An underwater photograph showing a diver in the upper left, illuminated by a bright blue light source. The foreground is filled with diverse coral life, including a prominent yellow branching coral. A small, colorful fish is visible near the center. The background is a deep, dark blue.

# Cardiovascular disease & diving

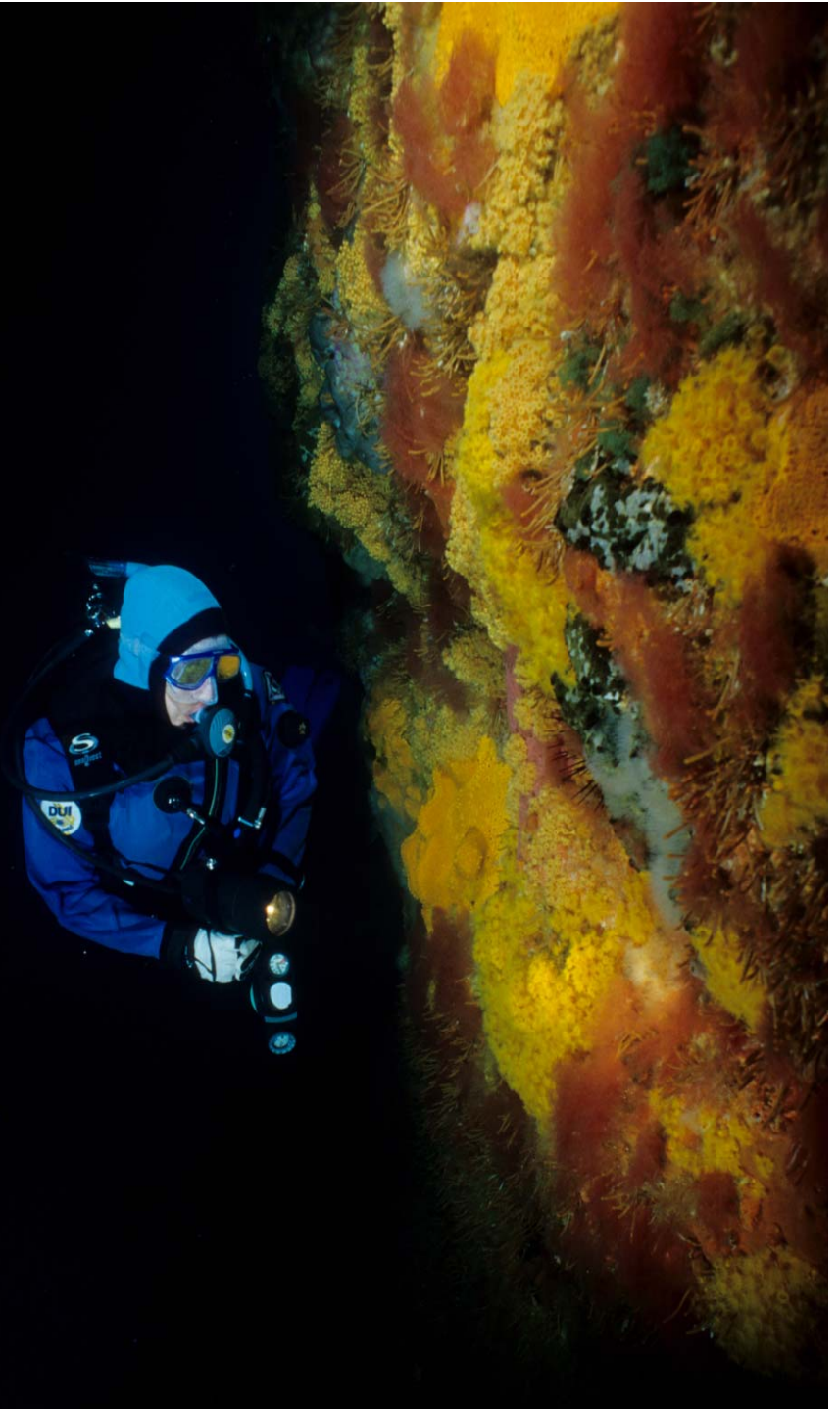
## What is the problem?

DAN Fatality Workshop  
Durham  
April 2010

Assoc Prof Simon Mitchell  
MD, PhD, DipDHM, FANZCA  
Department of Anesthesiology  
University of Auckland

# Topics

1. Scuba deaths and their causes
2. Systems for evaluating health of diver candidates
3. Systems for monitoring health of divers
4. The task ahead of us at this workshop





**Background:  
Scuba deaths and  
their causes**



## Original articles

### Scuba injury death rate among insured DAN members

Petar J Denoble, Neal W Pollock, Panchabi Vaithiyanathan, James L Caruso, Joel A Dovenbarger and Richard D Vann

#### Key words

Accidents, age, cardiovascular, deaths, diving accidents, DAN – Divers Alert Network, epidemiology

- Annual death rate among insured DAN members 2000 – 2006 = 16 per 100,000
- Confluent with previous estimates

# How should we view that number?

**Any death is bad. We should make every effort to identify and ameliorate contributory risks**

**These numbers are small. Diving is a safe sport. No need to panic.**

- ~ 13 per 100,000 joggers die annually from heart attacks whilst jogging

Any death is bad. We should make every effort to identify and ameliorate contributory risks

These numbers are small. Diving is a safe sport. No need to panic.

In fact, these perspectives are not mutually exclusive: both views have merit

What are the contributory risks that can be modified?

