Spiny Lobster (*Panulirus argus*) Fisheries

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ABSTRACT

The destructive and illegal practice of using chemicals (bleach, dishwashing liquid, gasoline) to catch spiny lobster (*Panulirus argus*) is thought to be common throughout much of the Bahamian Archipelago. Injection of a chemical irritant into a lobster den will result in either a rapid escape response or a subduing effect, both of which make it easier to capture spiny lobster. We used laboratory trials to determine the efficacy of a Starch-Iodide swab technique, previously developed for the detection of bleach usage in the American lobster (*Homarus americanus*) fishery, on *P. argus*. Tests were conducted on male and female spiny lobsters of varying sizes (juvenile, sub adult and adult), each of which were swabbed for the presence of test chemicals on their exoskeleton at varying intervals before and after exposure. All lobsters exposed to bleach tested positive immediately following exposure and for varying periods thereafter. No false positives were detected on control lobsters. The length of time that the chemical remained detectable on the exoskeleton varied, some individuals testing positive 12 hours after exposure. This swab technique will provide fisheries enforcement officers with a powerful tool to reduce or eliminate the illegal use of bleach for harvesting lobster throughout the Turks and Caicos Islands, Bahamas, and wider Caribbean.

KEY WORDS: Chlorine bleach, illegal fishing techniques, *Panulirus argus*

La Validación de una Técnica de Algodón de Almidón-Yoduro para Discernir el uso de Sustancias Químicas Ilegales en los Turcos e Islas de Caicos Langosta con Púas (*Panulirus argus*) Pesquería

La práctica destructiva y a menudo ilegal de utilizar sustancias químicas (decolorante, dishwashing líquido, la gasolina) agarrar langosta con púas (*Panulirus argus*) es considerado común a través de mucho del Caribe. La inyección de una substancia irritante química en una guarida de langosta tendrá como resultado o una respuesta rápida del escape o un efecto que druegan, ambos de que lo hacen más fácil de capturar langosta con púas. Utilizamos tanto los ensayos del laboratorio como el campo para determinar la eficacia de una técnica de algodón de almidón-yoduro, previamente desarrollado para el descubrimiento del uso de decolorante en la langosta Americana (*Homarus americanus*) pesquería, en *P. argus*. Las pruebas se realizaron en el joven, sub el adulto y el adulto, langostas masculinas y femeninas con púas, cada uno de que fueron limpiados para la presencia de sustancias químicas de prueba en su dermatoesqueleto en variar intervalos antes de y después de la exposición. Toda langosta expuso de blanquear probado positivo siguiendo inmediatamente la exposición, mientras no falso positivo siendo discernidos en langostas de control. El plazo de tiempo que la sustancia química se quedó perceptible en el dermatoesqueleto variado, algunos individuos que prueban positivas muchas horas después de la exposición. Esta técnica de algodón proporcionará pesquerías oficiales de aplicación con un instrumento poderoso reducir o eliminar el uso ilegal de sustancias químicas para cosechar langosta a través del Caribe.

PALABRES CLAVES: Langosta, *Panulirus argus*, decolorante, técnica de algodón de almidón-yoduro, Islas de Turks & Caicos

INTRODUCTION

In April 2002, the School for Field Studies (SFS) and the Turks and Caicos Islands (TCI) Government, Department of Environment and Coastal Resources (DECR), who are the regulatory and enforcement authority for the environment, entered into a Memorandum of Understanding concerning cooperation in the conduct of research and data sharing on topics including, but not limited to spiny lobsters (*Panulirus argus*). The spiny lobster fishery in the TCI is the most valuable marine export product to the economy each year. Locally at South Caicos, where SFS operates a teaching and research center (Center for Marine Resource Studies – CMRS), marine resource harvesting (e.g. conch, lobster) is the principle component of the economy and employment, and in combination with fisheries from the other islands of the TCI, contributes approximately 2.4% of the TCIs GDP (2000 estimate).

Lobster fishing is only permitted from August 1st to March 31st. During the closed season, no lobster can be exported or served in local restaurants. Minimum carapace length for harvested lobster is 3¼" (83 mm) (Fishery

Protection Ordinance 1998). In 1992, 1,312,795 lbs of lobster were landed in the TCI, however, this was soon followed by a dramatic decline in catches to a low of just 398,909 lbs in 1996. Since then, catches have remained relatively stable at around 550,000 lbs per year (Figure 1) with Catch Per Unit Effort (CPUE) also remaining relatively stable (DECR Unpublished data).

