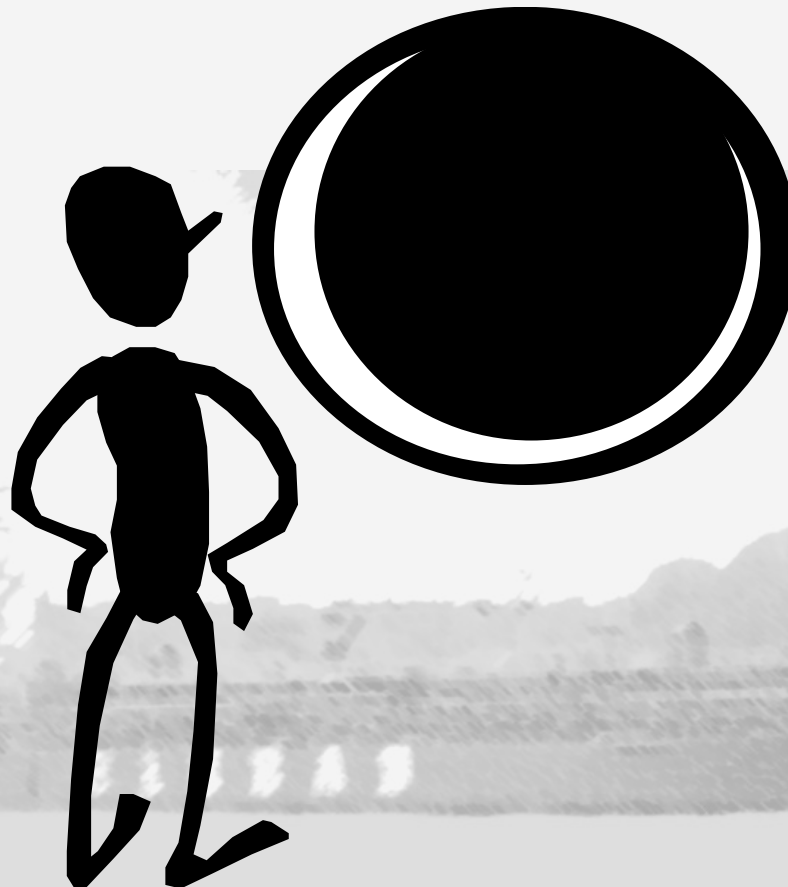


## Biological clock

- Regulates the daily cycle of activity and inactivity
- Nearly every body function is timed according to day-night cycle
- When freed of daily time cues, circadian rhythms are “free running” at about 25 hours
- 25 hr clock can be reset by about 2 hrs per day, allowing us to live comfortably on a 23 to 27 hour day



## Sleep / Wake Cycle





## Sleep / Wake Cycle

- Follows a 24 hour rhythm
- Approximately 1/3 of this time is spent sleeping
- Individual rhythms vary, but distinct peaks and dips
- A “credit and deficit” system – cannot be stored



## Sleep / Wake Cycle Credit & Deficit System

### One day:

- 2 points for every hour of sleep (max 16 points)
- 1 point deducted for every hour awake