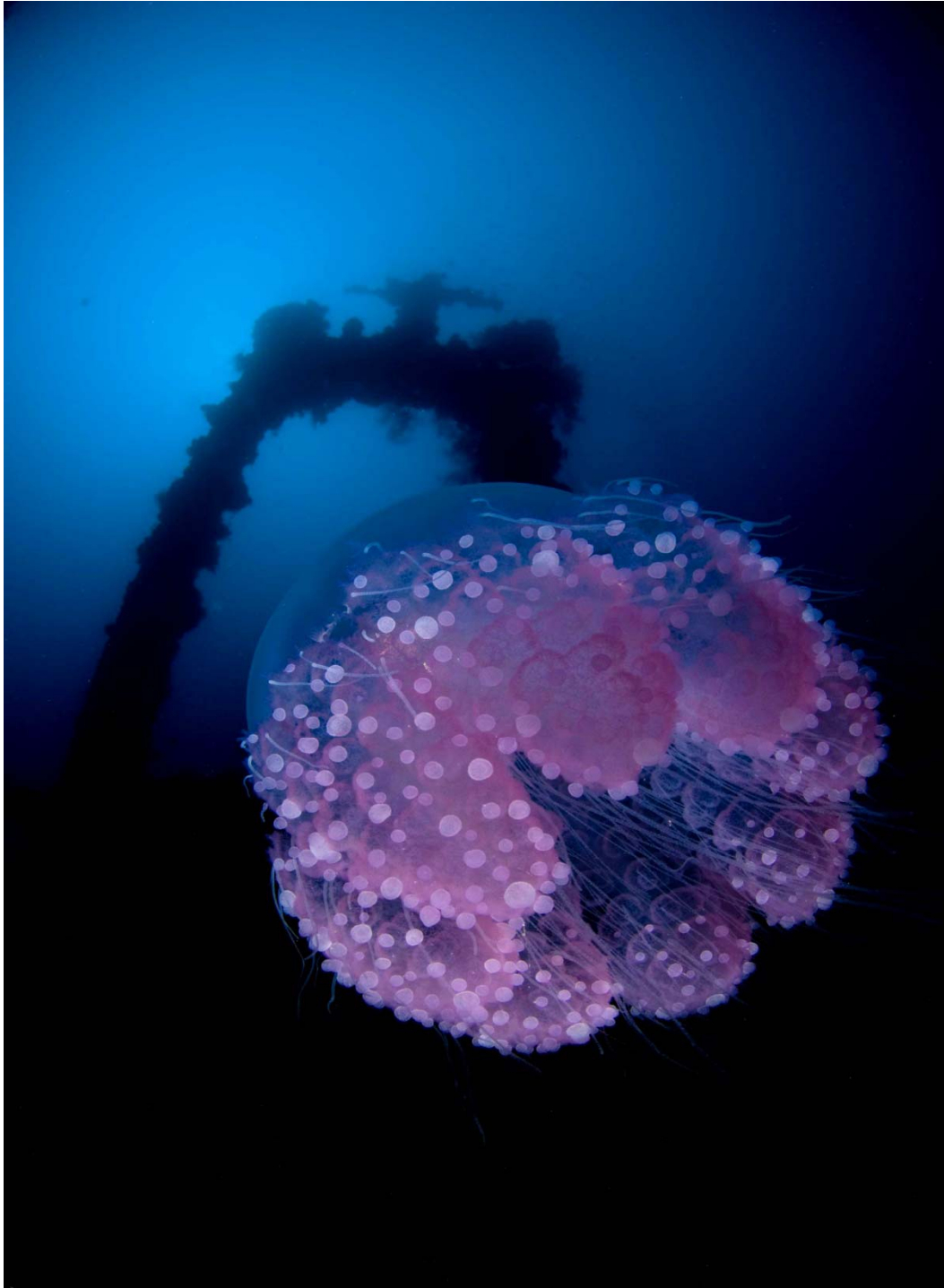
# **Common causes of open-circuit recreational diving fatalities.**

P. J. DENOBLE<sup>1</sup>, J. L. CARUSO<sup>1,2,3</sup>, G. de L. DEAR,<sup>1,2</sup> C. F. PIEPER,<sup>4</sup> and R. D. VANN<sup>1,2</sup>

*<sup>1</sup>Divers Alert Network, <sup>2</sup>Center for Hyperbaric Medicine and Environmental Physiology, Department of Anesthesiology; <sup>4</sup>Center for Aging, Division of Biostatistics and Bioinformatics, Duke University Medical Center, Durham, NC 27710, <sup>3</sup>Armed Forces Institute of Pathology Office of the Armed Forces Medical Examiner, Rockville, MD 20850.*