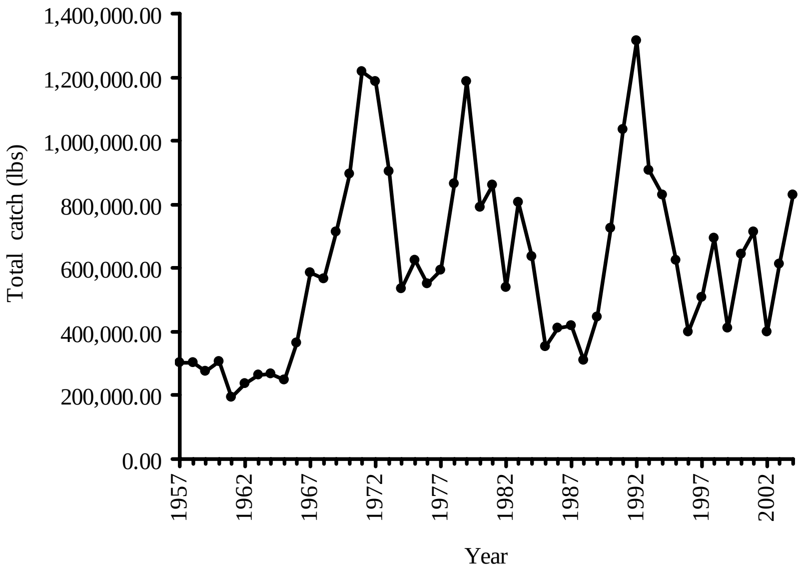

Figure 1. Spiny Lobster catches in the TCI from 1957 to 2004 (source: DECR landing data).

There is no harvest quota for spiny lobster, thus local stocks are subject to intensive fishing pressure during the open season. Spiny lobsters are harvested predominantly by “free diving” (i.e. without underwater breathing support - the use of SCUBA for fishing purposes is illegal) with the remainder being caught with traps. Free diving is in itself a form of effort limitation on the rate and quantity of harvesting, due to the depths that the divers can achieve. Free divers fishing for lobsters currently utilize several illegal fishing methods, most notably “the hook” (a large fishing hook fixed to the end of a 3 - 5 ft fiberglass rod) and household bleach, or liquid detergent sometimes mixed with gasoline, to force spiny lobsters from their dens (Clerveaux and Vaughan 2001, Rudd 2003). Chlorine bleach injected into lobster dens has a ‘subduing’ effect, making them easier to catch. As a side-effect of this form of fishing, the surrounding habitat is quickly destroyed and algal blooms follow (Campbell 1977). Specifically, corals and other organisms are killed by the bleach, with fleshy and turf algae rapidly recolonizing the area, thereby making the recolonization by corals and other organisms difficult and slow. This process, known as a coral-algal phase shift (Hughes 1994), can be accelerated when noxious chemicals or other pollutants are discharged into coral reef environments (McManus et al. 2000). The DECR is currently looking to eliminate the use of the hook, implement a harvest quota, and develop additional/further techniques to detect the use of illegal chemicals in the fishery.

The use of noxious substances to capture marine fishery products is prevalent in many fisheries around the world. Cyanide is the most common, with fisherman in the aquarium trade using cyanide to stun ornamental fish for collection (Barber and Pratt 1998, Halim 2002, Mak et al. 2005). Chlorine bleach has also been employed widely, with uses ranging from the stripping of eggs from berried (egg-bearing) females in the Maine rock lobster (*Homarus americanus*) fishery (Austin 1995, Cogger and Bayer 1996, Lobster Institute 1997, Heckmann et al. 2000), to its use as a subduing agent in both reef fish and crustacean (spiny lobster) fisheries in the Bahamas (Campbell 1977) and the TCI (Lang et al. 1998, Clerveaux and Vaughan 2001, Rudd 2003, Tewfik and Bene 2004). The deleterious effects of chlorine bleach on marine organisms are well documented (Carpenter et al. 1972, Campbell 1977, Lehtinen et al. 1988, Rosemarin 1994), with effects ranging from decreased productivity to partial or total community mortality (Campbell 1977).

In the Maine lobster fishery, ovigerous (berried) lobsters are taken by fisherman, and the eggs are subsequently removed by dipping the tails into a seawater and bleach solution. Bleach solutions frequently exceed 20% concentrations and result in the complete removal of eggs in less than two minutes (Cogger and Bayer 1996), quicker at higher concentrations. To combat this illegal technique, researchers developed two techniques to detect the use of bleach. Firstly, Cogger and Bayer (1996) developed a microscopic examination technique, where chemical scrubbing of berried lobster using bleach was detectable from the damaged caused to the plumose setal hairs on the lobster tail. However, this technique required the removal of the swimmerets for microscopic evaluation, thereby causing physical damage to the lobster (Lobster Institute 1997). An alternative and less invasive technique developed by Heckman et al. (2000), involved the use of a simple swab test, that combined two chemicals (Potassium Iodide and a Starch Indicator Solution) to detect the use of concentrated (20% or greater solutions) chlorine bleach (5.25% NaOCL) on lobster.

