Diving behaviour and decompression sickness among Galapagos underwater harvesters.

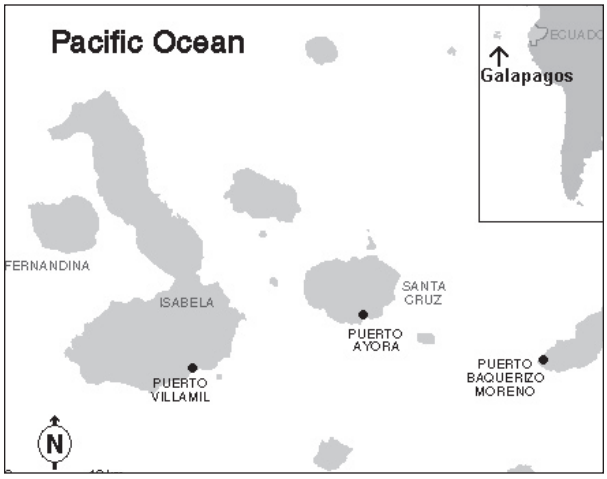
A.A. WESTIN[1], J. ASVALL[1], G. IDROVO[2], P. DENOBLE[3], A.O. BRUBAKK[1]

[1]Department of Circulation and Medical Imaging, Norwegian University of Science and Technology, Trondheim, Norway.
[2]Protesub medical centre, Puerto Ayora, Galapagos. [3] DAN, Durham, NC, USA.

Westin AA, Asvall J, Idrovo G, Denoble P, Brubakk AO. Diving behaviour and decompression sickness among Galapagos underwater harvesters. Undersea Hyperb Med 2005; 32(3):175-184. Diving conditions, dive profiles, vascular bubbles, and symptoms of decompression sickness (DCS) in a group of Galapagos commercial divers are described. They harvest sea cucumbers from small boats with surface supplied air (hookah). Dive profiles for 12 divers were recorded using dive loggers, and bubble formation was measured in the pulmonary artery. DCS symptoms were assessed by interview. A total of 380 immersions were recorded over a nine day period. The divers did on average 6.3 immersions per day, in a yo-yo pattern. Mean overall depth was 34.5 FSW. Maximum recorded depth was 107 FSW. Average bottom time per day per diver was 175 minutes. 82 % of all ascents exceeded the recommended maximum ascent rate of 30 FSW/min. High bubble grades were observed on six occasions, but the test was unreliable. Muscle and joint pain was reported on five occasions, in three different divers. Symptoms were typically managed by analgesics, in-water recompression or not at all. The divers were extremely reluctant to seek professional help for DCS symptoms, mostly due to the high costs of treatment. We conclude that the fishermen dive beyond standard no-decompression limits, and that DCS symptoms are common.

INTRODUCTION

The Galapagos Islands are situated 600 miles west of Ecuador along the equatorial line (Fig 1). Today approximately 16000 people live there. Sea cucumber harvesting commenced in 1992 and has now become one of the most lucrative industries, second only to tourism (1). The great majority of the sea cucumbers are exported to East Asian markets, where it is valued as a delicacy and aphrodisiac (2). Today there are more than 800 registered harvest divers in the Galapagos (1). They dive from small boats and receive compressed air via a hose and a mouthpiece (hookah). Although they use modern equipment, such as fins, neoprene wet suits, weight belt and mouthpiece with demand valve, their lack of diving knowledge is apparent. Unpublished reports from the hyperbaric treatment facility in Puerto Ayora indicate that joint pain is common among these divers and that they routinely dive with symptoms of DCS (Idrovo, unpublished). No studies have yet been performed on the dive habits of this population.



In the present study we monitored

Authorizations

Prior to the field work, project authorisations were obtained from the head of the Galapagos National Park and the diving companies. All participating divers signed an informed consent, allowing anonymous use of the recorded data.

