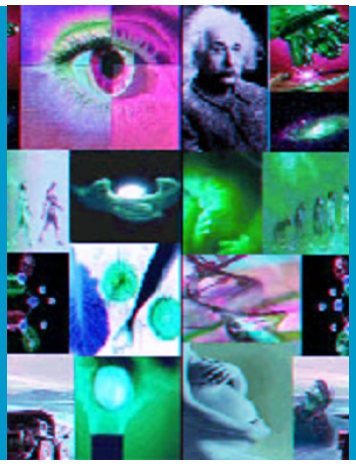
Comisión Nacional de Investigación Científica y Tecnológica - CONICYT



PROGRAMA FONDECYT

INFORME FINAL

ETAPA 2011

COMISIÓN NACIONAL DE INVESTIGACION CIENTÍFICA Y TECNOLÓGICA

VERSION OFICIAL Nº 2

FECHA: 15/12/2011

Nº PROYECTO : 3100085 **DURACIÓN :** 2 años **AÑO ETAPA :** 2011

TÍTULO PROYECTO : EARLY DEVELOPMENT OF SANDY-BOTTOM MACROBENTHIC COMMUNITIES OFF NORTHERN CHILE: EFFECTS OF PATCH SIZE, PREDATORS AND COLONIZATION MECHANISMS

DISCIPLINA PRINCIPAL : ECOLOGIA Y CIENCIAS AMBIENTALES

GRUPO DE ESTUDIO : BIOLOGIA 1

INVESTIGADOR(A) RESPONSABLE : ALDO SANTIAGO PACHECO VELASQUEZ

CIUDAD : Antofagasta

REGIÓN : II REGION

FONDO NACIONAL DE DESARROLLO CIENTIFICO Y TECNOLOGICO (FONDECYT)

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INFORME FINAL
PROYECTO FONDECYT POSTDOCTORADO

OBJETIVOS

Cumplimiento de los Objetivos planteados en la etapa final, o pendientes de cumplir. Recuerde que en esta sección debe referirse a objetivos desarrollados, NO listar actividades desarrolladas.

Nº	OBJETIVOS	CUMPLIMIENTO	FUNDAMENTO
1	The effects of patch size and vertical isolation in the mechanisms of colonization of macrobenthic communities.	TOTAL	This objective was achieved however a first manuscript submitted for publication was rejected by the editorial board of Marine Ecology Progress Series. However, we took all the comments of the reviewers that help us to improve our manuscript and the revised version was submitted to a new journal (see section products).
2	The importance of bedload transport in the colonization of a new patch of sediment	TOTAL	This objective was achieved and an early version of a manuscript it is attached to the printed version of this report.
3	The effects of predators creating patch mosaic communities in soft sediments	TOTAL	The field work of this experiment was finished and the preliminary results provides support to accept our initial hypothesis about the effect of predators influencing the structure of subtidal macrobenthic communities. Samples are being processing and once the whole data set is analyzed a publication will be prepared.

Otro(s) aspecto(s) que Ud. considere importante(s) en la evaluación del cumplimiento de objetivos planteados en la propuesta original o en las modificaciones autorizadas por los Consejos.

As stated in the middle report, the order of the objectives were changed as the rationale and results of the first experiment (objective N°1) provided the conceptual framework for the realization of experiments for objetive N°2 and N°3. Such experiments were conducted during 2011, in late May, June, July, August and early September. I have to mention here that during March and April I had two surgeries due to kidney stone problems so I was unable to dive thus resulting in a delay of the time schedule proposed for field experiments in the original plan. However, both experiments were conducted, the second experiment (objective N° 2) was succesfully done and results and conclusions are presented. In the case of third experiment (objective N°3) the field work was conducted but sampling processing is still under course. However, preliminary results from the first sampling of this experiment suggest that the hypothesis regarding the effects of crab predators creating different patch with distinct macrobenthic communities at different successional time can be approved. Data and analysis are provided.