**Analysis of 947 open circuit recreational diver deaths  
1992 – 2003**





## **Denoble et al.**

### **Hierarchy of causative events**

- Trigger
- Disabling agent
- Disabling injury
- Cause of death



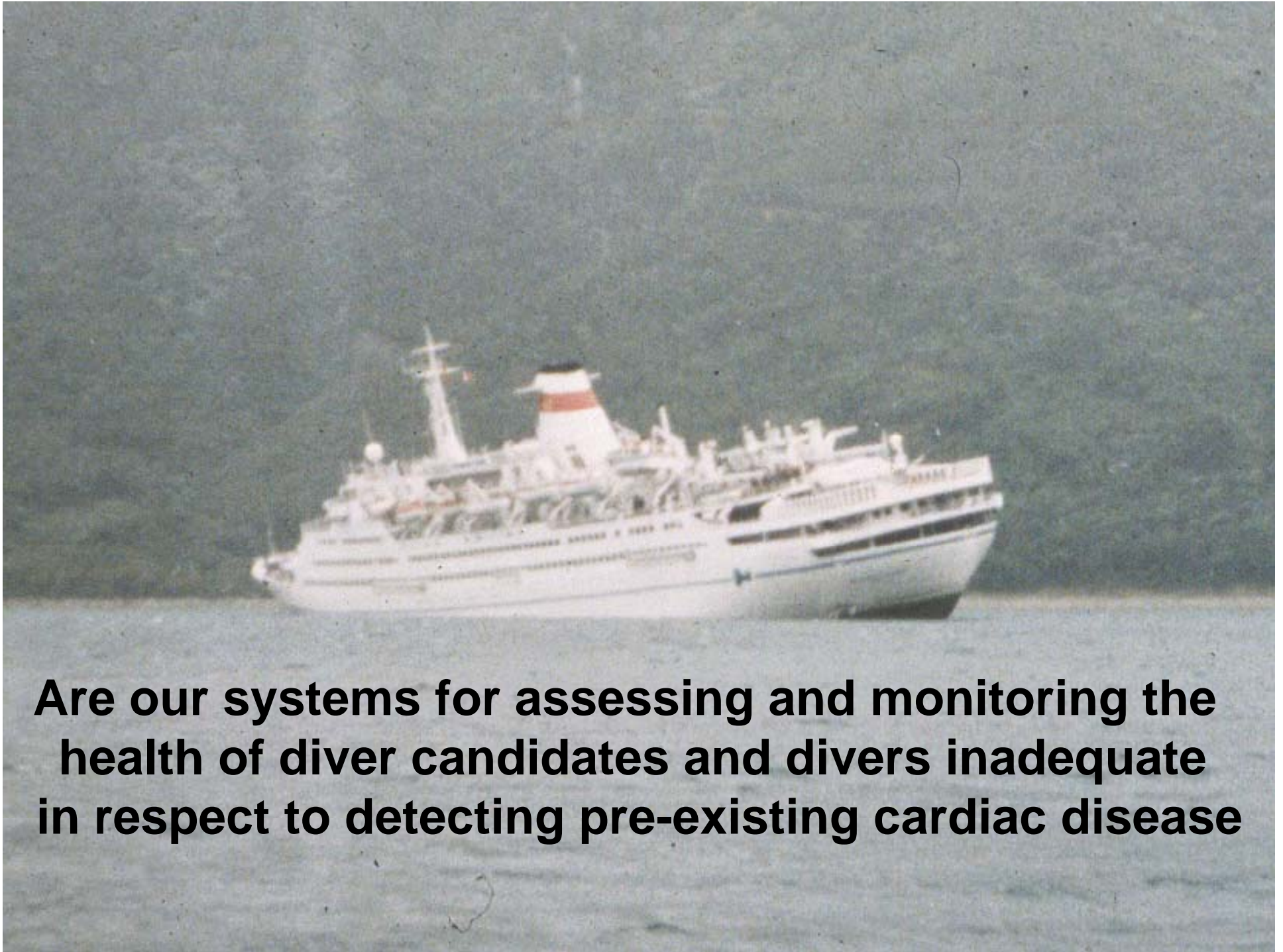
Denoble et al. 2008

A cardiac incident was  
the disabling injury  
in 26% of cases

Pre-existing cardiac  
disease and age  
>40 were strongly  
associated with  
cardiac incidents







**Are our systems for assessing and monitoring the health of diver candidates and divers inadequate in respect to detecting pre-existing cardiac disease**