RESULTS

Field observations

The fishing was performed from 15-25 feet open boats, typically with one diver and one engine tender in each boat. The air compressors were run by gasoline driven engines with 4-10 hp. The compressors had an inbuilt 20 litre pressure tank, providing the diver with air for up to five minutes in case of compressor stop. A scuba second stage was mounted at the end of the 70 meter plastic hose, regulating air pressure. The hoses were inexpensive and were often leaking from many small holes. At depths greater than 70-80 feet the hoses would partially collapse under the water pressure, reducing air supply, and making forced inspiration necessary for the diver to receive air (information from diver). The divers did not have any secondary air source.

The quality of the compressors and the efforts made to maintain them varied greatly. Even though the overall standard was acceptable, some of the boats were observed to have frequent compressor trouble, forcing the diver to make many rapid ascents, in one observed case four times in 90 minutes. None of the compressors had external air intake or air filters, and exhaust gases from the running compressor and boat engine contaminated the air supply of the diver. As would be expected, having headaches after diving was not unusual.

During diving, no communication was possible between the diver and the engine tender. If the engine tender wanted the diver to ascend, he pulled the hose as a signal. A lot of hose coiling was some times needed before the signal was finally transmitted.

While harvesting, the divers wore their own personal mask, fins, weight belts and wet-suits, including hood and shoes. Additional regular clothing was worn underneath the wetsuit in the belief that it would minimize heat loss. No buoyancy compensators were used. Nine divers in this study used a watch while diving, three did not. Seven divers used depth meters always, the other five reported to use it just occasionally. However, the depth meters were normally put inside the wet-suit, and would therefore not provide the diver with any information until after surfacing, and then only the maximum depth of the dive.

Dive sites were selected by the captain and his crew, based on the knowledge of former good spots and on rumours from encountered fishermen. The harvesting was performed from the small boats, on half-day trips around the mother vessel, while the latter provided the fishermen with food and lodging. Harvested sea cucumbers were boiled and salted onboard the mother vessel, and sold to merchants arriving every third day. The earnings from the harvest were normally split 50-50 between the diver (and his engine tender) and the captain of the mother vessel. In return the captain would provide all food and fuel during the trip. Despite being dependant on the catch, the captains were never heard instructing the divers on how or where to dive. However, at several occasions, when fishing was bad and moral was low, they were heard trying to motivate the divers, with promises of greater shares of the profits if they would dive more.

The observers tried not to influence the diver actions in regard to how much and where they dived. However, on two occasions the observers advised divers not to dive, due to the severity of their present DCS symptoms. One of them, however, went diving anyway.

12 Galapagos divers to observe their dive habits, record their dive profiles, register their symptoms of DCS and examine whether venous bubbles appeared after diving.

METHODS

The participants

The study took place in May 2003. The observers were Norwegian medical students, having no prior knowledge about the local boats or their crew. The observers selected two harvester boats with a "typical" size, and operating in the main sea cucumber area (around Isla Isabela, fig 1), hence assumed to be representative for the divers in general. Both captains accepted. The boats were mother vessels, to which the divers returned after each session of diving. The two boats had a total crew of 38 men. Sixteen were divers, the others were engine-tenders, cooks etc. The divers were asked to participate in the study after being informed of its purpose. One of the 16 divers declined to participate prior to the selection, for reasons unclear to the observers. Three more divers were omitted randomly, due to limited number of dive loggers. The remaining twelve divers were recruited, six from each boat. The selected divers were asked to complete a one-page questionnaire about former episodes of symptoms and treatment of DCS. DCS symptoms were common, but no subjects were excluded on that basis. Nor were any diver excluded on the grounds of drug use, although many divers admitted to this, and 3 of the recruited divers were observed smoking marihuana.

The 12 participants were all male, with a mean age of 34 years (range 17 to 47), and mean dive experience of 11 years (range 3 to 25). Their heights and weights averaged 168 cm (range 150 to 185) and 74 kg (range 59 to 90), respectively. Three divers had received diver education (navy or PADI), the others were taught by friends or relatives. See participant overview in Table 1, below.