RESULTS OBTAINED:
For each specific goal, describe or summarize the results obtained. Relate each one to work already published and/or manuscripts submitted. In the Annex section include additional information deemed pertinent and relevant to the evaluation process.
The maximum length for this section is 5 pages. (Arial or Verdana, font size 10).

Objective 1: The effects of patch size and vertical isolation in the mechanisms of colonization of macrobenthic communities

This objective was fulfilled during the first year of the project. A field experiment was conducted at two subtidal sites (Bolsico and Colorado beaches) in the coast of Antofagasta in northern of Chile. Detailed information of the experimental design, sampling and sample processes and numerical analyzes are provided in the manuscript submitted for publication (see products). The principal results of this experiment are summarized in figure 1 and 2.

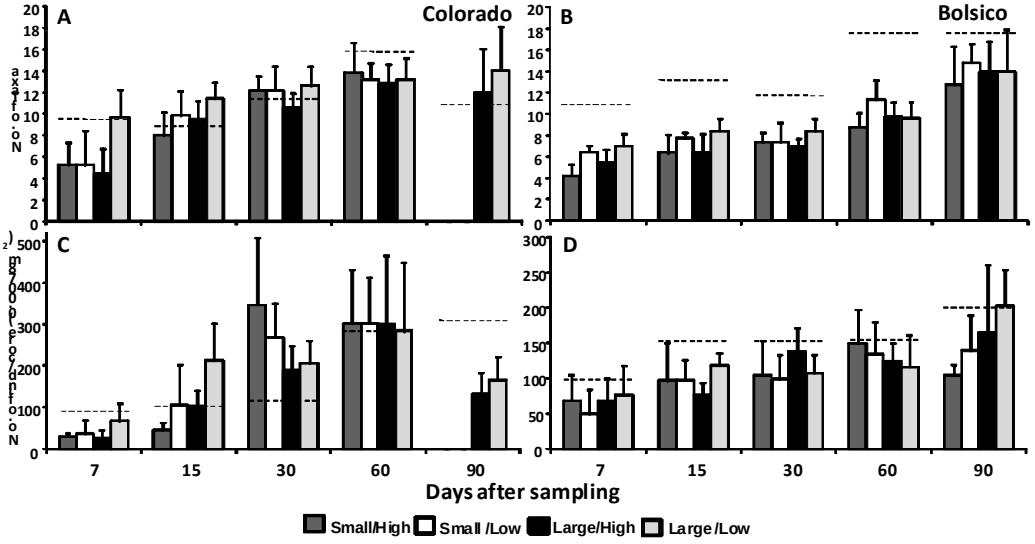

Figure 1. Summary of the changes of univariate parameters measured during the experiment in both sites. Different color bars (mean + SD; n=5) represent container types i.e. treatments. Dotted lines represent the mean abundance in the reference samples.

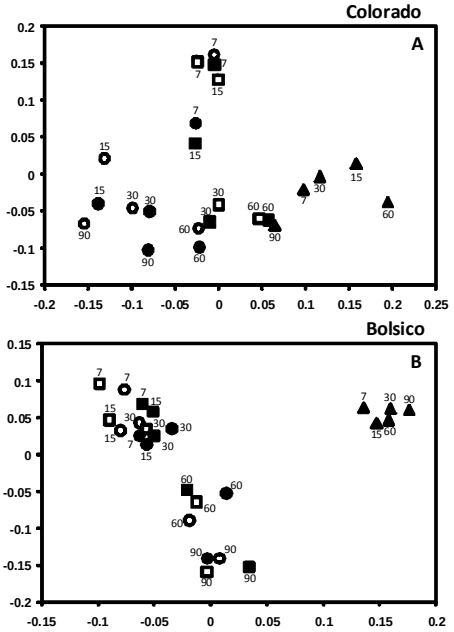

Figure 2. Canonical ordination plots of community structure (A = Colorado and B = Bolsico) calculated from Bray-Curtis similarity/dissimilarity distance matrix with square root-transformed data of the average (i.e. centroids). Small/high containers (□), small/low (■), large/high containers (○), large/low containers (●), reference samples (▲). Numbers indicated the time interval of sampling in days.

