Underwater interpretative trail: guidance to improve education and decrease ecological damage

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Abstract: Studies of environmental education on trails in the sea and their impact are scarce, especially as regards the Brazilian coast. Herein is analysed an implemented model of an interpretative guided underwater trail (free diving), undertaken in the Anchieta Island's Park, southeast Brazil. The activity consisted of a preparatory lecture, followed by a 350 m trail along the rocky shore. The results therefrom were evaluated through the application of questionnaires and by tabulation of the visitor's behaviour and impact. A high degree of satisfaction with the activity (average mark = 2.7, maximum 3) was recorded. Even though initial expectations of the participants were related to the dive (36%), the main aspect pointed out afterwards was the educational experience within the marine environment (71%). The scraping off of organisms (e.g., *Phallusia nigra*) and the suspension of sandy bottom sediment due to flipper movements were the main impacts.

Keywords: environmental education; marine environment; underwater trail; Brazil; trekking; trail; snorkeling; dive; rocky shore communities; marine ecosystems.

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1 Introduction

Nowadays, it is believed that, for the betterment of living conditions as well as of those related to the environment, changes in basic values, principles and attitudes are fundamental (La Trobe and Acott, 2000). Environmental education, through its encompassment, furnishes a way of perfecting the individual as a whole.

In the marine environment, environmental educational activities are rare, especially when considering the Brazilian coast, where these are offered, mostly by divers, as basically involving the observation of local ecosystems associated to the learning of techniques. Even though there are no scientific records, the start of this in Brazil is related to the increase of an environmental conscience at the end of the 1970s, besides a sensitive reduction of the ictiofauna as a consequence of underwater fishing undertaken in the prior decades.

In relation to snorkeling trails, there is only one record of implantation and study of four snorkeling guided trails on the south coast of Brazil (Wegner, 2002) during the summer of 2001.

On a worldwide scale several works deal with experiences related to underwater trails, the evaluation of their impact on the natural communities (e.g., Hawkins and Roberts, 1993; Hawkins et al., 1999; Rouphael and Inglis, 2001) or assessing their educative effects (Medio et al., 1997).

Of these, Plathong et al. (2000) refer specifically to free diving, and Hawkins and Roberts (1993) compare damage caused by snorkeling and scuba diving.

All the cited works refer to coral reef communities, there being no available data regarding the impact of visits on rocky coast communities. Besides this, the lack of data on the educational effects of models implanted within the marine environment is also observed.

Within the present work, an experimental model of an underwater trail (snorkeling) introduced into the Insular Park of Ilha Anchieta, southeastern Brazil, is described, with an evaluation of its educational impact as to visitors, besides the damage caused to the rocky coast community. As from this experience, strategies for its perfectioning and for the diversification of activities are presented, in such a way that this becomes available to the public at different ability levels.

2 Methods

The activity was undertaken in the "Parque Estadual Insular de Ilha Anchieta (Ubatuba, SP, 23°32'S E 45° 03'W)", a Conservation Unit run by the 'Instituto Florestal, SMA-SP'. The trail was installed in a stretch of 350 m from the coastline, situated between Presídio Beach and Engenho Beach, being marked out by a long line of floats running parallel to the beach line at a distance of approximately 5 m, thus outlining a safety corridor to be used by participants. The place is well protected from waves through being on the inside of the Palms Inlet.

The activity was undertaken during the month of January when the seawater visibility ranges from 1 m to 5 m and temperatures between 25°C and 30°C.

Target public consisted of visitors from all age groups and educational levels that arrived on the island in tourist-transport schooners.

The activity consisted of a preparatory lecture followed by the trail, this with a forecast duration of around one hour. On termination, participants were requested to fill in a post-trail evaluation. All stages were conceived with a view to defined educational objectives, which at times, went beyond those immediately perceivable by the practitioner.

During the lecture, information was passed on regarding the park and the necessary care to minimise the impact on those communities present on the island, with a view to avoiding touching any species, to come near to the bottom, which could result in touching or in the suspension of sediment. The objective of this stage was also to stimulate a sense of protection and care for the environment. Aspects relating to safety were also focalised, and pre-activity questionnaires related to a charaterisation of the type of public, the determination of their expectations, degree of knowledge and exemption from responsibility, were filled in.