Doppler examination and DCS symptoms

The observers lived together with the fishermen for nine days, one observer in each boat. They conducted a daily bubble detection procedure on the divers, using continuous wave ultrasonic Doppler recorders ("Mini Dopplex", Huntleigh Healthcare, UK) with handheld 5MHz transducers aimed at the pulmonary artery. The Doppler examination was performed during 30 seconds with the subject standing upright, and

Table 1 The participants

Diver	Age (years)	Height (cm)	Weight (kilos)	Experience (years)	Learned diving from	Maximum depth (feet)	Chamber treatment
1	19	170	70	4	friends/relatives	105	never
2	43	150	59	20	friends/relatives	90	never
3	47	165	68	25	friends/relatives	75	once
4	32	167	70	10	marine infantry	150	never
5	37	165	86	17	friends/relatives	150	once
6	47	174	84	18	friends/relatives	90	once
7	19	178	86	3	PADI	75	never
8	17	185	90	3	friends/relatives	60	once
9	47	165	68	15	marine infantry	90	once
10	43	170	64	6	friends/relatives	129	once
11	25	160	68	5	friends/relatives	135	never
12	26	168	68	4	friends/relatives	90	never

then during another 30 seconds after the subject had performed a slow deep knee-bend. As noise is a common problem in obtaining adequate Doppler signals, high quality headsets were used during examination. Due to the observers' lack of experience in detecting and grading bubbles, the results were assessed using a simplified Spencer scale, with a binary value of "little or no bubbles" or "many bubbles". All the sounds were recorded on tape and were reviewed by one of the authors (A.O.B)..

During each Doppler examination the subject was asked to report any present symptoms of DCS. A list of 13 DCS symptoms written in Spanish was shown to the diver. The symptoms on the list were: sensibility loss, paralysis, weakness, unusual fatigue, muscle/joint pain, itchy skin, skin rash, urinary incontinence, blurred vision, vertigo, headache, respiratory problems, and nausea/vomiting. No medical or neurological examination was performed, as this has proved in a similar study to be of limited value (3).

Dive profile recording

The dive profiles were recorded using 12 Sensus Pro dive loggers (ReefNet Inc, Canada.) They provide no information until the device is connected to a computer and the profiles are downloaded. The loggers were accurate to 1 FSW, to a maximum depth of about 500 FSW. The loggers activate at the pressure of 3 FSW and deactivate after 3 minutes of less than 4 FSW. While activated, the loggers record time, depth and water temperature at a preset interval (1-120 seconds). All loggers were set to record at 10 second intervals to allow them to be used for the whole dive period. All loggers were tested in a hyperbaric chamber and proved to be accurate.

Each diver was assigned his own logger for the observation period. The loggers were attached to the zipper of diver's wet-suit using double plastic tie-wraps. The loggers were small and did not hinder the diver in any way. Manipulating or removing the logger could not easily be done without detection. The loggers remained attached to the divers' wet-suits during the whole observation period and the observers controlled the tie-wraps regularly. All dives of all divers were recorded. The recorded data was unavailable to both the divers and observers during the period, as no computer download was possible on the boat.

DCS risk assessment

The data was later analysed at Divers Alert Network, using their software (DASIND). DCS risk was estimated using a probabilistic model (4). The model is calibrated to 3322 well documented military dive trials, and has been used for DCS risk estimation in several studies similar to this (3,5,6). The calculation provided a percentage risk of DCS for each dive.

Statistics

Fisher exact test was used to compare the predicted incidence of DCS with that observed.

Definitions

In order to describe the repetitive pattern of diving among the Galapagos fishermen, we use two different terms: *Immersions* and *dives*. One *immersion* starts when the diver leaves the surface (FSW>1) and ends when he has spent 10 seconds at the surface. Two consecutive descents with less than 10 seconds interval would thus count as one single immersion. We use the U.S. definition of *dive*, meaning 10 minutes has to be spent at surface before the dive ends. One dive can thus consist of one or several immersions.

Bottom time refers to the time from leaving surface to arriving at the surface, i.e. the total time spent underwater.

