Recruitment of Spiny Lobsters, *Panulirus argus*, to Submerged Sea Cages off Puerto Rico, and its Implications for the Development of an Aquaculture Operation

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ABSTRACT

Spiny lobster, *Panulirus argus*, is an important fisheries species in Florida and the Caribbean region. The high value of this species and the limited extent of their wild fisheries make them an ideal candidate for commercial culture. One of the major constraints to spiny lobster culture is that the aquaculturist must rely on the steady supply of post larvae (pueruli) from the wild for nursery and growout. The focus of this research project was to advance the culture of spiny lobster through novel pueruli collection methods. Recruitment of 1000's of spiny lobster pueruli to submerged fish sea cages in Puerto Rico was first observed by Snapperfarm, Inc. in spring of 2003. With funds from NOAA SBIR Phase I, studies were conducted from July 2003 to January 2004 to determine the feasibility of collecting spiny lobsters from sea cages for growout. Results showed that year-round collection of pueruli from submerged sea cages is feasible, with the highest collection occurring in the spring and near the new moon phase. Newly settled pueruli and pigmented post larvae were observed during each month of the study. Over 400 juvenile lobsters were collected from the submerged sea cages; 40 were placed in a growout study and the rest were relocated to a nearby marine reserve. The findings from this study indicate that collection of lobster pueruli and juveniles from sea cages for growout is technically feasible and has potential to be developed into a commercial venture.

KEY WORDS: Pueruli, recruitment, spiny lobster

Colección del Pueruli de la Langosta Espinosa en Puerto Rico: Un Enfoque Integrado de la Acuacultura

La langosta espinosa, *Panulirus argus*, es una especie de importancia comercial en las regiones de Florida y el Caribe. El alto valor económico de esta especie y la distribución geográfica limitada de su pesca la hacen una candidata ideal para la acuicultura. El cultivo exitoso de sus estadios larvales aun no son posibles dado su complejo ciclo de vida. Por tanto, investigación de la langosta y proyectos pilotos de acuicultura para la crianza a tamaño de mercadeo dependen de la colección de los puerulus silvestres. Entender la dinámica del reclutamiento de la langosta es el primer paso en el desarrollo de un programa de acuicultura de la langosta que depende de una fuente de semilla silvestre. A principios de Febrero del 2005, Harbor Branch Oceanographic Institution, la compañía Snapperfarm, Inc. y varios colaboradores empezaron un proyecto de investigación con fondos de la NOAA SBIR Fase II en la isla de Culebra, Puerto Rico para: 1)desarrollar métodos óptimos para coleccionar puerulus con colectores tipo Witham en las cercanías de jaulas de cultivo de peces, y 2) desarrollar métodos para la crianza de langosta desde su etapa de puerulus a tamaño de mercadeo en jaulas sumergidas. Los resultados de los primeros siete meses del estudio indican que la profundidad óptima para la colección de los puerulus en la Sonda de Vieques, Puerto Rico es entre 50-85 pies, con menores cantidades de puerulus a profundidades de 10 pies. Pulsos de reclutamiento máximo ocurren durante los meses de verano, particularmente en Junio con 93 puerulus colecionados de uno de los colectores Witham localizado a 80 pies de profundidad. Los valores máximos de puerulus fueron coleccionados en Julio cuando 474 puerulus fueron coleccionados en 19 colectores Witham en profundidades entre 50-85 pies. Prototipos de jaulas sumergidas para la crianza de juveniles serán probadas en el otoño. Estos resultados demuestran que es posible coleccionar grandes cantidades de puerulus de la langosta para crianza a tamaño de mercadeo como una fuente de ingreso

adicional al cultivo de peces en jaulas en Puerto Rico.

PALABRAS CLAVES: Acuicultura, puerulus, reclutamiento, langosta espinosa ó langosta

INTRODUCTION

The world market for spiny lobsters is approximately 80,000 metric tons annually and is supplied almost entirely by wild fisheries (FAO 2005). The spiny lobster, *Panulirus argus*, is found throughout the Gulf and Caribbean and forms the largest commercial fishery for spiny lobsters in the world at around 38,000 metric tons. The high value of spiny lobsters and the limited extent of their wild fisheries are generating an increasing worldwide interest in aquaculture (Jeffs and Hooker 2000). The commercial aquaculture of spiny lobsters is estimated at 3,000 tons per year and is being cultured in a number of countries including Japan, Australia, Taiwan, and New Zealand, with the vast majority grown in Vietnam (Jeffs and Hooker 2000). This spiny lobster aquaculture is based on the collection of post-larva and early juveniles from the wild.

The prospects for farming the Caribbean spiny lobster, *P. argus*, profitably are higher than for temperate spiny lobster species due to the greater availability of wild seed lobsters and a faster growth rate (Booth and Kittaka 2000, Jeffs and Davis 2003). At this time, the spiny lobster, *P. argus*, is not commercially cultured, however, a great deal of research has been accomplished on this species and similar species that are directly relevant to the development of aquaculture of *P. argus* (Lellis 1991, Jeffs and Hooker 2000).

One of the major constraints to spiny lobster culture is obtaining a steady supply of post larvae for nursery and growout. Spiny lobsters have been successfully mated and spawned in captivity. However, researchers have had difficulty rearing large numbers of phyllosoma larvae through the many stages of the year-long complex larval cycle. An alternative is to bypass the larviculture stage and collect the pueruli from the wild as they drift to nearshore habitats. There has been good success with the collection of wild spiny lobster pueruli on floating artificial habitats (Witham collectors), in crevice collectors, or large plankton nets (Witham *et al*. 1964, Calinski and Lyons 1983, Reid *et al*. 1991, Gutierrez-Carbonell *et al*. 1992, Field and Butler 1994, Phillips and Booth 1994). The transparent pueruli settle on the collectors during the new moon to the quarter moon phase. Lunar cycle plays a role in settlement and collection numbers. In addition to lunar cycles, wind, tides, hydrological features, and seasonality influence the timing and magnitude of lobster recruitment to artificial habitats.