The trail was initially undertaken with a group of a maximum of 5 visitors, escorted by two monitors, one being responsible for conducting, and the other for a behaviour evaluation. A support raft 1 m and 5 m wide accompanied the group, this consisting of polyurethane floats, joined by ropes, and designated both for safety as well as to serve as a support platform for discussion and note taking.

On the beach itself, stretching and warming up exercises were done, with a view to transmitting the correct techniques for doing this, and to show the need for an adequate preparation leading up to physical activities. Time was taken to revise the correct way to use snorkeling equipment. The aim of this stage was to stimulate physical activity, and in particular the diving activity itself, through greater contact with the equipment.

Once in the water, everyone was requested to stay still so at to become aware of the marine environment, first with closed eyes and then with them open. Awareness initially had in mind to stimulate the ability to observe and identify the various elements making up the marine environment, such as sounds, temperature or movement of the sea, light and colours, etc. The aim was also training in the use of all the senses and an holistic perception of the environment.

Following this, displacement along the trail was initiated, with recycling as to the correct movements in equipped swimming and snorkeling.

Throughout the trail, six interpretative points were distributed, thus trying to transmit concepts related to the ecological characteristics of the coastline, to zoning, to the difference between abiotic and biotic factors, and to the characteristics and recognition of animals and plants. At each point these aspects were outlined, either through a briefing by

the monitor or through the use of underwater plastic interpretative cards, measuring 20 × 30 cm, consisted of 21 illustrations distributed on both sides, showing the organisms and aspects of the physiognomy of the coastline, accompanied by the respective name. Stopping at other points was permitted and stimulated, depending on the curiosity of the participants.

A safety scheme accompanied the activity, including the two monitors, the support raft, a motorboat that remained parked near the trail but away from the longline, linked to base by a talk-about radio. All members of the team had been previously trained in water rescue and first aid.

Evaluation of whether the proposed objectives and visitors expectations had been attained, as well as the overall gain in knowledge, was done by the comparison between the answers from the open and multiple choice questions presented to participants after finishing the activity (post-activity questionnaire), and those of the pre-activity questionnaire.

This analysis was completed by the evaluation of behaviour accomplished during the activity, through a questionnaire with questions preestablished after preliminary test activities. For this, a PVC notebook that permitted underwater writing with a pencil, was used.

Answers from the questionnaires were tabulated, analysed and compared through variance analysis (one-way Anova – parametric data), and then complemented by the Bonferroni Test (Meter and Wasserman, 1974), in order to compare treatments two by two when differences were shown to be significant. The Ruzyka index was adapted to determine similarity of response between two groups.

In all the cases, empirical observations were of value in complimenting these data.

3 Results

3.1 Logistic

As a whole the model used proved to be efficient.

The distance of 350 m showed to be practical for most of the participants, even for those who did not swim well, this being mainly due to the presence of the support raft.

The width of the strip marked out by floats, of approximately 5 m, was not sufficient when all participants were grouped together around the raft, this resulting in excessive nearness to the coastline, thus increasing flipper impact on organisms and the risk of wounds from barnacles and sea urchins especially at points where the depth was less.

The initial number of five persons was reduced to four with a view to better placing around the raft, this resulting in a smaller occupied area and in less touching of the coastline and hits among participants. Besides this, it allowed for a better interaction of monitor with each visitor and an increase in safety.

The circular format of the support raft proved to be inadequate, resulting in an excessive diametrical placing of practitioners, the flippers of some coming very close to the coastline, while the remainder stayed far from it, often having to leave the raft to examine the rocky-shore.

As to safety, the method used proved to be adequate. The 3 incidents observed were related to tiredness and panic of visitors, whereas the support raft proved to be adequate for initial aid until the arrival of the motorboat. The biggest safety risk was observed in

those cases where dispersion and wandering occurred, this in spite of monitor's recommendations to the contrary.

Although the interpretive cards were useful, the model proved to be inadequate for a monitored visit, due the low size of the illustrations and the need for transportation by the visitants. Instead, plastic cards with a single picture each that remains with the monitor are more fit.