The Turks and Caicos Islands spiny lobster fishery is plagued with similar problems as those in the Bahamas and other areas throughout the world where chlorine bleach is readily available. In recognition of this fact, in March 2004, the DECR requested that the SFS-CMRS carry out a research program designed to develop a portable test kit for the detection of noxious chemicals such as household bleach (e.g. Clorox™) in the TCI fishery, thereby providing the DECR with an effective enforcement tool. Following the request from the DECR, we embarked upon a series of laboratory experiments to develop such a kit. Specifically, we aimed to determine the efficacy of the Starch-Iodide swab technique developed by Heckman et al. (2000), to detect bleach use on *P. argus* in a controlled laboratory environment.

METHODS

Study Site

The efficacy of a Starch-Iodide swab technique was tested in a laboratory environment at South Caicos, T.C.I. (Figure 2), from August through November 2004.

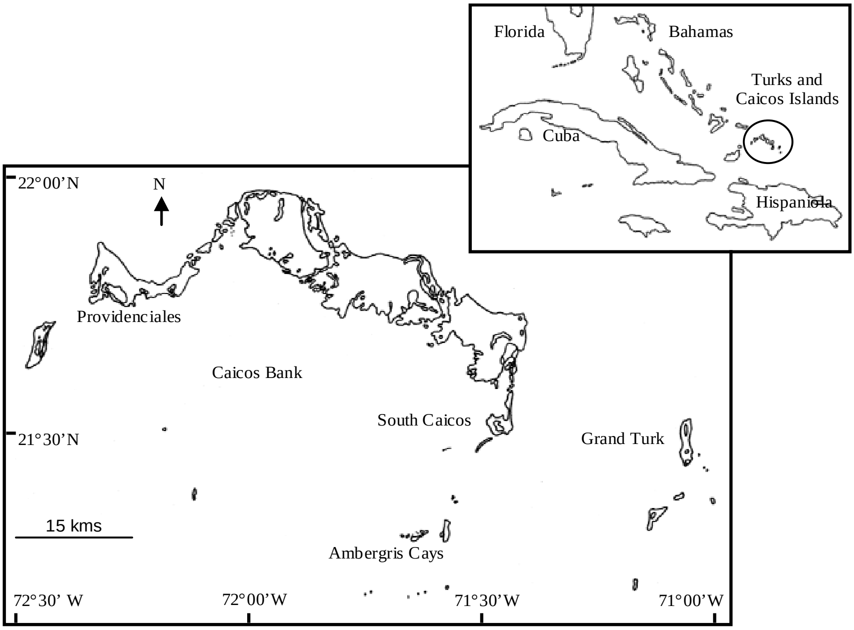

Figure 2. Location of the Turks and Caicos Islands at the southern end of the Bahamian Archipelago.

Starch-Iodide Swab Technique

Rather than starting from scratch, we chose to use a Starch-Iodide based, chlorine bleach detection method developed for the Maine rock lobster (*Homarus americanus*) fishery by Heckman et al. (2000), on spiny lobster (*Panulirus argus*) from the T.C.I. fishery. The swab test consisted of two primary chemicals (Potassium Iodide and a Starch-Indicator). The Potassium Iodide crystal (Spectrum Chemical® code #P1335-10) was prepared as a 0.1% solution prepared in distilled water. The Starch-Indicator solution (Fisher Scientific® code #SS408) was used in its manufactured concentration.

The Efficacy of the Starch-Iodide Swab Technique in a Controlled Laboratory Environment

Using the aquarium facilities located at the Department of Environment and Coastal Resources (DECR) South Caicos base, five raceways measuring 3 x 0.5 x 0.5 m (length x width x depth) were used in the experimental manipulations. Four of the raceways were used as replicate treatments with the fifth raceway as the control (Figure 3).