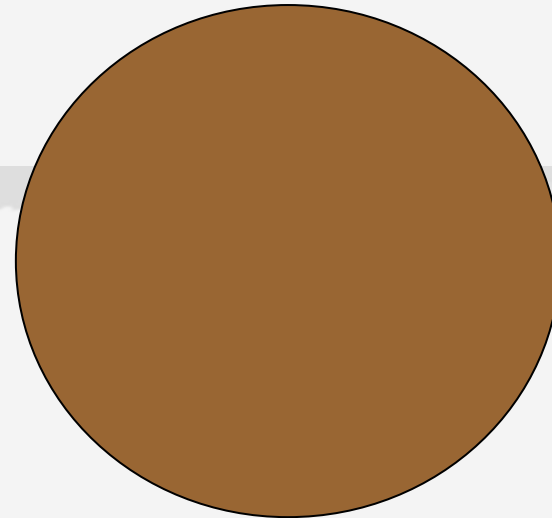
## Nature & Function of Sleep





## Sleep Stages

- Stage 1 Transitional





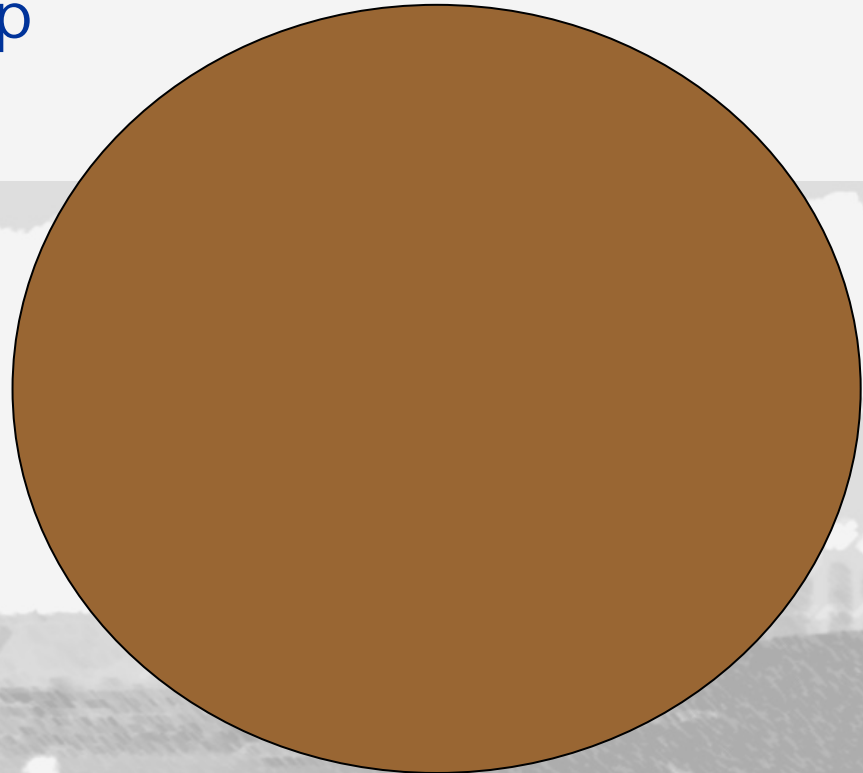
## Sleep Stages - Stage 1 Transitional

- About 10 minutes long
- Can sleep without knowing it
- If awoken during this stage, may deny sleeping



