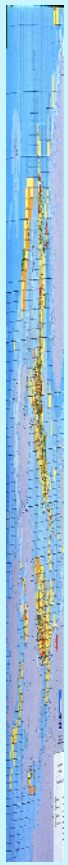

Extended work periods and shift work offshore

Current knowledge and research needs

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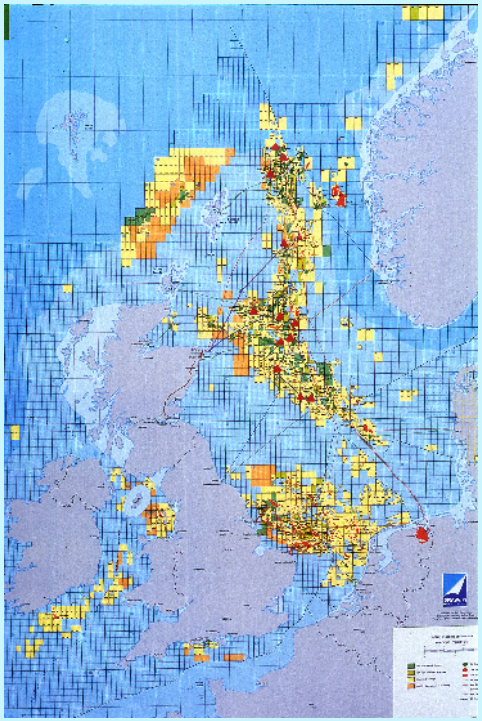
University of Oxford

Stavanger, 15 March 2007

Offshore work environment



Remote locations

Limited space

Round-the-clock work activity

Offshore work environment

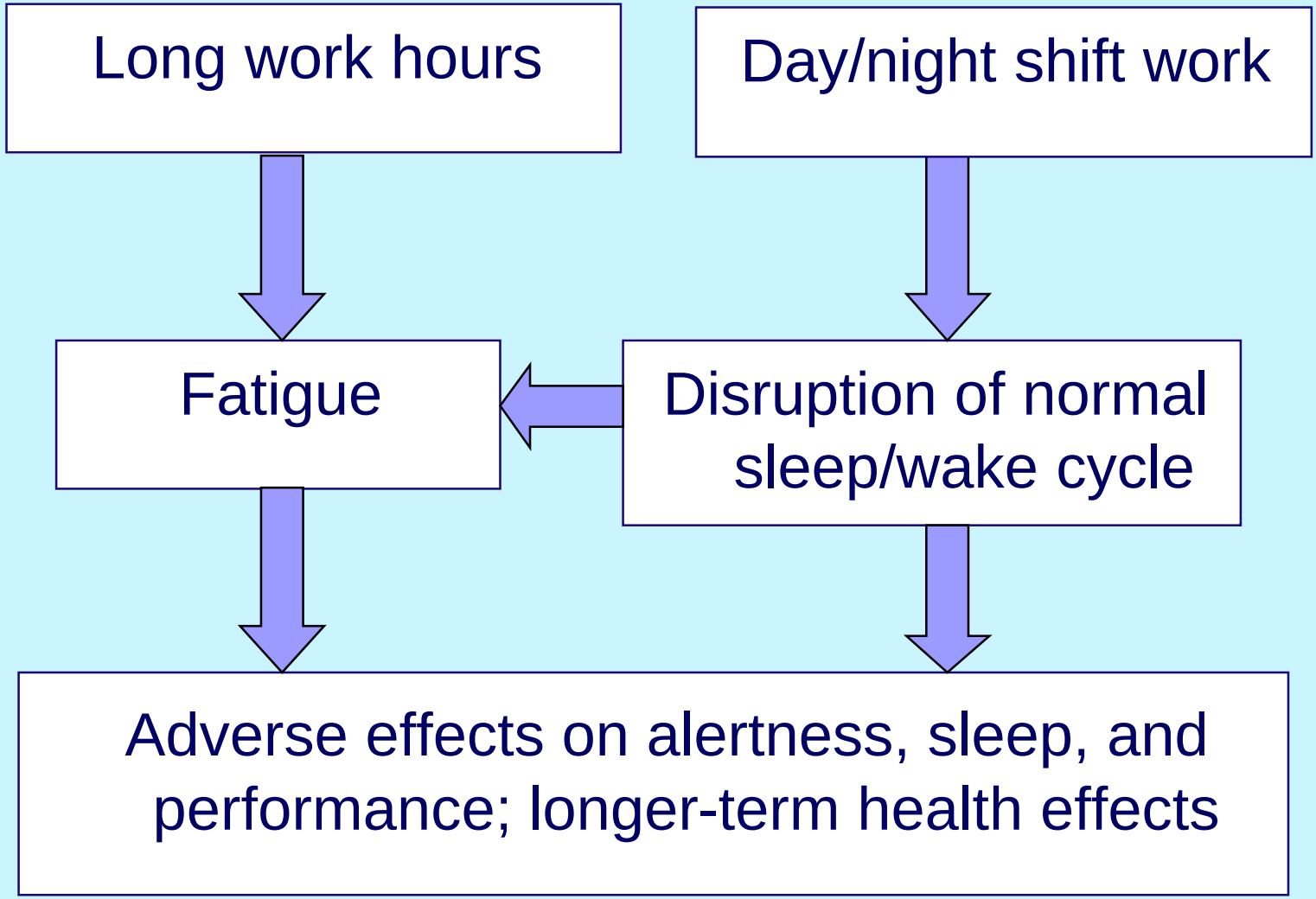
- Remote locations
  - Daily commuting not possible
  - 2-week offshore tours are the normal pattern
- Round-the-clock work activity
  - Day/night shift work (30 – 45% of offshore personnel)
- Limited space and cabin accommodation
  - Only two crews on board at any one time
  - 12 hr shift duration

Offshore work schedules: current issues

- Day/night shift rotation
  - 'Fixed' shifts versus 'rollover' (mid-tour) rotation
- Work/leave patterns
  - 2-4 (Norway); 2-2, 3-3, 2-3 (UK)
- Long work hours
  - Basic 84 hr week, but some personnel work much longer hours
- Irregular work patterns