Timing of the activity was approximately within that foreseen, between 30 and 60 minutes, a result of equipped swimming ability and interest of participants. Longer periods proved to be limiting due to people's resistance to the temperature of the water. The number of interpretative points showed to be adequate for the distance considered and available time.

3.2 Satisfaction of expectations and gain in knowledge

As from open questions grouped by category of the answer, it was noted that (Table 1) the main motivating factors for undertaking the activity were those related to an attraction to the marine environment and to diving itself (36%, 3% of the answers). A like percentage of answers (36%) were related to the search for knowledge. Responses linked only to tourism (tourism, outing/leisure) corresponded to 27% of the total. The Ruzicka Index showed a low similarity between the answers of participants from different levels of schooling (Table 2).

Table 1 Initial motivations to join the activity (spontaneous answer)

	F	*S*	*G*	*PG*
Dive		1	4	1
Knowledge	1	3	1	
Tourism	2		2	
Curiosity			2	1
Love the sea	1	1		
Fun	1		1	

F: primary school complete; S: secondary school; G: graduation; PG: postgraduation.

Table 2 Evaluation of the similarities (Ruzicka index) of the answers given by the different schooling groups within the questionnaires corresponding to Tables 1, 3 and 4

	Table 1	*Table 3*	*Table 4*
F vs. S	0.14	0.75	0.23
F vs. G	0.29	0.00	0.26
F vs. PG	0.00	0.20	0.08
S vs. G	0.20	0.08	0.25
S vs. PG	0.13	0.20	0.43
G vs. PG	0.43	0.22	0.25

F: primary school complete; S: secondary school; G: graduation; PG: postgraduation.

After the activity (Table 3) the preferred aspects were those related to the educational activities (71% of the answers), whereas only 4% referred to diving itself. The compared answers according to level of schooling of participants also showed low similarities (Table 2), with the exception of those between groups of the first and second degree (0, 75), both of them pointing out the biodiversity as the most appreciated item on the trail (62%, 5%).

Table 3 Preferred aspects in the activity (spontaneous answer)

	F	*S*	*G*	*PG*
Biodiversity	8	6		1
Information			1	1
Monitors		1	1	
Contact with the sea			1	1
Everything			2	
Diving			1	

F: primary school complete; S: secondary school; G: graduation; PG: postgraduation.

Most of the interviewed persons (Table 4 open questions) did not point out any negative aspect on the trail (44%). Amongst affirmative answers most were related to disagreeable or dangerous characteristics of the environment (28%) e.g., sea urchins, followed by problems related to the structure (20%), e.g., the lack of children's equipment, and to technical aspects of diving (8%).

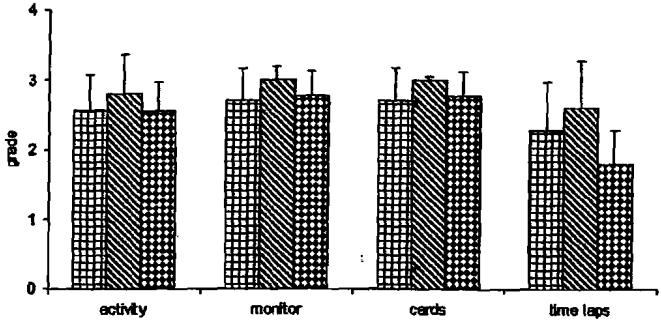
Table 4 Preferred aspects in the activity (spontaneous answer)

	F	*S*	*G*	*PG*
Nothing	1	3	4	3
Sea-urchins	2	1		
Low visibility	1		2	
Short time	1		1	
Flipper	1			
Water swallow	1			
Waves		1		
Equipment			1	
Divulging			1	

F: primary school complete; S: secondary school; G: graduation; PG: post-graduation.

Numerical evaluation of four aspects of the trail (Figure 1) showed high marks, with averages mostly superior to 2.5 (a maximum of 3), independent of the visitor' s level of schooling. Significant differences were noted ($F_c = 7.3 > F_{0.05(3;32)} = 2.9$), only in evaluating the time-span of the activity for the third grade group (average 1, 77). No significant differences were noted between marks given by visitors with different levels of schooling.