**How do we assess  
health of recreational  
diver candidates?**



NEUMAN & THOM

# PHYSIOLOGY AND MEDICINE OF HYPERBARIC OXYGEN THERAPY

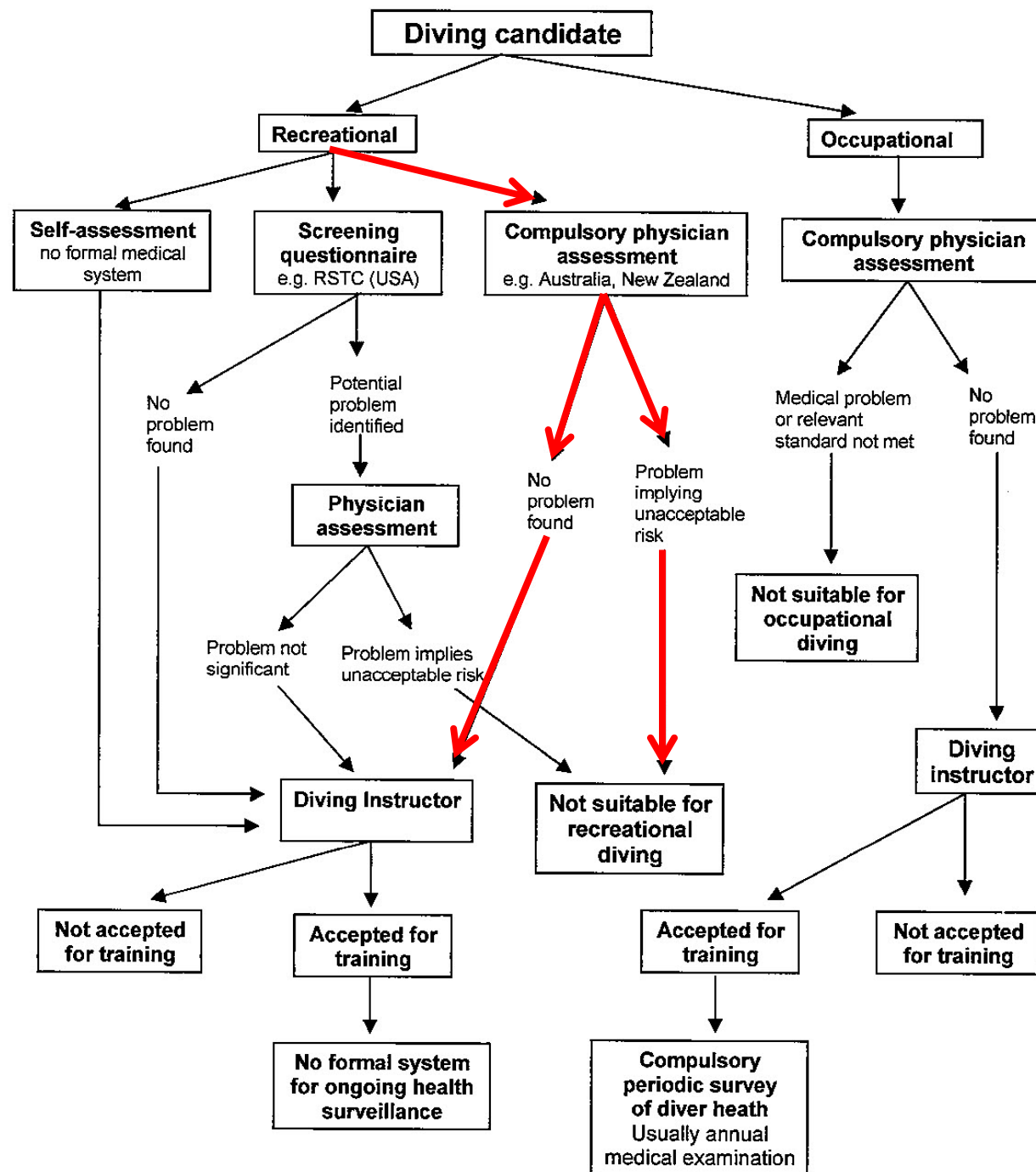


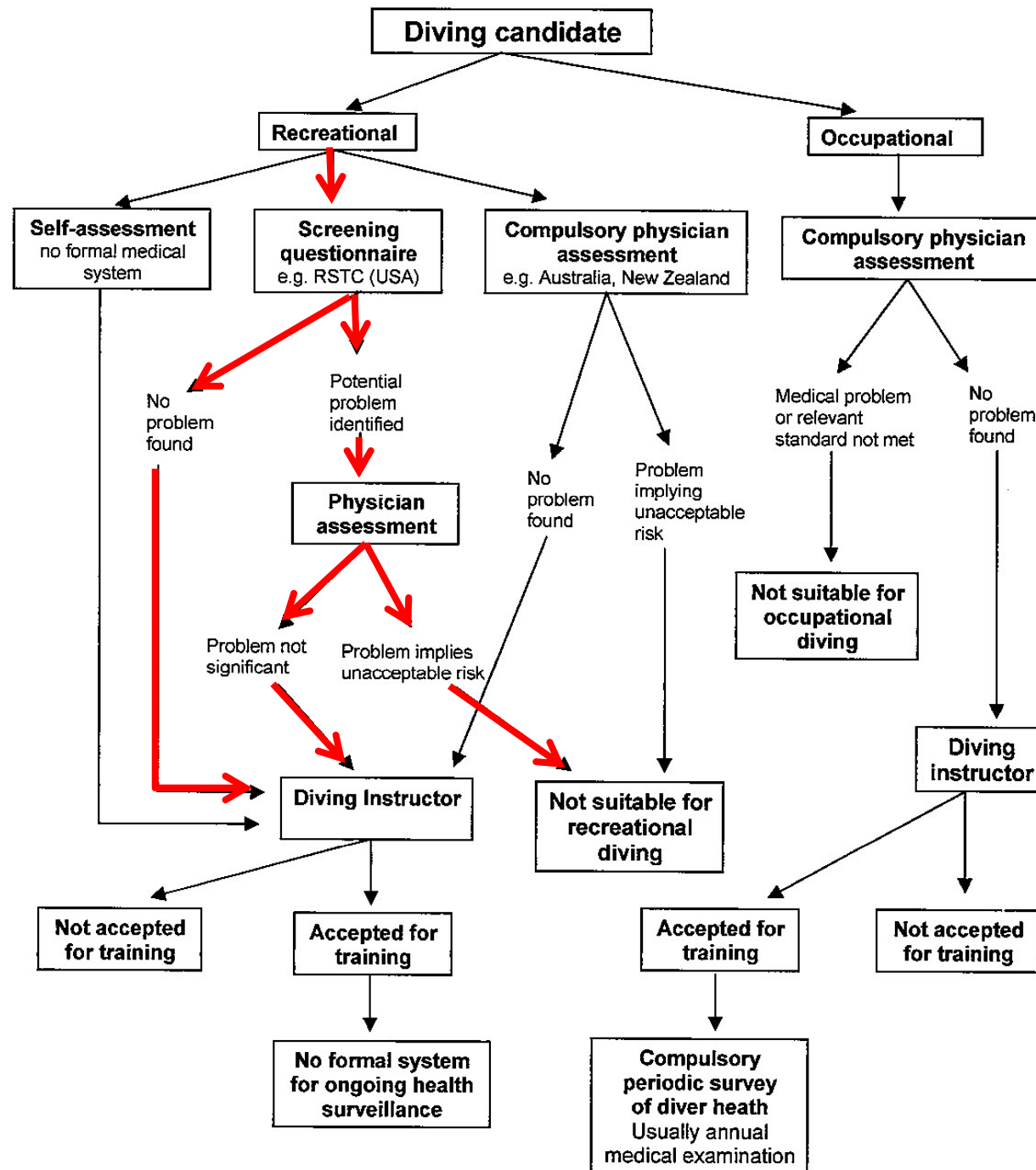
SAUNDERS  
ELSEVIER

**Mitchell SJ, Bennett MH**

**‘Clearance to dive and  
fitness for work’  
2008**







# Is this where the problem lies?

Is the widely used screening questionnaire system inferior to a compulsory medical system?

- “Divers might lie on the questionnaire”
  - True, but that could also apply to the history given in an office consultation
- The examination might detect important problems that are missed by history
  - True, but how often does this happen, especially in young candidates?