NOTE. 'Fatigue from shift work and overtime' is high on the UK Energy Institute's list of the 'Top Ten Issues'

Working time offshore, fatigue, and sleep



Risks to safety and health offshore

Operational risks

Resulting from human error

e.g. Explosion, fire, structural failure, shut-down, reduced productivity

Individual risks

Risk to physical and psychological well-being of individuals

e.g. Injury, illness, sleep disorders, anxiety

Day/night shift rotation offshore

- Fixed-shift schedules
  - Alternating day-shift (14D) and night-shift tours (14N)
- ‘Rollover’ schedules
  - 7 night-shifts followed by 7 day-shifts (7N/7D)
  - 7 day-shifts followed by 7 night-shifts (7D/7N)

Studies of adaptation to offshore day/night shift rotation over 2-week tours

- Assessment of sleep duration and quality, subjective alertness, positive mood, and cognitive performance

  Parkes et al, 1997

- Studies of circadian adjustment as indicated by changes in melatonin levels, and objective sleep recordings

  Gibbs et al, 2002, 2005

- Subjective alertness assessed across 2-week tours, and initial 7 days of shore break; evaluation of bright light treatment intervention.

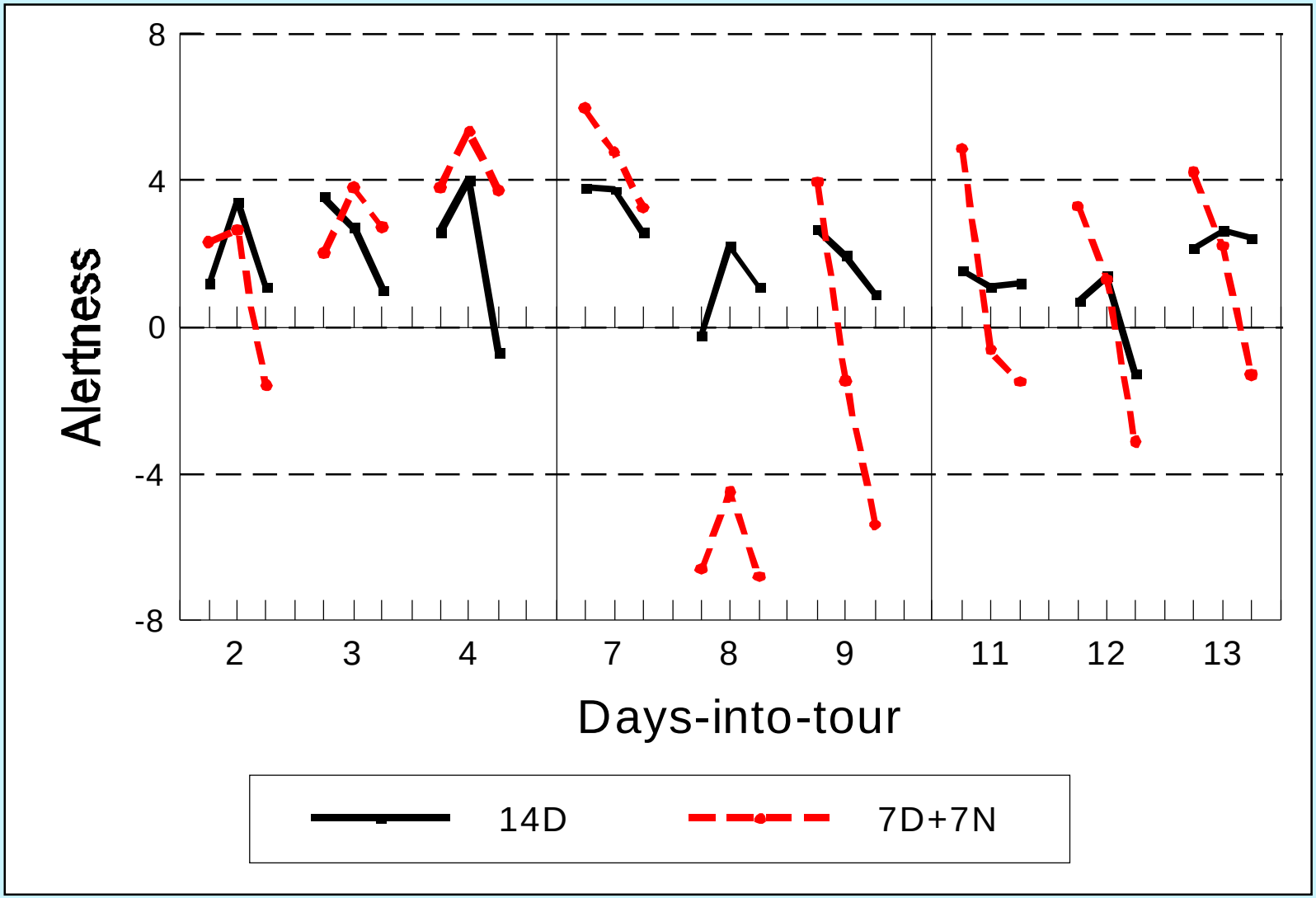
  Bjorvatn et al. 1998, 1999

Sleep, alertness, and performance in relation to day/night shift rotation

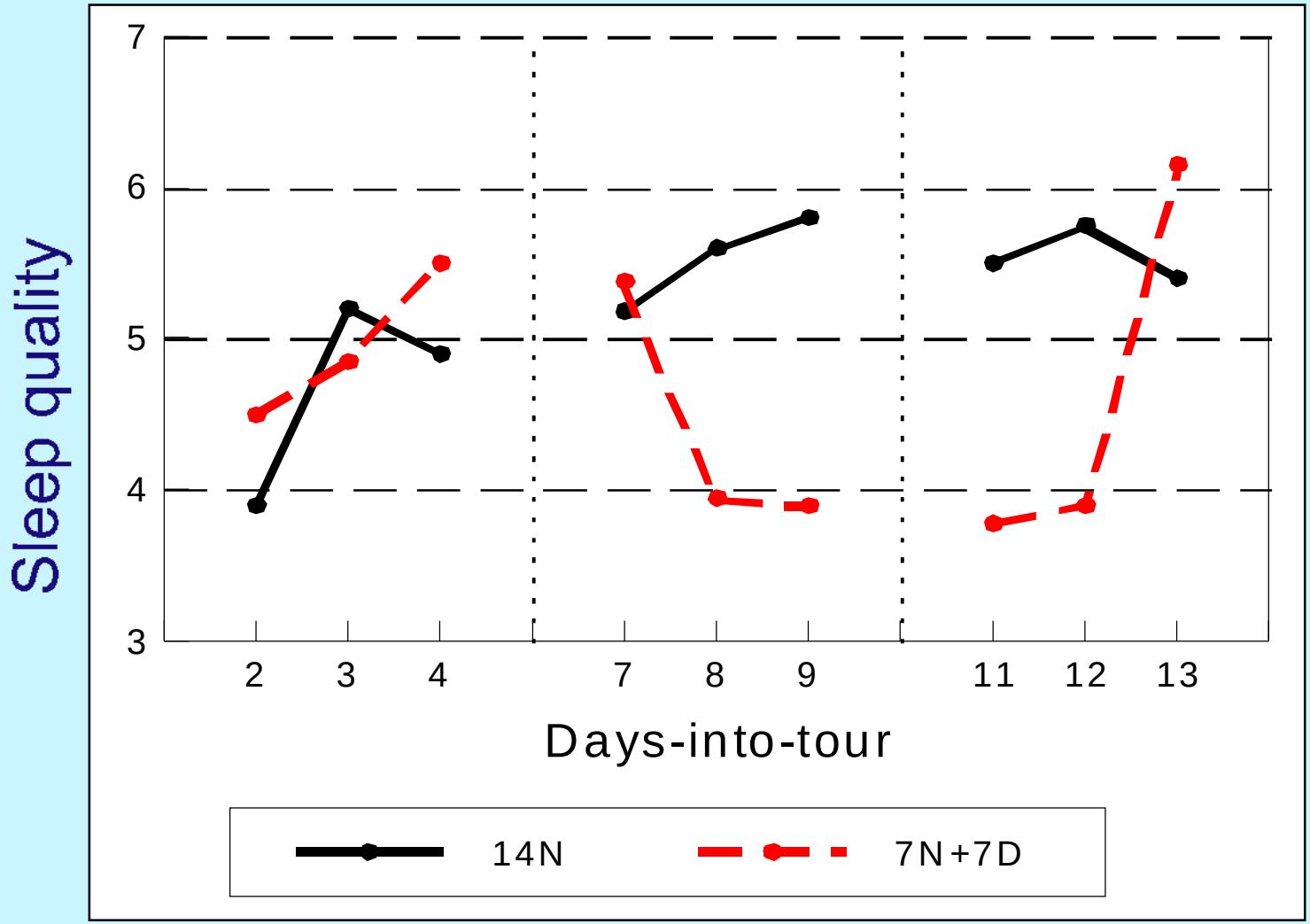
- 14 Days. Relatively stable profiles of sleep, subjective alertness, and cognitive performance across 14 shifts.
- 7D/7N. Change to night shifts in the second week impaired sleep, alertness and reaction times; sleep was disrupted, reaction times slowed, missed signals increased, and alertness decreased.
- 14 Nights. Adaptation to night shifts occurred during the first week, as indicated by increasing alertness and better sleep quality; end-of-shift reaction time decreased over the 14N shifts.
- 7N/7D. Adaptation to night shifts during the first week was disrupted by the change to day shifts; there was little evidence of re-adaptation to day work during the second week.