Collection of pueruli from the natural environments will not put pressure on the fisheries stocks. There are indications from pueruli collection studies that collectors only remove a small fraction of the number of pueruli in the water column and that a very large number of pueruli are lost mainly due to predation or lack of appropriate settlement habitat (Ryther *et al.* 1988, Butler and Herrnkind 1989). In nature it is estimated that only 4% of post larvae survive to juvenile stage (Forcucci *et al.* 1994). Under controlled culture conditions survival could be as high as 50-75% during this stage (Lellis 1991).

Snapperfarm, Inc. has two 3,000 cubic meter sea cages used to culture marine fish off the coast of Culebra, Puerto Rico. These structures are located in 28 meters of water depth. Over the course of the first six months after deployment, the cage became covered in a fine layer of macroalgae and diatoms. In the spring of 2003, 1000s of spiny lobster pueruli recruited to these submerged sea cages. These juvenile lobsters were the first indication that these large sea cages are ideal settlement collectors for spiny lobster pueruli. With funds from NOAA SBIR Phase I, Snapperfarm, Inc. and researchers from Harbor Branch Oceanographic Institution, University of Miami - RSMAS, Florida Sea Grant Extension, and NMFS conducted studies from July 2003 - January 2004 to advance the culture of spiny lobster through novel pueruli collection methods.

OBJECTIVES:

The main goals of the project were to determine methods to collect spiny lobster pueruli that recruited to offshore submerged sea cages in Puerto Rico, and to assess the commercial viability of a spiny lobster mariculture operation in association with offshore cages used for fish culture.

METHODS AND RESULTS

The study was conducted by Snapperfarm, Inc. and collaborators in Culebra, Puerto Rico. Snapperfarm has two SeaStation™ 3,000 cubic meter offshore cages off the coast of Culebra, Puerto Rico. Each cage is 15 m deep, 25 m in diameter and has a total surface area of 1,115 square meters. The cages are submerged in a water depth of 28 meters with the top 8 m below the sea surface. The site is fully exposed to the Atlantic Ocean to the northwest and the Caribbean Sea to the southeast. The site receives strong open ocean currents (0.5 knots).

Scuba diving surveys of the sea cages for spiny lobster pueruli were conducted during each month of the study (July 2003 – January 2004) and showed that the majority of the lobsters recruited to the sea cages on the new moon and during the week following the new moon. Low numbers of pueruli were visually found during transect surveys of the seacages, due to the small size of the pueruli (6-7 mm CL) and their cryptic nature (e.g., clear to slightly pigmented). The greatest number of pueruli (total of 14) were seen while night diving with lights on a small section of the sea cage in August. Pueruli were also observed in the daytime during each month of the study (up to five pueruli/month). The pueruli were found near the chimney top of the sea cage, in the folds of the harvest net, and under clumps of red algae, *Laurencia* sp., which is known to trigger lobster settlement. This is the first time that lobsters of this size

have been observed in the wild on large submerged sea cages.

Collection devices, such as PVC pipes and window screen pinwheels, were secured to the sea cages in an experimental array. Lobsters did not recruit to the PVC pipes, but were attracted to the screen pinwheels. Up to five pueruli and juveniles were found in the screen pinwheel collectors each month (October 2003 – January 2004). The best results were when the pinwheels were placed on the sea cages one week prior to the new moon in order to provide soak time and promote biofouling. However, these collection devices (i.e. PVC pipes and pinwheels) were not ideal for pueruli and juvenile lobster collection, due to predacious crabs that also recruited to the collection devices.

Due to the cryptic nature of the pueruli, making them very difficult to identify and collect in the field, an alternative collection method used during the study delayed removing spiny lobster juveniles off the sea cages until after they had gone through several molts and became pigmented (two months after settlement). Over 400 juvenile lobsters (2 to 8 months old) were collected from the two sea cages during the study. The majority were placed in a nearby marine reserve, however, 40 were removed for a preliminary growout study. They ranged in size from 3 – 6 cm CL (five to eight months in age). The lobsters were placed inside a 55-gallon plastic barrel that had holes drilled in the sides and shelter inside. The barrel was secured to the sea cage mooring on bottom of the ocean (28 m deep). The lobsters were fed cobia mortalities from the sea cage every five to seven days. Lobster survival over the three month study period was 60%, however, growth was slow over the three months due to lack of adequate feed variety.

DISCUSSION

There is every indication from this study that lobster pueruli and juveniles can be collected year round from submerged sea cages in Puerto Rico. Due to the cryptic behavior and clear color of the pueruli, it is not surprising that it was difficult to obtain an accurate count of the number of pueruli during the surveys. The results from this study show that year round collection of lobster pueruli and juveniles from sea cages is technically feasible and has potential to be developed into a pilot-scale venture. This is consistent with the purpose of NOAA SBIR Phase I to determine the technical feasibility of the proposed research. Recruitment of lobsters to the fish sea cages will provide Snapperfarm, Inc. with an added revenue source to support the fish farming operation. The company was awarded a NOAA SBIR Phase II to continue the research and development of pueruli collection on submerged sea cages and submerged cage growout of juveniles for market.

This is Harbor Branch Oceanographic Institution Contribution Number 1567.

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