## Sleep Stages

- Stage 2 Light Sleep





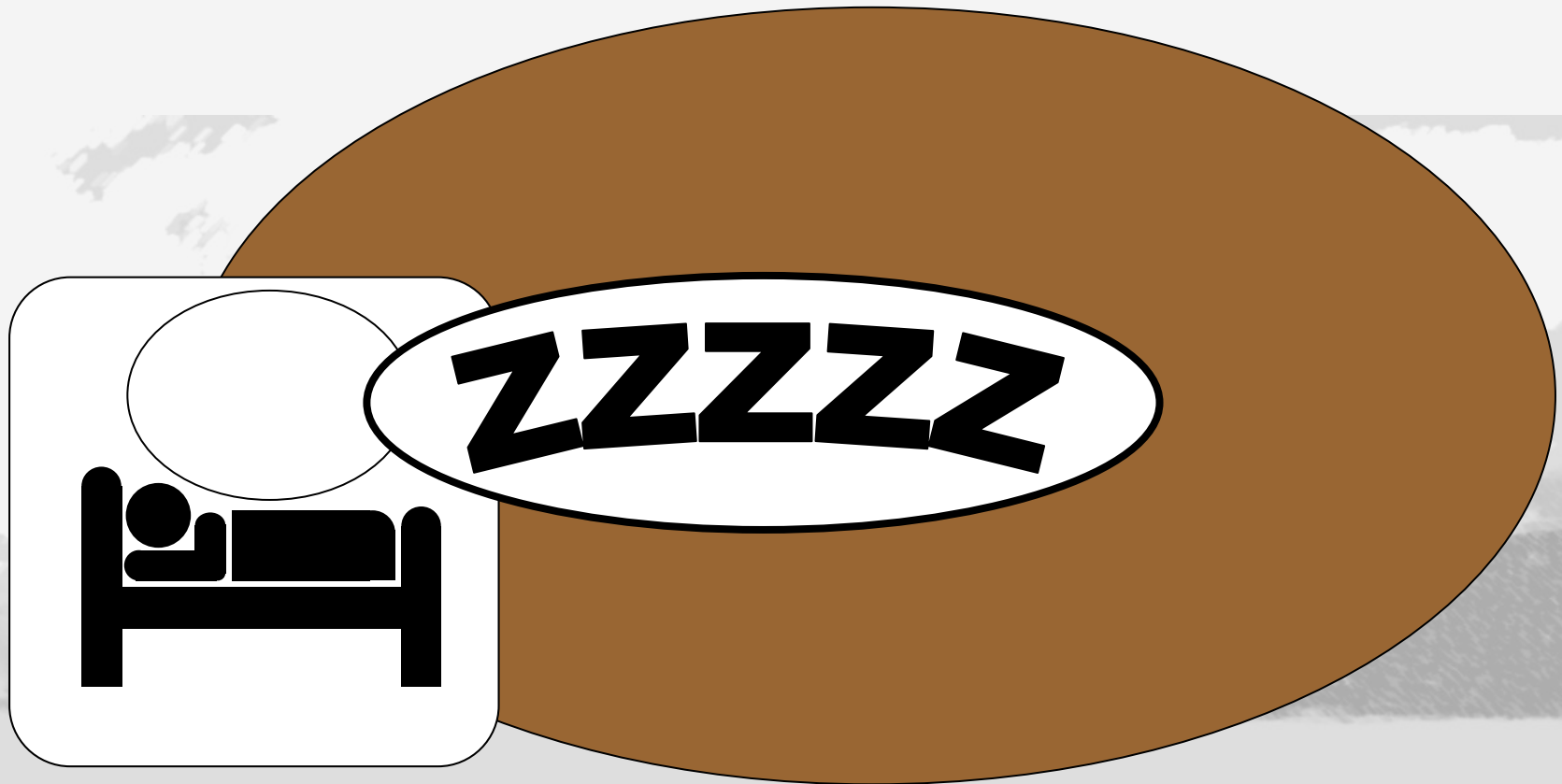
## Sleep Stages - Stage 2 Light Sleep

- 15 minutes long
- Light level of sleep
- If awoken, likely to feel alert and refreshed
- About 50% of our sleep is in this stage



## Sleep Stages

- Stage 3 Deeper Sleep





## Sleep Stages - Stage 3 Deeper Sleep

- About 15 minutes long
- The onset of deeper sleep



## Sleep Stages

- Stage 4 Deepest Sleep (REM Sleep \*)





## Sleep Stages - Stage 4 Deepest Sleep (REM Sleep \*)

- Last from 10 minutes to 1 hour
- The deepest stage
- If awakened, likely to feel groggy, disoriented and suffer from sleep inertia
- Sleep inertia is a period of impaired functioning that can last from 10 minutes to 1 hour
- REM occurs at about 79-80 minutes into sleep



## Sleep Stages –

- Stages 3 and 4 relate to body restoration
- REM may be related to strengthening and organizing memory
- Complete stages 1 – 4 in 90 minute cycles which repeat throughout the night



## Quality of Sleep



## Quantity of Sleep



## Quantity of Sleep

- 90% of population needs 7.5 to 8.5 hours per 24 hour day
- Alertness and performance are related to quantity
- Chronic under sleeping can lead to cumulative sleep debt
- The seriousness of a small sleep debt can be significant for performance
- Sleep requirements do not change with age, sleep patterns do!



## Quality of Sleep

- All sleep is not the same and does not provide the same recuperative benefits
- Quality sleep is restorative sleep
- Naps – most effective are about 20 minutes
- Naps of 30 to 60 minutes do not provide more restorative sleep than a 20 minute nap



## Quality of Sleep

- However, a 2 hour nap will more than double the restorative sleep of a 1 hour nap because two hours is long enough to come out of deep sleep
- Timing of sleep is critical to sleep duration, not amount of time awake



## Sleep Disorders/Disturbances

- Sleep Apnea – repeated cessation of breathing during sleep
- Narcolepsy – a disease of uncontrollable sleep attacks
- Insomnia – 15-30% of adults, difficulty sleeping. May also be Situational
- Irregular Schedules – Shift work desynchronizes the body rhythms. During