## Medical supervision of sport diving in Scotland: reassessing the need for routine medical examinations

Stephen Glen, Steven White, James Douglas

- Records of 2962 'traditional' medical evaluations examined
- 174 subjects had abnormalities on examination
- No examination abnormality alone resulted in withholding of clearance to dive
- All problems that resulted in withholding of clearance were revealed by questionnaire



**ORIGINAL ARTICLE**

## Three year follow up of a self certification system for the assessment of fitness to dive in Scotland

S Glen

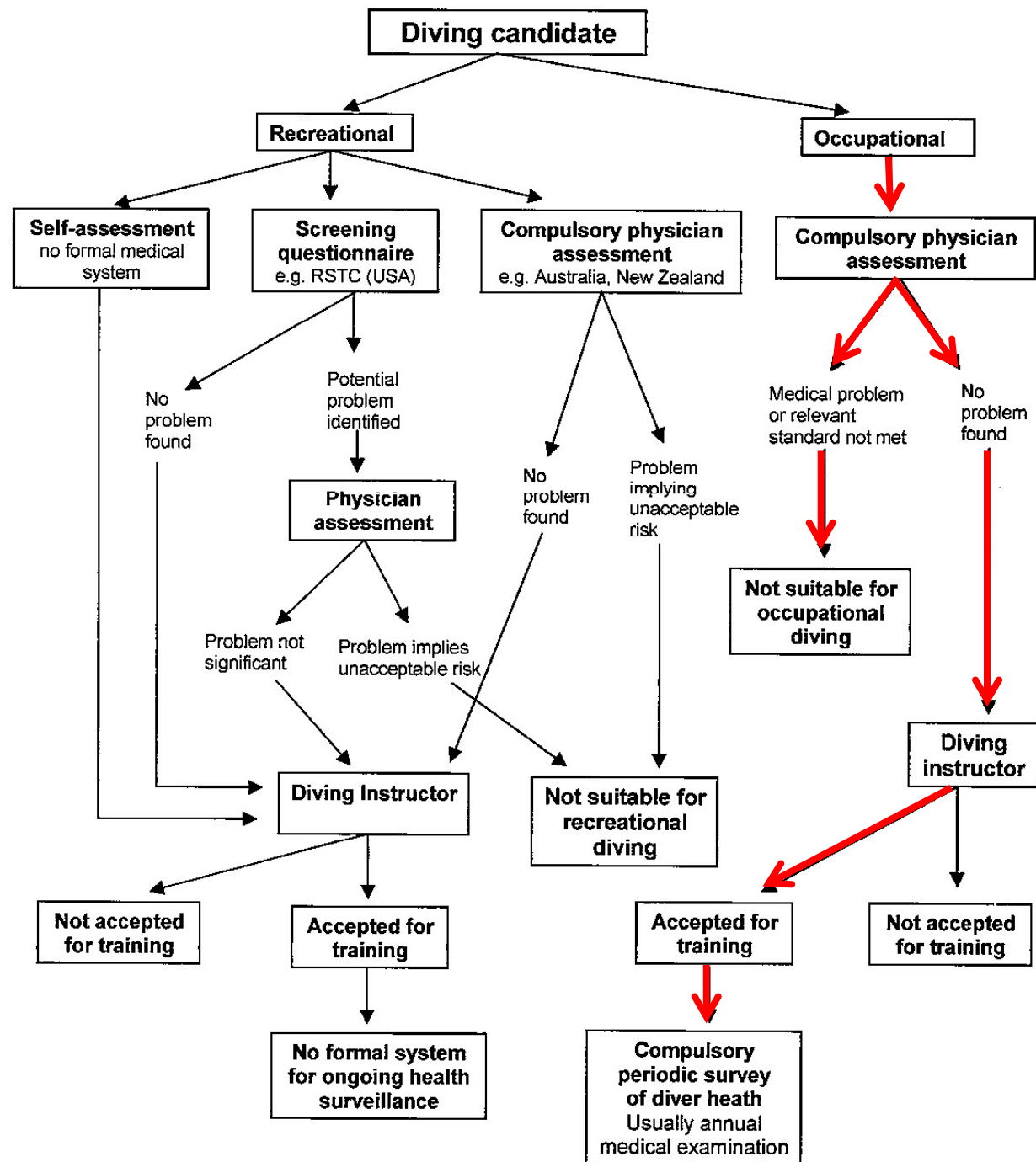
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*Br J Sports Med* 2004;**38**:754–757. doi: 10.1136/bjsm.2003.008987

- Numbers difficult to interpret
- 7.7% of divers referred for evaluation on basis of questionnaire
- 2% had clearance withheld
- 15 incidents involving divers assessed under new system – none related to undetected medical problems

## Medical consultations in occupational diving...





# Occupational diving

- This requirement for compulsory medical evaluation and periodic health surveillance is driven by health and safety in employment legislation....
- But is a comprehensive annual medical really necessary?



# New Zealand '5 yearly' system

- Compulsory comprehensive medical evaluation on entry to industry
  - Repeated only 5 yearly unless more frequent review indicated
  - Centrally reviewed
- In intervening years, comprehensive questionnaire with central review
  - Positive responses to questionnaire trigger medical evaluation



BRIEF COMMUNICATIONS

**Utility of regular medical examinations of occupational divers**

C. Sames,<sup>1,2</sup> D. Gorman,<sup>2,3</sup> S. J. Mitchell<sup>2,3</sup> and G. Gamble<sup>3</sup>

<sup>1</sup>Naval Health Services, Royal New Zealand Navy, <sup>2</sup>Diving Medical Directorate to the New Zealand Department of Labour, and <sup>3</sup>School of Medicine of the University of Auckland, Auckland, New Zealand

- Audit of all NZ occupational diver records
- At time, 336 had completed the first 5 year cycle of the new medical system
  - Initial medical → 4 questionnaires → 2<sup>nd</sup> medical
- 10 had assessment outcomes that temporarily or permanently affected their careers

**Table 2 Details of 10 New Zealand occupational divers whose employment was affected by the outcome of an iterative medical examination or questionnaire**

Category	Sex / Age	Method of Identification	Medical problem
Permanently unfit for diving	M / 35	Questionnaire	Spinal Injury
Temporarily unfit for diving	M / 33	Spirometry	Impaired lung function
	M / 55	Questionnaire	Heart surgery
	M / 36	Questionnaire	Deafness and tinnitus
	M / 36	Questionnaire	Deafness and head injury
Conditional certification for diving	F / 45	Spirometry	Impaired lung function
	M / 34	Questionnaire	Otic barotrauma
	M / 49	Questionnaire	Heart surgery
	M / 58	Questionnaire	Asthma
	M / 53	Questionnaire	Atrial fibrillation

No critically important health problems were missed by the questionnaire

~336 x 4 = 1344 medical consultations were avoided

## Is this where the problem lies?

Is the widely used screening questionnaire system inferior to a compulsory medical system?