Parkes et al. 1997

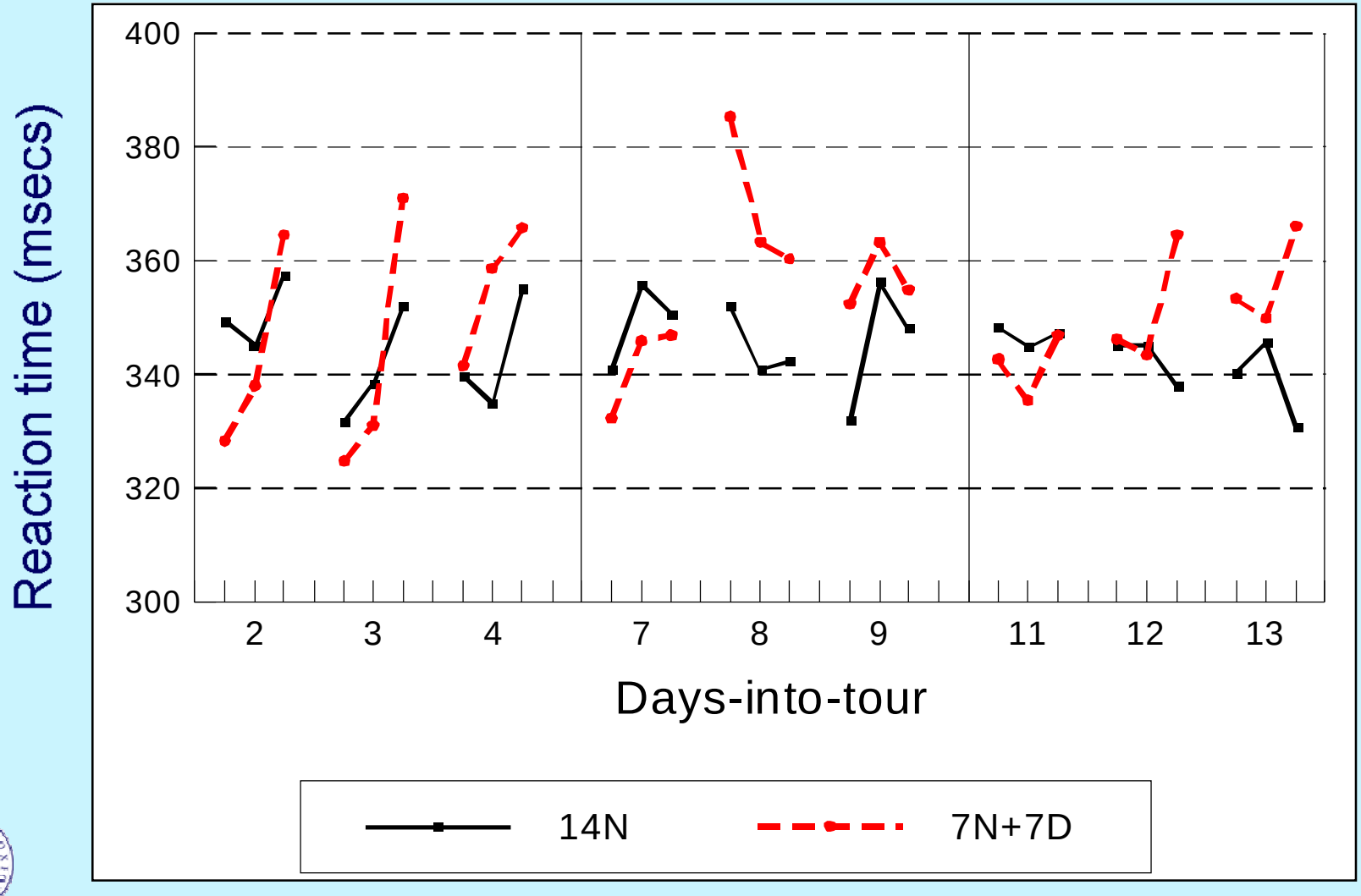
Alertness: 14 days vs 7 days/7nights



Sleep quality: 14 Nights vs 7 Nights/7 Days



Reaction time: 14 Nights vs 7 Nights/7 Days



Cognitive performance and safety

"There is no heuristic available to translate, for example, a 10% change in reaction time into some safety or health consequence" (Rosa et al, 1989)

- But comparisons can be made with the effects of alcohol on performance.
  - After 17 hrs of wakefulness, cognitive task performance declined to a level equivalent to that found for a blood alcohol level of .05% (Dawson et al, 1997)
  - Increases in reaction time during the 'rollover' shift change were 5-10%, comparable to the impairment associated with blood alcohol levels of .10% (Kennedy et al. 1993).

Melatonin studies
(Surrey University, UK)

Background: The hormone melatonin shows a light-dependent circadian rhythm closely linked to the regulation of sleep. Assessment of changes in melatonin levels over time can indicate the extent of adjustment to night/day shift changes.

Melatonin studies of offshore shift work

Gibbs et al. (2005) studied melatonin, sleep, exposure to light, and lifestyle factors among offshore day/night shift-workers in relation to 14N, 7D/7N, and 7N/7D shift rotations as compared with 14D.

- 14N. As assessed by melatonin changes, adaptation to night work occurred within the first week of night shifts.
- 7N / 7D. Adaptation to night-shifts took place by the end of the first week, but majority of the group did not adapt back to day shifts in the second week.
- 7D / 7N (Drill crew schedule). Partial adaptation, or no adaptation, to night shifts following the day-shift week.

Seasonal effects. The rate of adaptation to night-shifts was faster in Summer (mean 1.77 hr/day) than in Winter (1.32 hr/day) as a result of seasonal fluctuation in light levels.

7N / 7D mid-tour rotation

> “ . . for a 7-day sequence of 12-hr shifts, starting with the night shift, individuals would be ‘out-of-phase’ for at least 5 out of 7 days on night shifts, followed by 4-5 days out-of-phase on day shifts. Thus, in this case, optimal working conditions might only be achieved for ~5 days of a 14-day work period.”

Arendt (2001)

Fixed and rollover shift patterns: circadian changes, sleep deficits, and 'desynchrony load'

Shift pattern	Number of 12-hr circadian changes in 2-week tour		Total 'sleep deficit' over 2-week tour	'Desynchrony load' ** (Gibbs et al)
	Offshore	Shore break		
14D	0	0	12.6	13.9
14N	1	1	16.4	28.0
7D / 7N	1	1	17.7	(26.2)
7N / 7D	2	0	20.3	61.7

** Desynchrony load' is a measure of the disruption the schedule causes to circadian system over the two-week tour duration.

Adaptation of offshore personnel to night work, and re-adaptation during shore leave

- Adjustment to 14 days of offshore night work, and to the first week of shore leave, was studied using a sleep-wake diary.
- Adaptation to night work occurred ‘within a few days’; re-adaptation to normal daytime pattern at home was found to be relatively ‘slow and difficult’.
- Adaptation was facilitated by bright light treatment, particularly re-adaptation on return home.

(Bjorvatn et al. 1998)

Subjective ratings of reduced alertness during 14 night shifts offshore, and 7 days at home