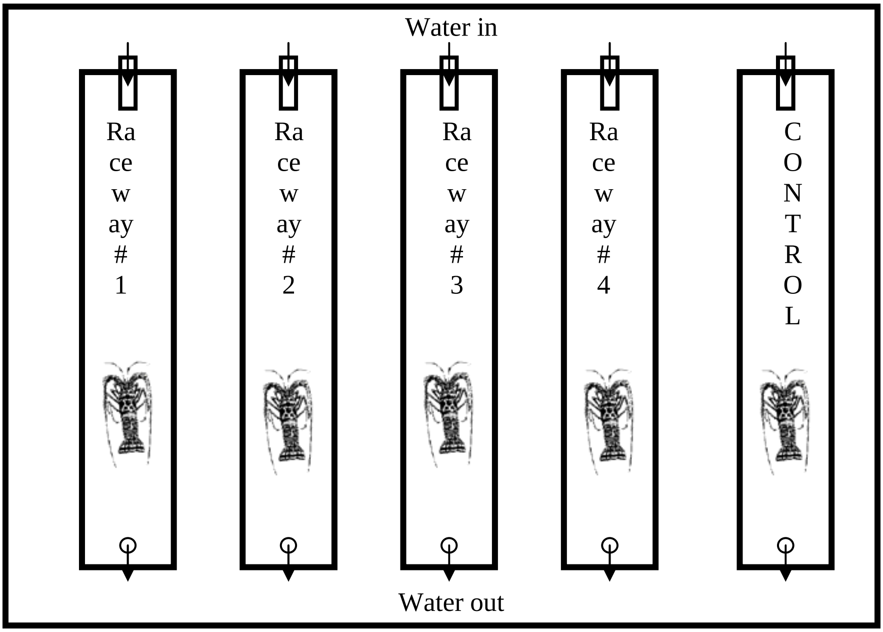

Figure 3. Experimental aquaria and layout for the bleach detection experiments in the laboratory. Each raceway had a single lobster of known size and sex for each trial.

The laboratory trials were repeated five times for female lobsters (n = 25) and five times for male lobsters (n = 25). Lobsters for experimental trials were collected using industry standard lobster traps to minimize potential injury to, and ensure no previous exposure to bleach. Prior to each trial the water in each raceway was tested for the presence of bleach using a standard chlorine test kit. In all cases the test produced a negative result. Five lobsters were then taken from a main holding tank and were swab tested for the presence of bleach. If negative (all were negative), each lobster was measured to the nearest mm carapace length, sexed, then placed into a separate raceway. This gave four treatment raceways and one control for each trial (n = 5). Water flow was then turned off and 40 ml of household bleach was added to each experimental tank using two 20 ml syringes (40 ml) (not the control) and left *in situ* for a period of approximately 60 seconds. Lobsters were then removed from all raceways and placed in separate holding baskets. The lobsters were then swab tested using the Starch-Iodide solution (including the control) to test for the presence of bleach and the result recorded as either a "+" or "-". A positive result occurred when the white swabs turned purple after being rubbed on the bleach exposed exoskeleton of a lobster. Lobsters were placed back into their separate holding baskets for further swab tests to be carried out at 2, 4, 6, 8, 10, 12 and 14 hrs after initial testing. At the end of each trial, the raceways were drained, flushed with fresh seawater, and left to dry until the next morning. Prior to the next trial, the raceway was flushed again and filled with seawater. The experiment was repeated using the protocol described above.

Analysis of bleach detectability between male and female spiny lobsters was conducted using a t-test. A logistic curve (Non-linear regression) was then used to determine the predictability of lobster testing positive to bleach at intervals post-exposure.

RESULTS

Trials produced clear results with all lobster that were exposed to bleach testing positive using the swab technique immediately after exposure with no false positives. The percentage of male and female lobster that remained positive (two hourly swabs) slowly declined with time (Table 1). The comparison of test efficacy between male and female lobsters showed no significant difference between sexes ($p = 0.92$). Both results for male and female lobsters were then combined as a total percentage testing positive post-exposure to bleach (Table 1). The logistic curve analysis of the combined data shows that the detectability of bleach on lobster slowly decreases over time (Figure 4).

Table 1. Laboratory swab test results on male and female spiny lobsters over time, from exposure to bleach (0 to 14 hrs). Expressed as a percentage that test positive. T-test indicated that there were no differences between male and female lobsters (p = 0.92. n = 40).

Sex	Time (hours)							
	0	2	4	6	8	10	12	14
Male %	100	100	95	64	41	14	5	0
Female %	100	95	82	64	45	14	0	0
Total %	100	98	89	64	43	14	2	0

Independent Validation

To further validate the swab technique using a semi-independent technique, three officers from the Department of Environment and Coastal Resources (DECR) were given a blind test using the swab technique. For the validation, lobsters went through the same exposure and non-exposure regime as described previously. The DECR officers then tested ten experimental lobsters for the presence or absence of bleach four hours after the initial treatment. The swab tests by the DECR officers correctly identified all bleached and unbleached lobsters (n = 10) (Table 2).