Table 2 - Previously experienced symptoms of DCS

Diver #	Sensibility loss	Paralysis	Weakness	Unusual Fatigue	Muscle/ joint pain	Ichy skin	Skin rash	Urinary. incontinence	Blurred vision	Vertigo	Headache	Respiratory problems	Nausea/ vomiting	Symptoms/ diver
1	N	N	N	N	**Y**	N	N	N	N	N	**Y**	N	N	2
2	N	N	N	N	**Y**	N	N	N	N	N	N	N	N	1
3	N	N	N	N	**Y**	N	N	**Y**	N	N	**Y**	N	N	3
4	N	N	N	N	**Y**	N	N	N	N	N	N	N	N	1
5	N	N	N	N	**Y**	N	N	N	N	N	N	N	N	1
6	N	N	N	N	**Y**	N	N	N	N	**Y**	**Y**	N	N	3
7	N	N	N	N	N	N	N	N	N	N	N	N	N	0
8	N	N	N	N	N	N	N	N	N	N	**Y**	N	N	1
9	N	N	N	N	**Y**	**Y**	N	N	N	N	N	N	N	2
10	N	**Y**	N	**Y**	**Y**	**Y**	N	N	**Y**	N	N	**Y**	**Y**	7
11	N	N	N	N	**Y**	N	N	N	N	N	N	N	N	1
12	N	N	N	N	N	**Y**	N	N	N	N	N	N	N	1
Total	0	1	0	1	9	3	0	1	1	1	4	1	1	

Former and present symptoms of DCS

The questionnaires on former symptoms of DCS were completed by all divers. Muscle and joint pain were the most common dive related symptoms. As we can see in Table 2 , nine of the 12 subjects had experienced this at one or more occasions prior to the study. Headache was also usual, reported by four divers, but this could be due to dehydration and air pollution rather than symptoms of DCS. Excluding headache, 10 of the 12 divers had one or more former episodes of DCS symptoms after diving. The long term effects of DCS were less frequent. Two divers reported frequent headaches, two divers reported excessive tiredness and one had chronic joint pain. Six divers had received hyperbaric chamber treatment due to acute or chronic symptoms of DCS.

During the nine day observation period the observers recorded five new events of DCS,

Table 3 - DCS events

Event #	Diver #	Observation day #	Symptoms	Treatment	Total bottom time of this day	Maximum depth of this day	Accumulated Pdcs at this point
1	6	2	Shoulder pain	None	17 min	37FSW	0.3%
2	4	3	Pain in shoulder and upper arm	None	1h 42 min	59FSW	6.7%
3	4	4	Respiratory problems	None	1h 46 min	71 FSW	n/a
4	4	6	Pain in wrist, back and stomach	NSAID + in water recompression	2h 17min	64 FSW	8.1%
5	1	6	Shoulder pain	None	2h 40min	69 FSW	3.6%

among the 12 subjects. These were three cases of shoulder pain, one case of neck pain and one case of low back pain, stomach pain and wrist pain (Table 3).As three of the events happened to the same diver, the result was 3 of 12 divers having new symptoms of DCS.

In most cases the divers having symptoms of DCS would not speak about this to the other crew members. They would mention it to the observer when asked directly during the evening examination, but then only in simple words, like "my shoulder hurts". In most cases, the divers seemed to ignore their symptoms, and would continue diving the next day. Diver number 4 was the only subject who made an attempt of in-water recompression (30 minutes at 17 metres, breathing regular compressed air), but it did not relieve the DCS symptoms of the diver. The same diver was also the only subject to quit diving due to DCS symptoms.

The profiles

All dives for all 12 divers were recorded during the nine day observation period. However, one logger malfunctioned during download, and all data from this logger was lost. Another subject was observed sharing wet-suit with a non-subject diver. As the logger was attached to the wet-suit, it would also record the dives of the other fisherman. We therefore excluded this logger from further calculation.

Data from the remaining 10 loggers were downloaded and analysed. The number of days diving varied between the divers (average 6.2 days, range 4 to 8). One subject quit diving on day six due to serious DCS symptoms. Another subject was caught fishing illegally on day nine and taken to the mainland by the national park rangers. All six divers on one mother vessel returned to Puerto Ayora day eight. Divers could also decide to skip diving some days due to lack of motivation. Excluding days where the subjects did not dive, we recorded a total of 380 immersions over 62 man-days of diving. Using the U.S. Navy definition of a dive, the 380 recorded immersions of this study make a total of 150 dives.