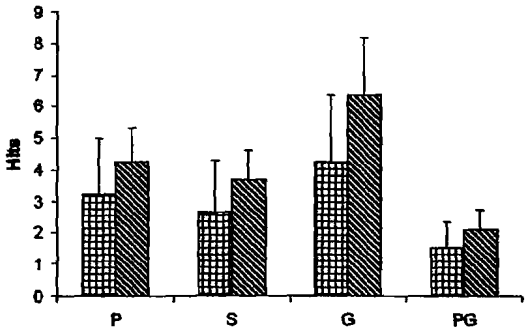
Figure 1 Numerical evaluation of some aspects of the trail (maximum 3)



Crossed lined bars: primary school complete; Horizontal lined bars: secondary school complete; doted bars: graduation complete; vertical lines: confidence intervals ($p = 0.05$).

The evaluation of apprenticeship of marine biology concepts through the variation of the average number of hits per question in the pre and post activity questionnaires, can be seen in Figure 2, showing through all round analysis, an increase in the number of hits ($t_c = 3.38 > t_{0.05;16} = 2.12$) ($t_c = 3.38 > t_{(0.05;12)} = 2.9$). An analysis by schooling level shows a significant increase in the number of hits only when considering university students. For the other schooling levels, even though differences have not been significant a tendency for an increase in the average number of hits in all cases can be observed.

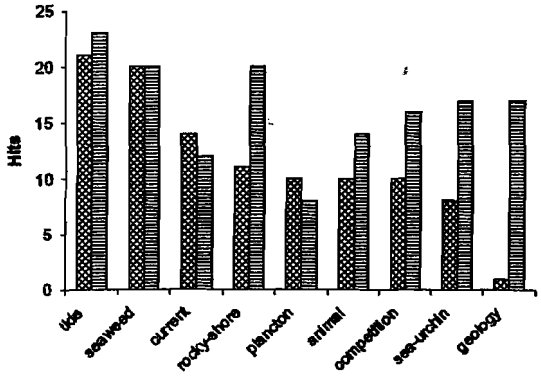
Figure 2 Mean number of hits for each participant observed before (crossed lined bars) and after (doted bars) the activity (maximum 9)



Vertical lines: confidence intervals ($p = 0.05$).

The questions where a larger increase of the number of hits was observed are (Figure 3) those related to the geological origin of the substrate, and the ecological factors that control the communities of the rocky coast. On the other side, questions on the influence of tides on the organisms of the rocky coast, and of seaweeds being marine plants had already been correctly answered in the pre-questionnaire (96% and 83% of the persons interrogated), including those of the first degree (respectively 100% and 73%), indicating prior knowledge on the subject.

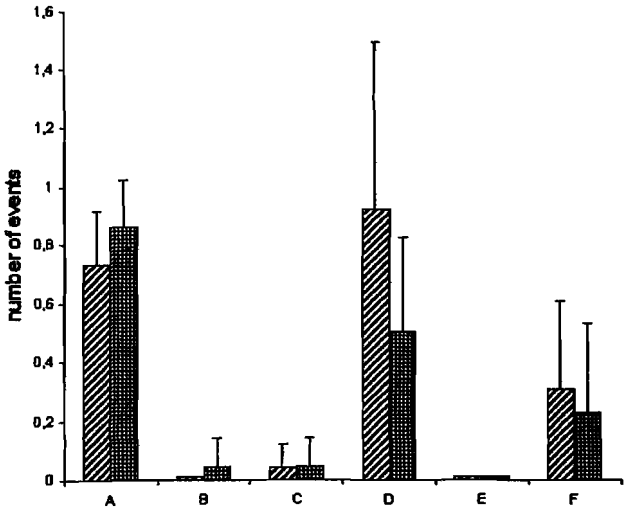
Figure 3 Sum of hits of all participants in each knowledge topic before (crossed lined bars) and after (doted bars) the activity



3.3 Observation of initial recommendations and impact on the rocky shore communities

Starting from observations accomplished during the activity, it was possible to define the impact of the activity on the communities of sessile organisms. Recommendations expressed in the initial lecture were followed on a whole by the majority of the participants. Figure 4 shows the number of infringements of these.