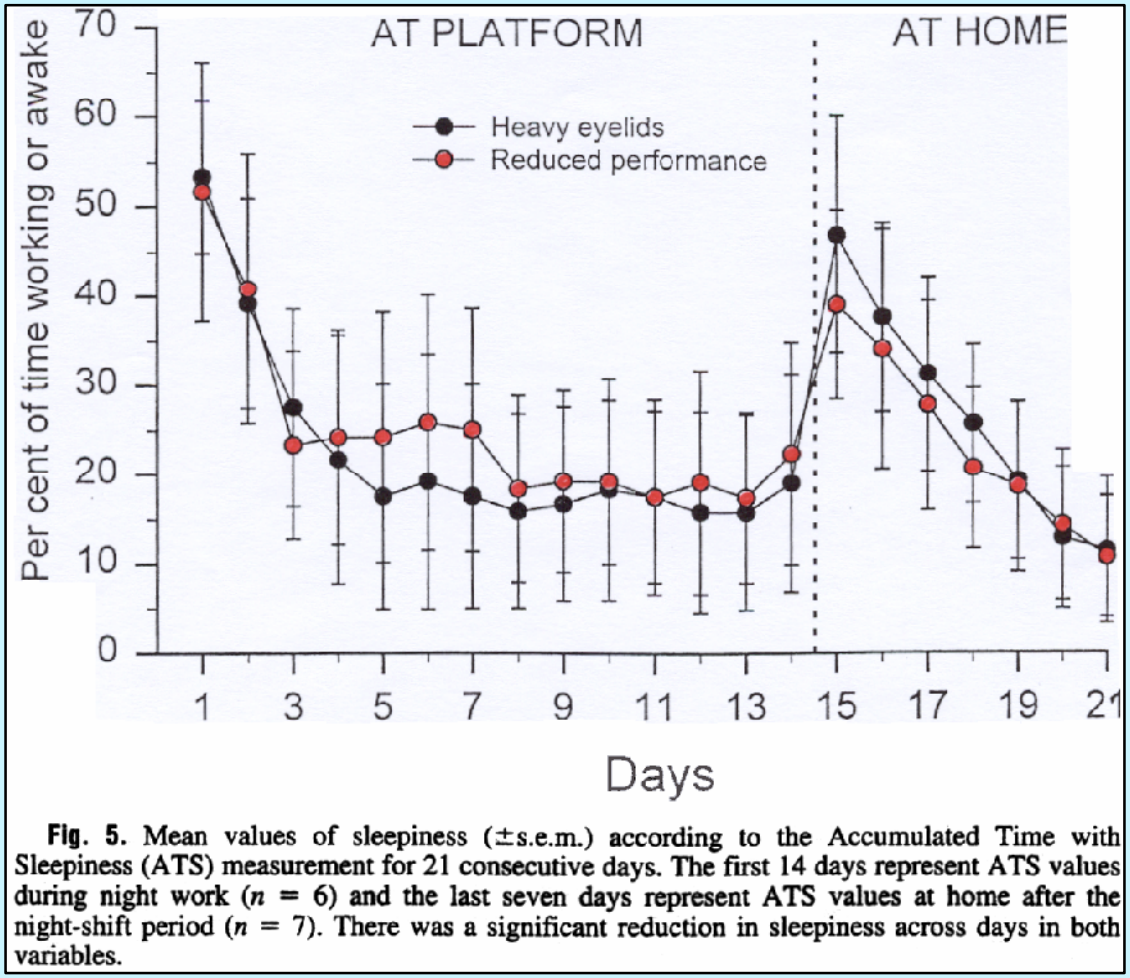


Fig. 5. Mean values of sleepiness (±s.e.m.) according to the Accumulated Time with Sleepiness (ATS) measurement for 21 consecutive days. The first 14 days represent ATS values during night work (n = 6) and the last seven days represent ATS values at home after the night-shift period (n = 7). There was a significant reduction in sleepiness across days in both variables.

(Bjorvatn, 1998, 1999)

Advantages of fixed-shift rotation as compared with rollover patterns

- Only half as many 12-hr circadian adjustments required in each year of offshore day/night shift work.
- Lowest overall levels of ‘desynchrony load’ and sleep deficits over a two-week tour, ie. least circadian disruption
- Greater stability of sleep, alertness, and performance over the two-week cycle: adaptation to night work is not disrupted by mid-cycle shift change.
- Little or no impairment of alertness or reaction time over individual shifts, during days or (after initial adaptation) during nights.

Disadvantages of fixed-shift rotation

- Disliked by many offshore personnel, who prefer to go on leave adjusted to a normal sleep/wake cycle. Having to re-adapt at home after 14 night shifts is particularly resented by personnel who have only 2-weeks leave.
- Potential danger of driving home from heliport after two weeks of night shifts. Accommodation provided at heliport?
- Need to schedule alternate day and night shift tours rather than the same shift pattern each tour.
- ‘Handover’ problems if both the day and the night crew leave on same day.

3-3 work/leave schedules

- 2-week offshore tours are the norm on North Sea installations, but some personnel in the UK sector work 3-3 rosters.
- 3-week offshore tours are disliked, but less so on drilling rigs than on production platforms. Spouses also dislike 3-3 work patterns.
- Studies of 3-3 patterns are scarce, but some evidence suggests a weak trend of reduced alertness across successive weeks.