The diving was performed in sets of multiple immersions of short duration, normally less than 30 minutes. The profiles were characterized by rapid ascents and short surface intervals. In diving terminology this is often referred to as yo-yo diving (7). A typical dive-day is shown in Figure 2. It illustrates the typical pattern of diving, with two sets of dives separated by a lunch break. The first four immersions are of short duration (average bottom time of 9 min), probably because no sea cucumbers were found. The following three dives are more typical harvest dives (average bottom time = 24 min, average depth = 37 FSW, maximum depth = 75 FSW, average surface

Fig. 2. A typical dive day

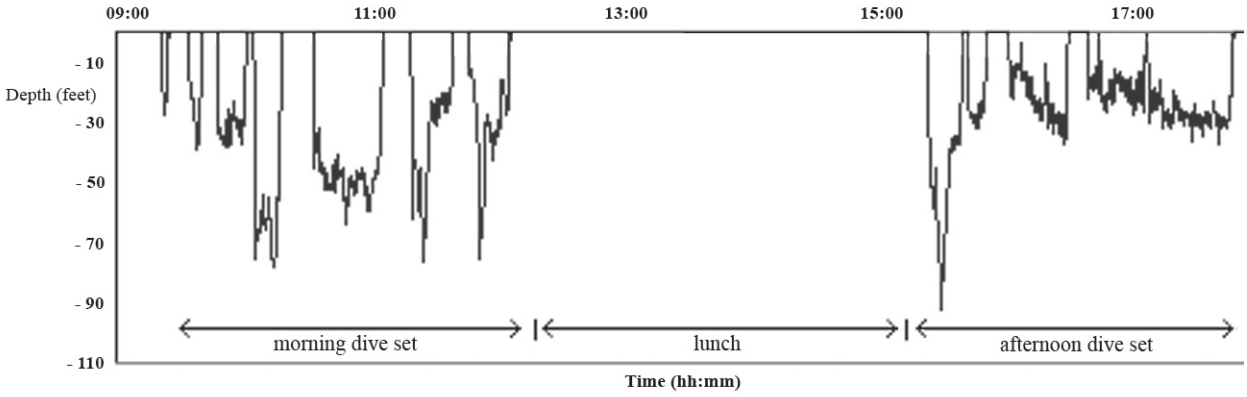


Table 4 - Dive characteristics and DCS risk

Diver #	D-days	Av BT/day	Av Imm/day	Maximum depth(FSW)	Av depth (FSW)	Maximum asc rate (FSW/min)	Symptoms	Cumulative Pdcs (%)(95% CI)
1	8	1:50	4	93	38	108	y	10.4 (6.7-42.6)
2	6	3:24	4	79	36	108		8.4 (6.5-10.9)
3	6	3:13	5	61	30	90		6.7 (2.9-70.8)
4	4	3:45	9	107	50	72	y	12.7 (7.3-88.5)
5	7	3:30	6	88	40	78		25.4 (19.4-72.2)
6	8	2:00	4	96	41	78	y	14.8 (9-169)
7	5	1:40	7	88	34	78		4.3 (0.3-103.7)
8	7	4:40	8	77	25	48		11.4 (4.9-36.2)
11	6	1:56	8	97	27	102		5.8 (2.9-28.6)
12	5	3:16	7	90	30	78		6.4 (3.4-117.4)
	Total:62	Avg: 2:55	Avg: 6		Avg: 34			Avg: 10.6 (StDev =6.2)

”D-days” means number of diving days, ”Av” means ”average”, ”asc rate” means ”ascent rate”

interval = 11min). The afternoon dive set is performed at a shallower dive spot (average depth 25 FSW). No decompression stops were made during either set of dives.

The overall statistics of the 380 immersions recorded show the same pattern as the example above. The average depth was 34.3 FSW, and the maximum depth recorded was 107 FSW. The average bottom time per day was 175 minutes. Average maximum ascent rate was 48 FSW/min and 82% of all recorded immersions had ascent rates faster than the recommended 30 FSW/min. The maximum ascent rate recorded was 108 FSW/min. Decompression stops were never made.