Figure 4 Number of infringements of the initial recommendations stressed during the initial lecture



Crossed lined bars: 14–17 years old; horizontal lined bars: over 18 years old.

A: dive till the bottom; B: wandering from the group; C: lack of interest; D: involuntary touching of the substratum (slippers); E: involuntary touching of the substratum (hand); F: voluntary touching of the substratum.

For the population of youngsters (14–17 years old), the most common fault was involuntarily touching the substratum with flippers (0.92 occurrence per participant –opp), which is significantly higher ($F_c = 9.15 > F_{0.05(5;150)} = 2.21$) than all the other items of behaviour with the exception of the item descent to the bottom (0.73 opp). The occurrence of touching with the hand on purpose (0.32 opp), was significantly less than the former ones but larger than the other items.

For the adult population (over 18 years old), the occurrence of diving till the bottom (0.86 opp) was significantly larger ($F_c = 12.44 > F_{0.05(5;126)} = 2.21$) than all the other items with the exception of involuntarily touching the substratum with flippers (0.50 opp).

For both ages it should be also noted the low occurrence of cases of lack of interest or wandering from the group.

Both for youngsters as well as adults the repetition of touching with flippers by the same individual was noted (up to a maximum of 4 occurrences), and can be related to the lack of equipped swimming ability of these participants.

The most dangerous touch for organisms was that of flippers, which brought about the suspension of bottom sediments and detachment of organisms. Amongst those animals that proved to be the most sensitive were the ascidia *Phallusia nigra*, the cnidarium *Schyzoporella* sp. and the crinoid *Tropiometra carinata*. Whereas the first two were totally torn off the substratum by a blow of the flipper or scraping of the body, the latter normally only were broken. Amongst the algae, the rhodophyte *Galaxaura marginata* (J. Ellis and Sol) J. Lamouroux, and the pheophyte *Padina gymnospora* (Kutz) Sonders, were those that suffered the greatest impact, being also totally torn off.

4 Discussion

The model of environmental education for the marine environment, as described in this work, differs from activities already existing in Brazil, which are linked to diving schools and operators.

Basic differences reside in the use of snorkeling diving techniques instead of those of scuba diving, in the longer distance covered, in the use of methodology for environmental interpretation, and in the existence of interpretative points along the trail. The only other similar project, was also undertaken in the south of Brazil during the summer of 2000 (Wegner, 2002), which also involved monitored snorkeling trails along the rocky shore. The author, however, did not refer to the use of interpretative points, the support raft or of plastified cards for underwater interpretation.

Even though there are no other projects involving underwater trails in Brazil, on a global scale several experiences are registered, the greater majority having been undertaken in communities (Hawkins and Roberts, 1993; Hawkins et al., 1999; Rouphael and Inglis, 2001), in which the architecture and biology differ greatly from that of the rocky coast.

Our proposed model is based on a holistic concept of environmental education, aiming at the development of the individual in terms of behaviour, ethics and enviromental values (Negra and Manning, 1997), instead of only transmitting ecological and biological concepts. This purpose has been attained in diverse ways.

The main one was certainly that related to the high degree of satisfaction after the activity, evident not only from obtained data, but also from observation of the physiognomy and behaviour of each participant on returning from the trail, it appearing to be highly probable that a high emotional involvement of the person with the ecosystem had been reached through undertaking the activity.

The trail also provided an alternative activity for seaside tourism, which linked fun to the preservation of the environment and learning.

Part of the objectives involved equipped swimming in the sea, related both to apprenticeship in the snorkeling equipment use as well as a challenge for physical resistance and individual ability. The simple experience of being able to cover the 350 m, with the safety of a raft and monitor, appeared to be rewarding and transforming to most participants. However, even though initial expectations were related to diving itself, at the end of the activity those most valourised aspects were linked to the learning. This result possibly reflects the greater emphasis, maybe excessive, given to those aspects linked to environmental ecology and biology, both during the lecture as well as throughout the interpretative points, in detriment of others.