- The evidence available at this time does not suggest that questionnaire systems are inferior to compulsory medical exam systems in detecting important medical problems
- It remains “on the table” but in my opinion “across the board” compulsory medical examinations are not the answer



Can the screening questionnaire be improved?





## MEDICAL STATEMENT

Participant Record (Confidential Information)

### Divers Medical Questionnaire

#### To the Participant:

The purpose of this Medical Questionnaire is to find out if you should be examined by your doctor before participating in recreational diver training. A positive response to a question does not necessarily disqualify you from diving. A positive response means that there is a preexisting condition that may affect your safety while diving and you must seek the advice of your physician prior to engaging in dive activities.

- \_\_\_\_ Could you be pregnant, or are you attempting to become pregnant?
- \_\_\_\_ Are you presently taking prescription medications? (with the exception of birth control or anti-malarial)
- \_\_\_\_ Are you over 45 years of age and can answer YES to one or more of the following?
  - currently smoke a pipe, cigars or cigarettes
  - have a high cholesterol level
  - have a family history of heart attack or stroke
  - are currently receiving medical care
  - high blood pressure
  - diabetes mellitus, even if controlled by diet alone

#### Have you ever had or do you currently have...

- \_\_\_\_ Asthma, or wheezing with breathing, or wheezing with exercise?
- \_\_\_\_ Frequent or severe attacks of hayfever or allergy?
- \_\_\_\_ Frequent colds, sinusitis or bronchitis?
- \_\_\_\_ Any form of lung disease?
- \_\_\_\_ Pneumothorax (collapsed lung)?
- \_\_\_\_ Other chest disease or chest surgery?
- \_\_\_\_ Behavioral health, mental or psychological problems (Panic attack, fear of closed or open spaces)?
- \_\_\_\_ Epilepsy, seizures, convulsions or take medications to prevent them?
- \_\_\_\_ Recurring complicated migraine headaches or take medications to prevent them?
- \_\_\_\_ Blackouts or fainting (full/partial loss of consciousness)?
- \_\_\_\_ Frequent or severe suffering from motion sickness (seasick, carsick, etc.)?

Please answer the following questions on your past or present medical history with a **YES** or **NO**. If you are not sure, answer **YES**. If any of these items apply to you, we must request that you consult with a physician prior to participating in scuba diving. Your instructor will supply you with an RSTC Medical Statement and Guidelines for Recreational Scuba Diver's Physical Examination to take to your physician.

- \_\_\_\_ Dysentery or dehydration requiring medical intervention?
- \_\_\_\_ Any dive accidents or decompression sickness?
- \_\_\_\_ Inability to perform moderate exercise (example: walk 1.6 km/one mile within 12 mins.)?
- \_\_\_\_ Head injury with loss of consciousness in the past five years?
- \_\_\_\_ Recurrent back problems?
- \_\_\_\_ Back or spinal surgery?
- \_\_\_\_ Diabetes?
- \_\_\_\_ Back, arm or leg problems following surgery, injury or fracture?
- \_\_\_\_ High blood pressure or take medicine to control blood pressure?
- \_\_\_\_ Heart disease?
- \_\_\_\_ Heart attack?
- \_\_\_\_ Angina, heart surgery or blood vessel surgery?
- \_\_\_\_ Sinus surgery?
- \_\_\_\_ Ear disease or surgery, hearing loss or problems with balance?
- \_\_\_\_ Recurrent ear problems?
- \_\_\_\_ Bleeding or other blood disorders?
- \_\_\_\_ Hernia?
- \_\_\_\_ Ulcers or ulcer surgery ?
- \_\_\_\_ A colostomy or ileostomy?
- \_\_\_\_ Recreational drug use or treatment for, or alcoholism in the past five years?