Parkes et al. 1997

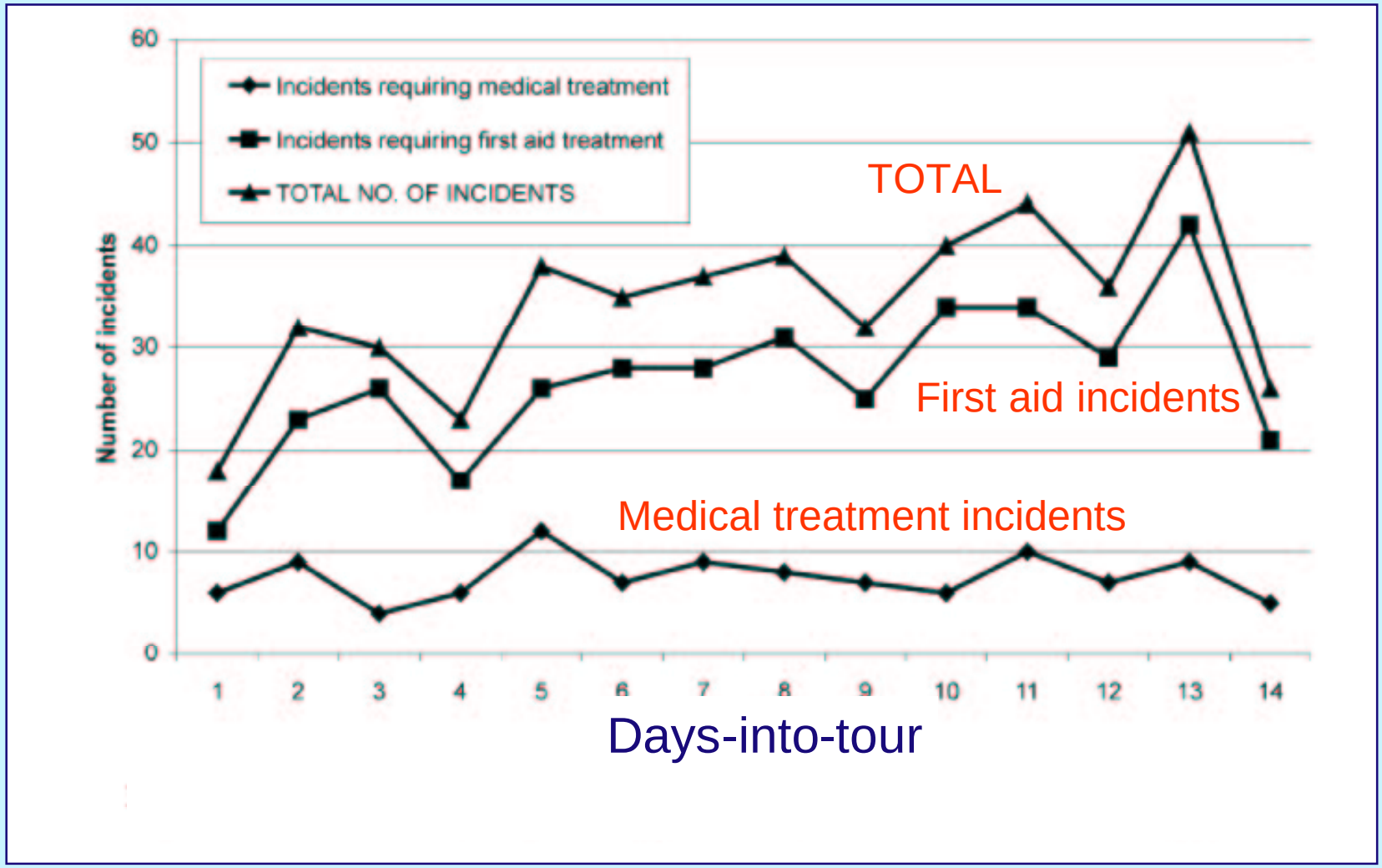
Individual risks in relation to offshore work hours

- Accidents and injuries
- Physical and psychological health problems
  - Sleep complaints
  - Psychosomatic problems
  - Psychological distress, anxiety
  - Longer-term health implications?

Injury rates in relation to shift rotation

- Forbes (1997). Among drill crew, injury rates for ‘rollover’ rotations were almost three times higher than for fixed-shift patterns, partly due to mid-tour shift changes. More incidents in the first week than in the second week.
- Lauridsen et al (1990). Injury rates were elevated during the initial shifts of night work, irrespective of whether it was the first or the second week. Crew change-over days showed increased injury rates.
- Mikkelsen et al (2004). ‘First aid’ incidents showed an increase in frequency across days-into-tour, but ‘medical treatment’ incidents did not. Length of prior leave period (3 vs. 4 weeks) did not effect number of incidents.

Incidents in relation to days-into-tour



Mikkelsen et al. (2004)

Analysis of large-scale injury data

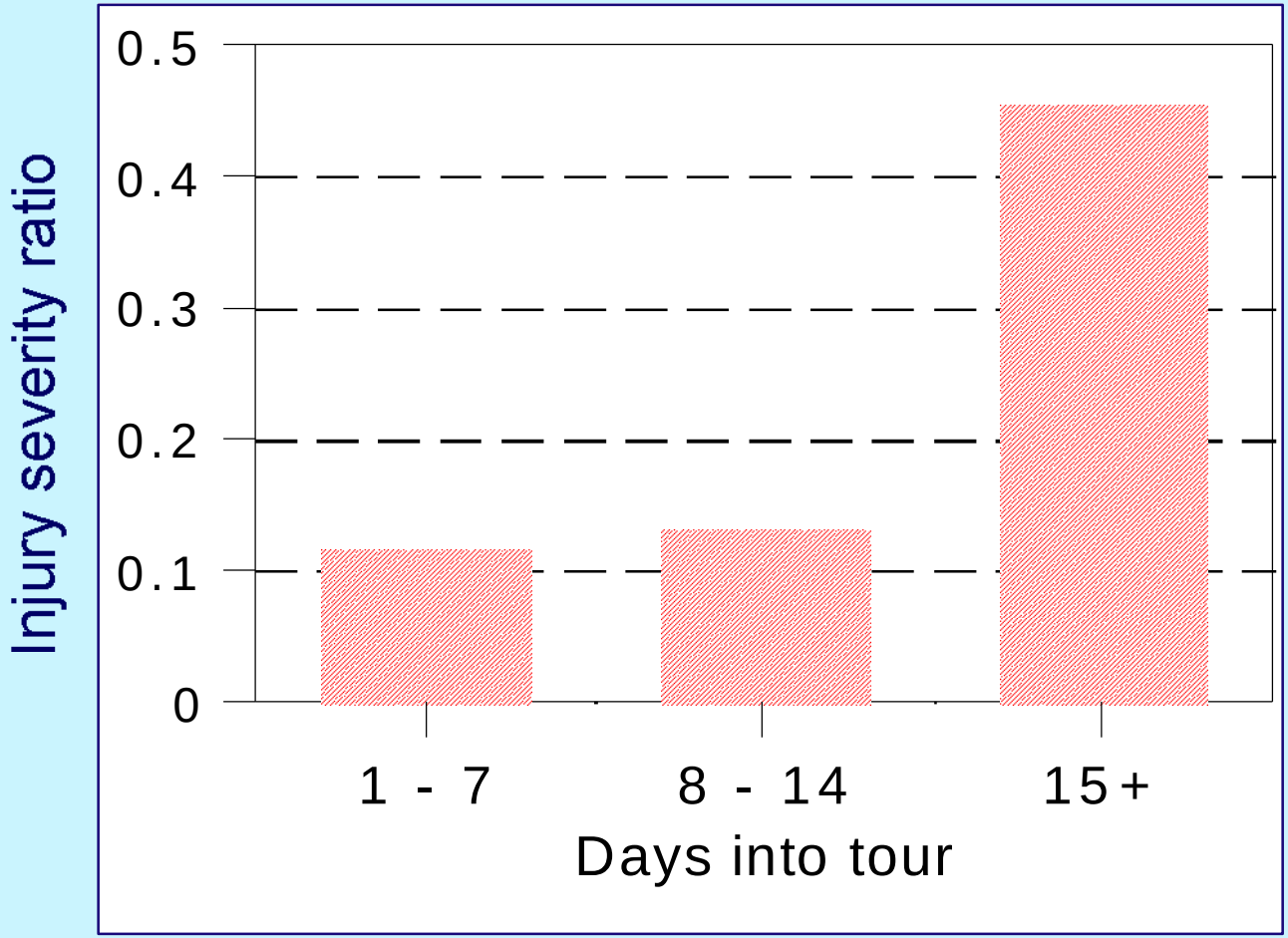
- In the absence of base rate ‘exposure’ information, injury severity can be examined in relation to working time.