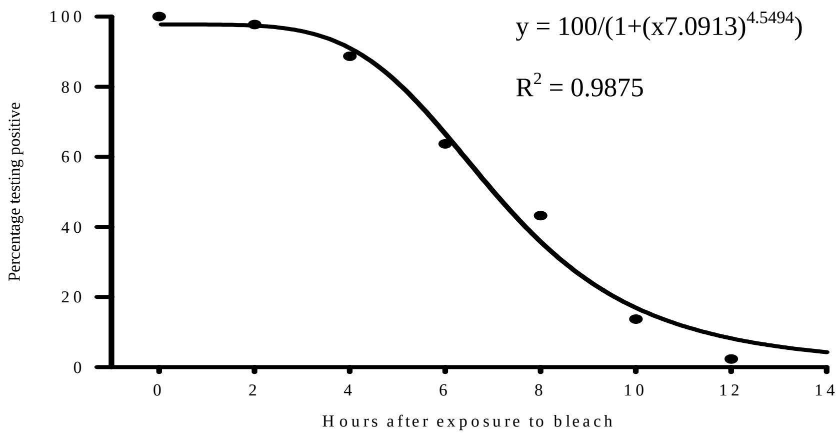

Figure 4. Predictive logistic curve applied to the total percentage data from Table 1.

DISCUSSION

The Starch-Iodide swab test described in this study proved to be an effective tool for detecting the presence of chlorine bleach in laboratory treated spiny lobster. The most important aspect of the swab test, is that it is consistent and easily interpreted (white swabs turn purple when rubbed on the bleach exposed exoskeleton), and is 100% accurate with no false positive results. In addition, the test does not cause any physical damage to the lobster (e.g. removal of pleopods for laboratory analysis), is fast and extremely accurate. The chemicals that form the test are also non-toxic (Potassium Iodide and Starch Indicator) and have been approved for food and drug use by the U.S. Food and Drug Administration (F.D.A. 2005). As such, the swab test poses no threat to the integrity of the fishery product for human consumption (Heckman et al. 2000).

A typical days fishing for spiny lobster in the TCI is less than eight hours (Pers. obs.). This involves departing the docks around 7:00 am, followed by a 30-60 minute boat ride to the desired fishing grounds. The days fishing usually lasts approximately eight hours, with fisherman returning to the landing docks from 3 - 5 pm. Thus, from the time fisherman arrive at the fishing ground and begin fishing (around 8:00 am) until they land their catch back in port, is approximately 7 - 9 hours. As shown in the laboratory trials for the bleach detection kits, ~50% of bleach exposed lobster tested positive up until eight hours after exposure. After this time, bleach detectability declined rapidly until 14 hours after exposure when no lobsters tested positive. Therefore, given that the average days fishing is less than eight hours, the likelihood of detecting bleach use by swabbing lobster at the landing docks is extremely high. However, before the bleach detection swab test can be used as a fishery management tool, it will need to be tested thoroughly in field validations.

If successful in field trials, we would recommend the bleach test kits be used not only at the landing docks, but also in the field (at lobster capture/ fishing grounds). Enforcement and conservation officers could board fishing vessels and swab test the most active lobsters in the vessel, as well as several which appear to have been caught early in the day (dead or in poor condition). This would circumvent any issues associated with fisherman only using bleach early in the day to catch spiny lobsters.

Previously, it was extremely difficult for enforcement and conservation officers to prove that a certain fisherman was using bleach to catch lobster, as there were no obvious external signs on the lobster. Typically, when fisheries patrol boats would approach a fishing vessel in the field, the fisherman could simply dispose of the bleach bottle under a coral ledge or just throw it overboard (in water discard), thereby removing any physical evidence. However, with the development of the bleach detection swab test, the fisherman would have to throw away their entire catch overboard when a fishery patrol boat approaches in order to avoid detection. Obviously, this is not an economically viable option for the fisherman. The largest benefit of the bleach detection kits therefore, will be that they will act as a deterrent to fisherman who currently use bleach as a fishing tool.

Once the bleach detection kits have been validated in the field, they will be ready for use in the TCI spiny lobster fishery and will be an effective fisheries management tool if used correctly and frequently. The swab test will provide fisheries enforcement and conservation officers with a powerful tool to reduce or eliminate the illegal use of chlorine bleach for harvesting lobsters throughout the Bahamas and wider Caribbean.

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