Slide by Dr Pamela Douglas

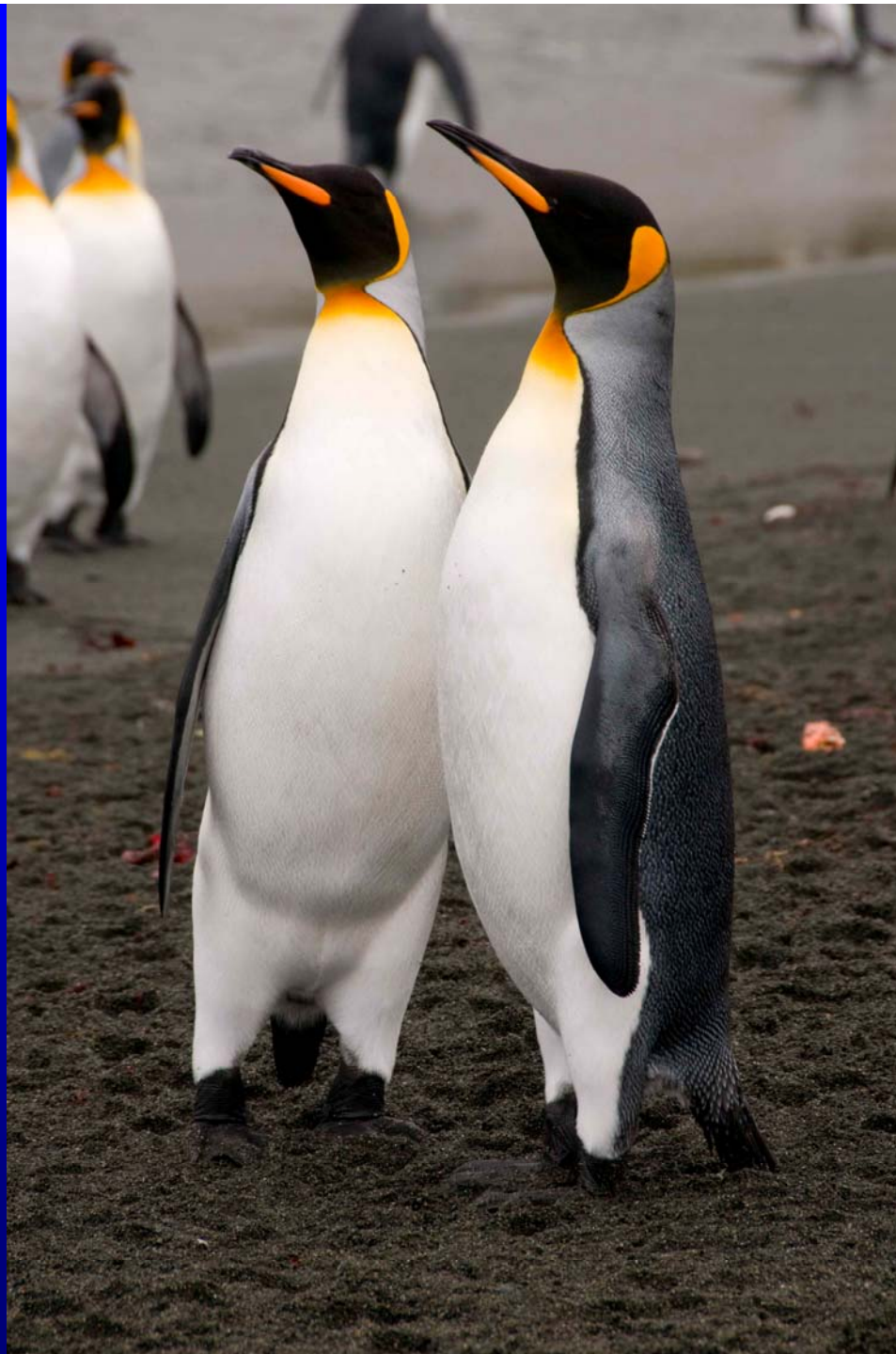
## How might it be modified?

- ? Everyone above a threshold age has a medical examination with a low threshold for investigations for CV disease
- ? A more demanding definition of appropriate functional capacity
  - Diving is generally not demanding, but for short periods may require better capacity than walking at 5 mph
- ? More sensitive indicators of cardiac risk

# Are we providing optimal advice to physicians who review divers based on their questionnaire responses?

- Current supporting documentation says:
  - “Individuals older than 40 years are recommended to undergo risk assessment for coronary artery disease. Formal exercise testing may be needed to assess the risk.”
  - “The suggested minimum criteria for stress testing is at least 13 Mets.”
- Is the 13 Met requirement appropriate?
- What “formal testing” is most appropriate in the modern context?













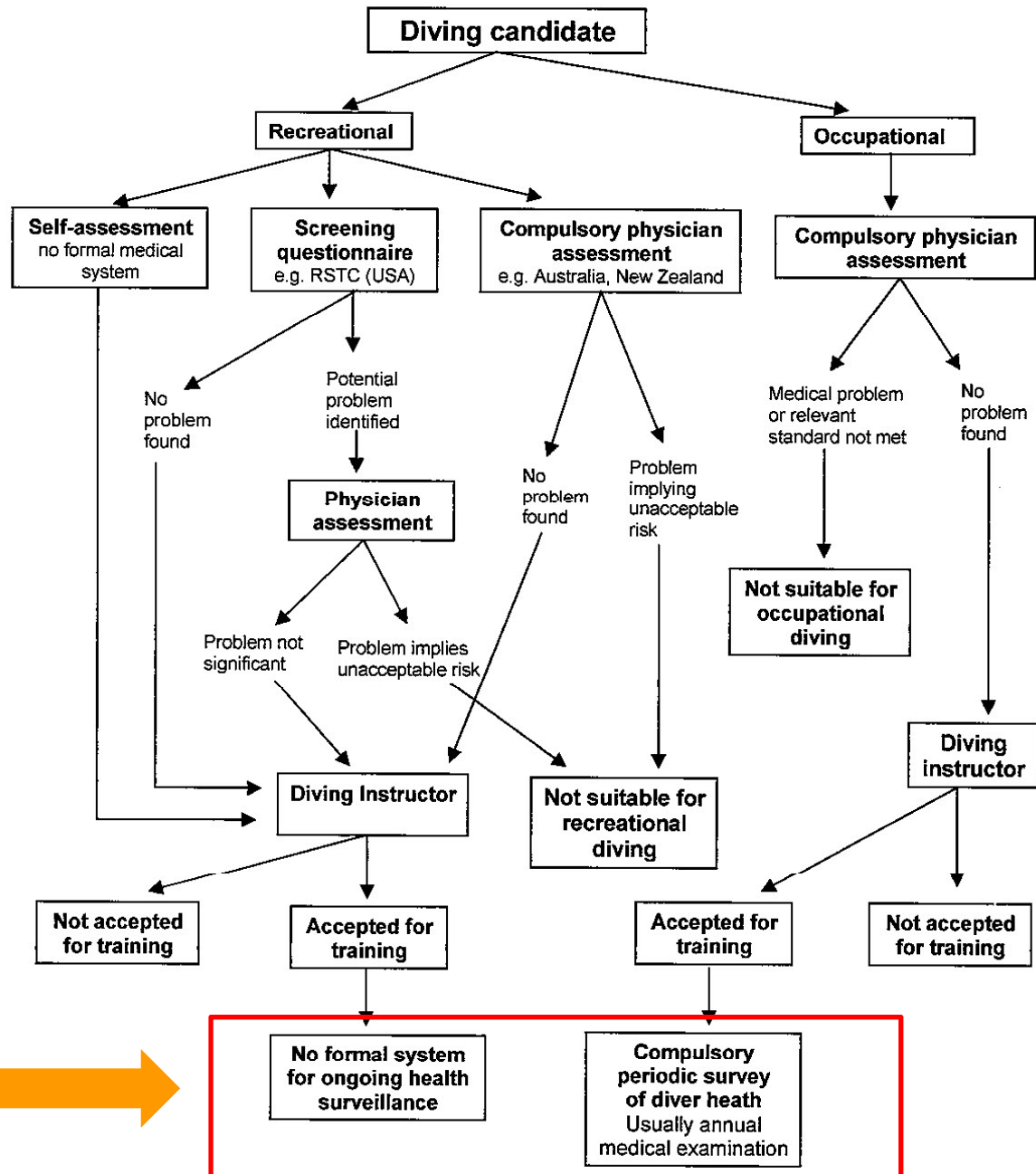
**How do we monitor health  
of recreational divers?**