  ‘If an injury occurs, does the severity of the injury vary across different work hours?’

- Day vs night shifts. Night shifts showed higher rates of serious injuries relative to 3+ day injuries.
- Hours-into-shift. The ratio of severe injuries to 3+ day injuries increased significantly for shift durations of greater than 12 hrs.
- Days-into-tour. The ratio of fatalities and severe injuries to 3+ day injuries increased steeply for tour durations of more than 14 days.

Parkes et al. 2000

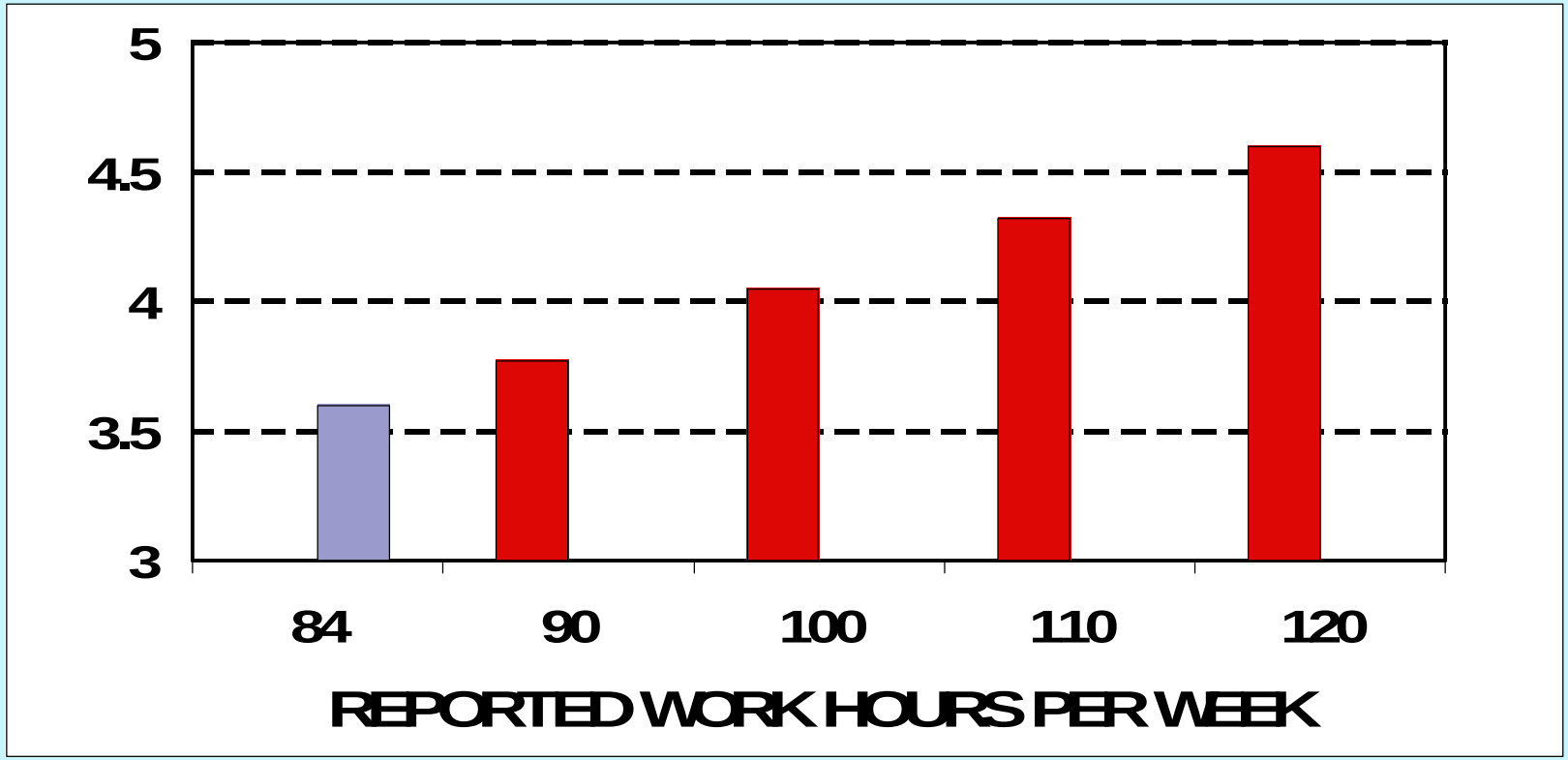
Ratio of fatalities/severe injuries to 3+ day injuries in relation to days-into-tour



Long work hours offshore

- Overall, 46% of day-shift personnel reported longer work hours than the standard 84hr week.
- Work hours >84 hrs per week were most likely to be reported by:
  - Senior management personnel
  - Operating company personnel on production platforms
  - Day workers as compared with day/night shift workers
- 55% of senior management personnel reported working >100 hrs per week.

Anxiety in relation to work hours: Offshore platforms (N=1047 personnel)



Analysis controlled for job type, shiftwork, personality, and age

Offshore work hours and sleep

- Longer work hours among offshore day-workers were directly and significantly related to shorter sleep durations.
- For those working a 84hr week, mean sleep duration was 7.01 hrs per night

  For those working >104 hrs per week, mean sleep duration was 6.03 hrs per night
- But sleep hours during shore leave were unrelated to work hours.