Risk analysis

Risk analysis was performed at DAN, predicting the percentage risk of DCS (Pdcs), by using probabilistic model (4). In T**able 4** the column to the right shows the total risk (in percent) and 95% confidence limits of prediction for each diver to develop symptoms of DCS during the observation period. The other columns show the dive profile characteristics of each diver, with number of days diving, average bottom time per day, average number of immersion etc. Based on the model, the estimated risk of DCS, or probability of DCS (Pdcs) varied greatly between the divers. The median cumulative Pdcs per diver was 9.4%, ranging from 4.3% to 25.4%. The diver with the highest Pdcs reported no symptoms at all during the observation period. The divers with the second, third and fifth highest Pdcs reported symptoms.

According to the model, the total cumulative risk of occurrence of DCS in the observed group was 1.06 cases (95% CI 0.6 – 7.4) out of 150 dives. Thus, the observed number of five cases of DCS is a non-significant increase at this 95% CI level.

Bubble detection

The Doppler measurements were made onboard the mother vessel when the divers

returned after each dive set. The lag time from the end of the last dive until examination varied from 10 minutes to four hours, with an average lag time of 55 minutes. A total of 57 Doppler recordings were made. Parts of all recordings were considered to be of adequate quality for analysis, although engine noise and noise due to probe movement could not be completely avoided. Among the 57 recordings 51 were considered negative ("little or no bubbles") and six were considered positive ("many bubbles"). Among the 51 subjects who tested negative, 49 had no symptoms and two had symptoms of DCS. Among the six subjects testing positive, three had symptoms and three did not. This means the Doppler examination in this study has 60% sensitivity and 94% specificity in detecting a diver *already experiencing* symptoms of DCS. However, there was little correlation, if any, between the Doppler recordings and the dive profiles just performed by the diver.

DISCUSSION

Our study shows that the Galapagos divers engage in diving activities that place them at considerable risk of DCS. The dive profiles were characterized by multiple descents separated by short surface intervals, in a yo-yo pattern. The dives were often of short duration (normally less than 30 minutes) and at shallow depths (normally around 40 FSW). The observed rate of DCS in our sample was 3.3%. In recreational divers, the rate of observed DCS in 15,385 dives was 10.5/10,000 dives, which equals 0.105% (8). The divers of this study thus perform dives at an over thirty times higher risk than recreational divers.

Symptoms of DCS were common among the divers, and three of the twelve subjects had new symptoms of DCS during the observation period. We suspect the high incidence of DCS to be caused by a long total daily bottom time (average 175 minutes per diver per day), lack of decompression stops, and probably most important, the repetitive (yo-yo) pattern of the profiles. Recent studies in other diver communities have suggested yo-yo diving to incur a considerably increased risk of DCS. Gold (6) described diving habits among 342 sea gypsy divers in Thailand. He registered dive depths by questionnaires and found shallow (<60 FSW) yo-yo dives, as in our study. Despite the shallow dives, he found one third of the active divers in the population to report having experienced symptoms of DCS. Douglas et al (5) describes three cases of DCS in fish farm workers diving 14 repetitive immersions of 5-10 minutes duration to 60 FSW. He reports a high incidence of DCS despite all immersions being within safe limits, even when regarded as one single dive. Dunford et al (3) recorded dive profiles in five Miskito Indian lobster divers in Honduras, using dive computers. He described repetitive dives at approximately 70 FSW of short duration (20 minutes) and short surface intervals (5 minutes). During seven days he recorded 10 events of muscle/joint pain, in three of five subjects. Using the same probabilistic model as in our study, he found an average Pdcs of 67.4% per diver at the end of seven days. This result is considerably higher than in our study (we found an average 10.6% DCS risk per person at the end of the study period), and probably relates to deeper dives. Gold, Dunford et al, and Douglas et al all conclude that the yo-yo pattern of dives contributes to an increased risk of DCS, not easily measured by most DCS risk models (3,5,6). DCS risk estimates for these stressful profiles are consequently the result of model extrapolations into depth-time regions that are well beyond those in which the present model can be expected to provide accurate estimates of actual DCS risks. The Gerth/Vann model predicted one case of DCS in the 150 dives, and we observed five. However the confidence limits of the model's prediction were 0.6 to

7.4, thus including the increased number of cases observed (five). While the model cannot predict what particular dive will result in DCS, we are nonetheless confident in model ability to rank different profiles according to risk. The finding that a substantial fraction of dives profiles incur estimated DCS risks greater than those associated with modern diving practice is therefore of particular concern.