The behavioural aspect was also worked over successfully, through the initial explanation, which resulted in, as is the example of other works (Medio et al., 1997; Tabanez et al., 1997), the reduction of environmental impact and increase of engagement. Even though our data does not allow one to know whether this really happened, the increase in the care taken by those involved as to the environment and its organisms, if extended to every day life, would be one of the most relevant conceptual gains of the trail.

Notwithstanding the care taken by the great majority of the participants, the existence of a significant impact on the communities of the rocky shore was evident, these being mainly caused by the accidental touching by flippers of persons with little or limited experience.

Three categories of impact were observed:

- the complete tearing off of those organisms that presented a large area in relation to its fixing structure (e.g., *Phallusia nigra*)
- the breaking of large portions of the branching organisms (e.g., *Tropiometra carinata*), in a similar way of what occurs in coral environments (Hawkins and Roberts, 1993; Hawkins et al., 1999; Plathong et al., 2000; Rouphael and Inglis, 2001)
- the suspension of bottom sandy-muddy sediments, especially notable during the low tide, which were afterwards partially deposited on organisms of the lower part of the shore.

The average number of touches per participant was 0.73 touches per hour (roughly the activity lap-time), this being less than that described by Medio et al. (1997) of 0.4 touches in 7 minutes., corresponding to 3.4 touches h^{-1}. Rouphael and Inglis (2001) observed 0.3 breaks each 10 minutes or 1.8 breaks h^{-1}, a much higher number than ours once is probable that only some touches resulted in breaks. However both cases refer to scuba diving whose impact is greater than that of snorkeling (Hawkins and Roberts, 1993).

Although voluntary touches were also observed by persons who laid their hand on the shore, notwithstanding the instructions given at the lecture, these never resulted in a visible impact on the shore. Infringements related to the descent to the bottom caused suspension of sediments.

The number of touches is dependant on the number of participants as a consequence of grouping around the support raft. The approximation of the raft to the shore also resulted in touches. The circular format of the raft contributes to a greater dispersion of participants around it as well, whereby the option of a rectangular format is preferable. Besides, tests performed with a rectangular float showed that it presents a much better dislodging in the seawater.

The disturbance consequences to the natural communities are difficult to foresee, due to lack of knowledge on their dynamics on the Brazilian rocky shore. Coimbra (1998) showed the existence of great intensity natural disturbances in a nearby region during cold fronts, resulting in drastic changes of its composition and structure. It is possible, therefore, that the alterations caused by visitors could even be insignificant in this context. A long-term follow up of these communities is being carried out since January, 2002 (Project Physiognomies of Benthonic Communities) aiming to make more clear the magnitude of the impact of visitation.

Having in mind that an impact was effectively ascertained, it is probable that activities undertaken by schools and diving operators have similar consequences, especially when considering that a part of diving operators do not undertake an 'ecological' briefing strengthening the need for care. Besides this, the activity of operators is intense and constant during the involving scuba diving and photography, which are potentially more dangerous than snorkeling (Hawkins and Roberts, 1993; Rouphael and Inglis, 2001).

After obtaining the results herein described, several alterations of the initial model were proposed and partially implemented during the summer of 2003.

The more active participation of the visitor is now being suggested, especially that related to vigilance and maintenance of the trail and of the park as a whole.

The models of activities were diversified, in order to allow people with different abilities and ages to participate. In a first stage we introduced

- a monitored visit to a natural aquarium (tide pool) where organisms are observed through an underwater observation device, without the need to dive
- an interactive lecture on the marine flora and fauna present along the trail
- a discovering scuba dive trail.

These new models, together with the snorkeling trail are being adapted to and tested with a public made up of the poor class of primary and secondary schools of the region.

A programme of continued education was introduced for university students to act as monitors where they simultaneously receive a sequential training in environmental education, marine biology, ecology, and diving, and applies this knowledge in a practical way in the activities.

The models presented in this work will be kept and amplified in such a way as to serve as a support for the implementation of marine environment educational activities at other points along our coast. However, the variety of forms and models that can be thought up is practically unlimited, the choice should be based on the local conditions,

the type of public to which they are directed, and on preliminary tests to determine their efficiency and the degree of environmental impact they can cause.

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