**We  
don't**

**Not recreational  
divers**

**Is this  
a crucial  
issue?**



## Is this where the problem lies?

- Even if questionnaire systems are adequate for assessment of diver candidates, the fact remains that a recreational diver may complete one at a 'young' age and then dive for decades without any further evaluation of health for diving
- Divers who are screened appropriately at entry to the sport may develop undetected cardiac disease over many years of participation

# How might this situation be modified?

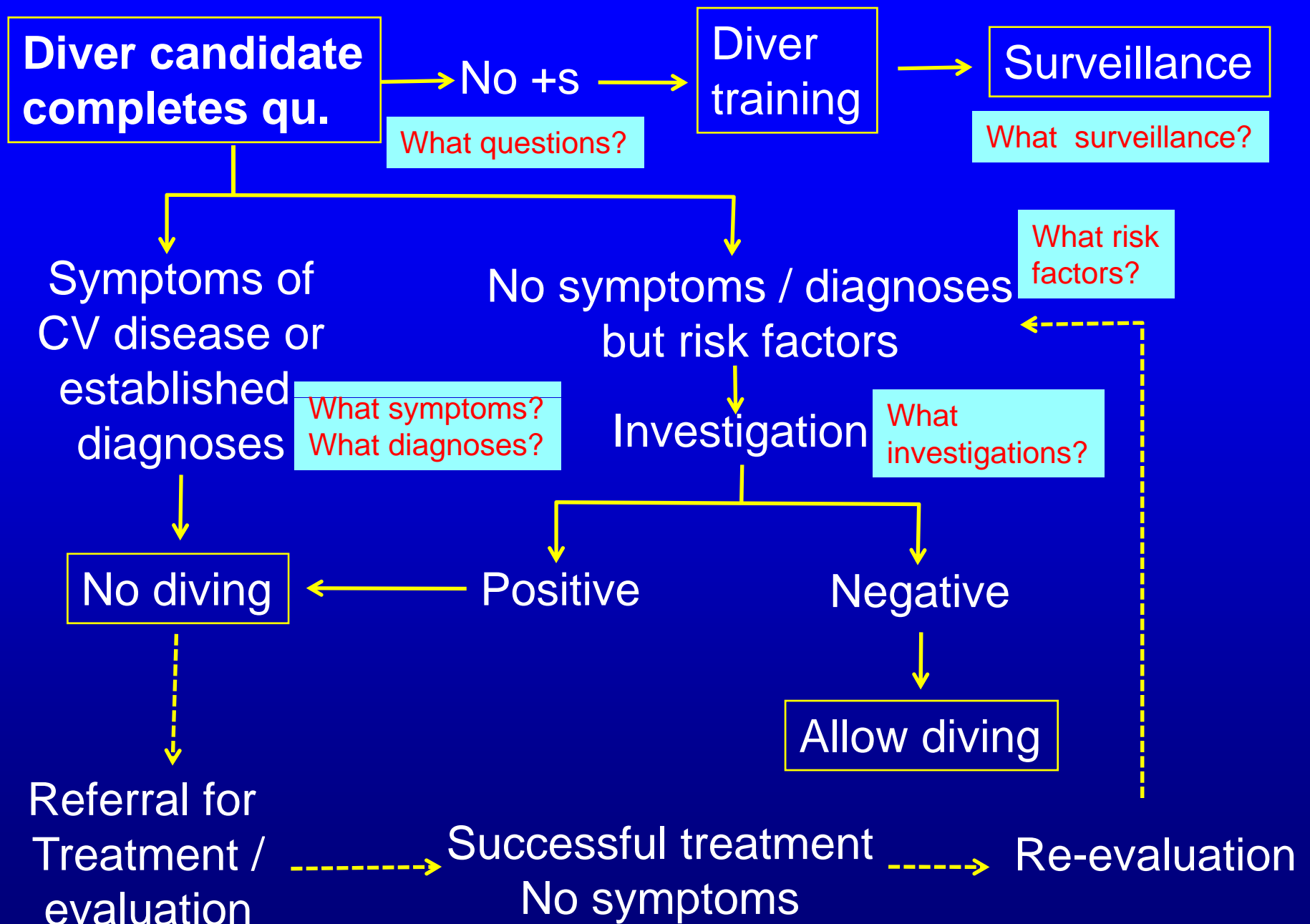
- This is more troublesome
  - We have no ‘control’ over behavior of certified divers unless they come forward for continuing education courses
- ? Can we incentivize health surveillance
- Failing that, should we (at least) be trying to educate divers about periodic review of their health status?
  - What triggers, and what “review” should we recommend?

In this session we will hear from 3 experts at the leading edge of cardiology who may help us to answer some of the questions I have raised:

- Dr Fred Bove
  - Perspectives on the relevance of CV diseases to diving
- Dr Paul Thompson
  - Epidemiology of CV disease
- Dr Pamela Douglas
  - Screening tests in asymptomatic adults

Tomorrow we will discuss a series of proposals for diver selection and surveillance based on these discussions, for example....















# Questions