Current issues in offshore industry

- An ageing workforce
- Recruitment problems and skill shortages
- Extending oil exploration and production to more remote and ‘hostile’ environments.
- Increased proportion of women offshore
- The European Working Time Directive

Operational and individual risks offshore: some areas of further research need

- Effects of age in relation to offshore shift patterns and workload levels. Do some work patterns place older workers at disproportionate risk?
- Identification of individual and environmental factors which may accentuate or reduce operational and individual risks associated with working time patterns.
- Health and performance effects of long work hours among offshore managers and other senior personnel
- Possible gender differences in the impact of offshore work patterns and long hours. Implications for families.
- Effects of irregular work patterns among contractors
- Longitudinal studies of health impact of offshore shiftwork

Website:

http://www.psy.ox.ac.uk/stressgroup/

E-mail:

kathy.parkes@psy.ox.ac.uk

Percentages of personnel reporting sleep problems and gastric problems in relation to shift rotations

Shift pattern	Sleep %	Gastric %	Sample size
Days only	41.3	28.6	1009
14 / 14 ‘fixed shift’	46.2	30.5	184
7 / 7 ‘rollover’	56.8	33.8	435

Comments about shift rotation patterns

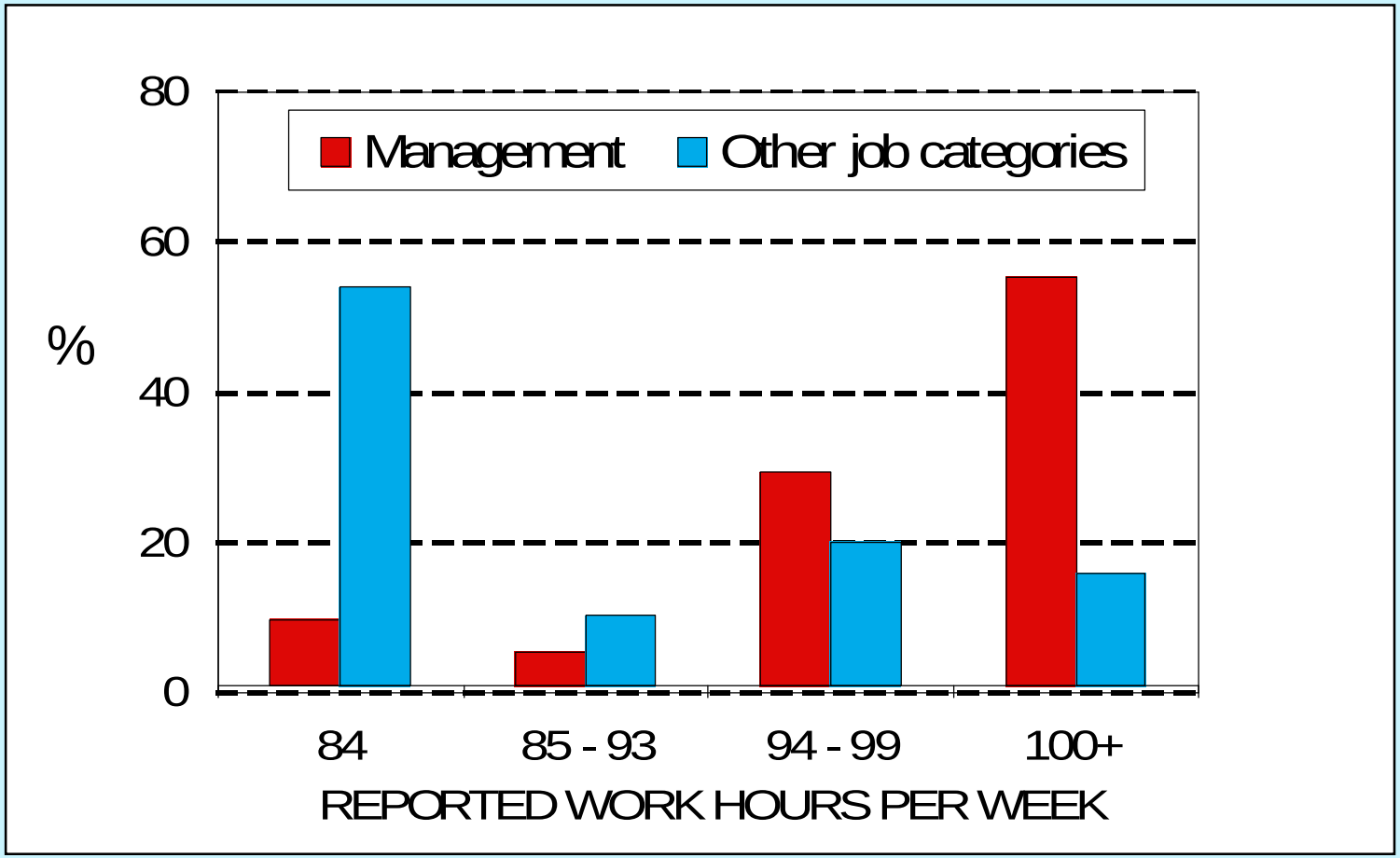
"I have felt a lot better over the last 3 months since we changed our shift pattern to 2 weeks days, 2 weeks nights as I sleep much better now" (14/14)

"Night shifts tire me a lot more than anything else and the effects last at least a week into my leave" (14/14)

"My only present concern is that . . . . we do a week of nights then change over to a week of days – this tends to upset sleep patterns" (7/7)

Work hours in relation to job type

Offshore platforms (N= 533, dayshift personnel)



- Effects of bright light treatment on the adjustment and re-adjustment. Participants were exposed to bright light for periods of 30 minutes for the first 4 night shifts offshore and the first 4 days on returning home.
- Adaptation was facilitated by bright light treatment, particularly re-adaptation on return home.

(Bjorvatn et al. 1999)