The Doppler examination provided little useful data to the study. The examination requires highly trained observers, as the placement of the probe is crucial for obtaining good recordings and accurate interpretation is important. The quality of the recordings was in many cases influenced by engine noise and movement of the probe. Evaluation of Doppler recordings are difficult to do accurately (9), the simplified Doppler grading system was selected to overcome this. In this study, no bubbles were found in 40% of the divers having symptoms of DCS. Due to practical limitations we conclude that the Doppler examinations were of limited value in this study.

Despite the frequent DCS symptoms among the fishermen, and the presence of a hyperbaric chamber in Puerto Ayora, the observers perceived an extreme reluctance to seek hyperbaric treatment. One reason to this was obviously financial, as the diver had to pay for his own treatment. Maybe more important was the divers' lack of knowledge on correct DCS treatment. This gave rise to rumors among the fishermen, insinuating that the local clinic made extended treatment for own profits (treatment was paid per hour). The rumors were obviously untrue. Some divers chose to receive treatment at a mainland hyperbaric facility, reputed for lower costs. Other divers chose to perform in-water recompression using air, although they obviously lacked knowledge on how to perform this safely. They claimed however, that this treatment frequently was quite effective.

The present study is part of a program called the Harvest Divers Improvement Program (HDIP). In spite of the obvious difficulty in obtaining high quality research data under field conditions, we feel that such data are useful in order to suggest changes that might reduce the risk of DCS.

The Galapagos fishermen need a closer collaboration with the local clinic to obtain more knowledge regarding the nature and treatment of DCS. They also need guidance on how to perform in-water recompression more safely. It seems obvious that in order to accomplish diver compliance, the necessary changes in their dive habits can not affect the outcome of the harvest. We therefore produced a brief information folder similar to the one given to the gypsy divers by Gold (6). The given advises aim to manage the simplest risks, like dehydration and heat loss. A recent follow-up study (Nilsen and Nestaas, unpublished) showed that the recommendations were not implemented by the divers.

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REFERENCES

1. Fundación Natura 2000, 2001, 2002. *Galapagos report 2000/2001, Galapagos report 2001/2002.* Quito, Ecuador
2. Sancho A, Buitron X (Eds). Evaluation of the rade of sea cucumber in the Galapagos Islands during 999. TRAFFIC South America 2000

3. Dunford RG, Mejia EB, Salbador GW, Gerth WA, Hampson NB. Diving methods and decompression sickness incidence of Miskito Indian underwater harvesters. *Undersea Hyperb Med* 2002; 29: 74-85
4. Gerth W, Vann R. Probabilistic gas and bubble dynamics models of decompression sickness occurrence in air and nitrogen-oxygen diving. UHM 24:275, 1997 *Undersea Hyperb Med* 1997; 24 (4): 275-292
5. Douglas JDM, Milne AH. Decompression sickness in fish farm workers. A new occupational hazard. *BMJ* 1991; 302: 1244-1245
6. Gold D, Aiyarak S, Wongcharoenyong S, Geater A, Juengpresert W, Gerth WA. The indigenous fisherman divers of Thailand: diving practices. *Occupational Safety and Ergonomics* 2000; 6: 89-112
7. Wong RM. Empirical diving techniques. In: Brubakk AO, Neuman TS (Eds.) *The Physilogy and Medicine of Diving*. London, Saunders 2003,
8. Report on decompression illness, diving fatalities and project dive exploration, Diving Alert Network, Durham, NC, USA
9. SawatzkyKD, Nishi RY. Assesment of inter-rater agreement on the scoring of intravascular bubble signals. *Undersea Biomed Res* 1991;18.373-396