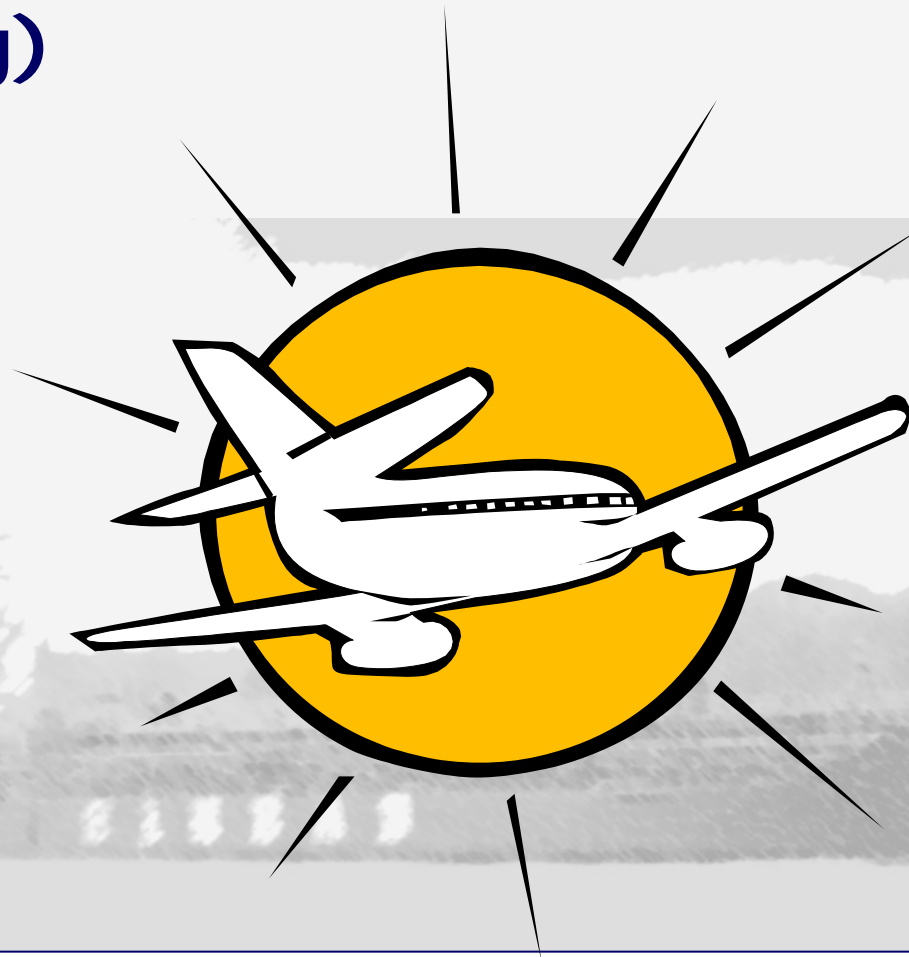


## Sleep Disorders/Disturbances

- Irregular Schedules –
  - Shift work desynchronizes the body rhythms.
  - During daytime, restorative sleep (stages 3/4) is reduced
  - Individual assessment of alertness is insufficient
  - Shift schedules should rotate forward, to later hours, in a clockwise direction – more compatible to the biological clock
  - If possible critical tasks should be scheduled during 0700 and 2300



- **Circadian Dysrhythmia  
(Jet Lag)**





## Circadian Dysrhythmia (Jet Lag)

- A maladjustment of body rhythms occurring after travel across time zones.
- Internal rhythm out of phase with local time
- Depending upon number of time zones crossed, it may take 2-3 days or up to one week for someone to adjust



## Effects of fatigue on performance

- Manual Dexterity
- Mental Arithmetic
- Reaction Time
- Cognitive Reasoning
- Mood
- Reduced attention
- Reduced motivation





## Fatigue Investigation guidelines

- Guideline 1: Establishing the Fatigued State
  - At what time of day did the occurrence take place?
  - Was the operators normal circadian rhythm disrupted?
  - How many hours since awakening?
  - Does the 96 hr sleep history suggest a sleep debt?



## Fatigue Investigation guidelines

- Guideline 2: Establishing the link between Fatigue & the Unsafe Act / Decision
  - First: The person or crew was in a fatigued state
  - Second: The unsafe act or decision is consistent with the type of behaviour expected of a fatigued person or crew



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## HUMAN ACTIVITY DATA FORM

### TABLE OF PREVIOUS 96 HOURS ACTIVITY (D-X day of Casualty)

D-4																		
D-3																		
D-2																		
D-1																		
D-X																		

X, Time accident; F, Meal; W, Watch; M, Maintenance work; S, Sleep; C, Cargo Watch;  
R, Recreation, including time ashore; A, Alcoholic drink



# World Maritime University

## HUMAN ACTIVITY DATA FORM

### TABLE OF PREVIOUS 96 HOURS ACTIVITY (D-X day of Casualty)

D-4																		
D-3																		
D-2																		
D-1	S	S	S	S	W	W	W	W	F	M	M	R	C	C	C	C	F	R
D-X	S	S	S	S	W	W	X											

X, Time accident; F, Meal; W, Watch; M, Maintenance work; S, Sleep; C, Cargo Watch; R, Recreation, including time ashore; A, Alcoholic drink



- **FATIGUE INVESTIGATION WORKSHEET**

**G-MOA Policy letter 5-97**

51

$$s(21.4) + wh(6.1) - sh(4.5) =$$

**Fatigue Index Score**



$$s(21.4) + wh(6.1) - sh(4.5) =$$

**Fatigue Index Score**

## Fatigue Symptoms (s)

- Forgetful
- Desire to sit or lay down
- Distracted
- Difficulty keeping eyes opened
- Sore muscles
- Less motivated
- Difficulty operating equipment



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$$s(21.4) + wh(6.1) - sh(4.5) = \text{Fatigue Index Score}$$

<b>Fatigue symptoms <math>s = 2</math></b>	<b>42.8</b>
<b>Hours of work <math>+ wh = 12</math></b>	<b>73.0</b>
	<b>115.8</b>
<b>Hours of sleep <math>- sh = 8</math></b>	<b>36.0</b>
<b>Fatigue Index Score</b>	<b>79.8</b>



## Fatigue Index Score

- A result of 50 or more and it gets recorded as contributing to the casualty
- USCG establishing a database to track
- This policy in effect since 1997



## Investigation for Fatigue

**Questions?**