Overall the results of this experiment suggest that the immigration of juveniles and adults through water column is key processes during the succession in subtidal sedimentary habitats. Different mechanisms of dispersion are involve during succession, while some species can move up and down from the sediment to the water column and then returning to a disturbed patch, others seem to depend on passive transport for colonizing. The alternation of using sediment and water column during colonization may alleviate strong interactions among colonizers, thus explaining the tolerance model of succession and patters of biodiversity in sedimentary subtidal habitats. Besides the submitted manuscript, a literature review of the conceptual framework of this study was presented as a talk in the II Congreso de Ciencias del Mar del Peru (see abstract and power point presentation are attached to the report). The results of the study were also presented at the XXX Congreso de Ciencias del mar, Chile (see abstract and power point attached to the report).

Objective 2: The importance of bedload transport in the colonization of a new patch of sediment

We further enhanced the initial question of this objective which initially aimed to quantitative measure of the amount of species that are displaced through bedload transport. Since the first experiment suggested that water column transport and diel vertical migrations played an important role in the colonization and succession of macrobenthic invertebrates, we designed a set the traps to evaluate the dispersion of macrobenthic invertebrates through water column and bedload. Figure 3 summarizes the type of trap and the mechanisms of dispersion aimed to indentify for the distinct species of macrobenthos in the study. Views of the artifacts are provided in the power point presentation and details of the designs are provided in the attached manuscript in the printed version of this report.

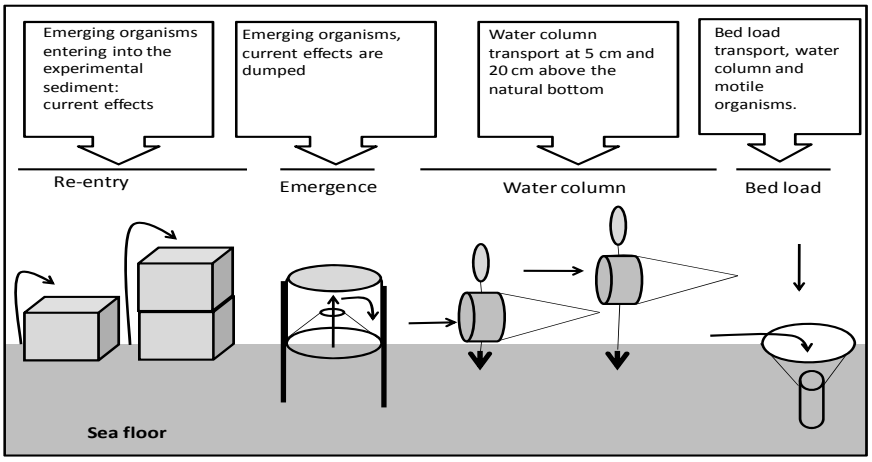

Figure 3. Design of traps used in the experiment to quantify macrobenthic organisms with different types of dispersion.

These set of traps were installed at the two experimental sites (Bolsico and Colorado) and experiments were conducted between the end of June and the middle of July. Since both sites present contrasting bottom hydrodynamic conditions i.e. Bolsico protected with low flow and Colorado more exposed with stronger flow we predicted that (a) mechanisms of post-larval dispersal would be species-specific thus, (b) the composition of the dispersing assemblage would be different among traps and ambient benthos and (c) the rate of post larval dispersal will be higher in the exposed site. At each experimental site between four and five replicated traps were sampled in four consecutive sampling days. Re-entry and emergence traps were exposed for a 24 hours cycle, while water column and bedload traps were exposed for 3 days. The captured taxa were carefully collected and preserved in a 10% formalin-methanol solution stained with Rose Bengal. Thereafter, in the laboratory, samples were washed and sieved through a 0.5 mm mesh with a 0.3 mm mesh underneath in the case of re-entry traps and reference samples. Benthic taxa were sorted, identified under a stereo microscope to the lowest taxonomical level possible and counted. The main results of the experiment are summarized in figure 4.

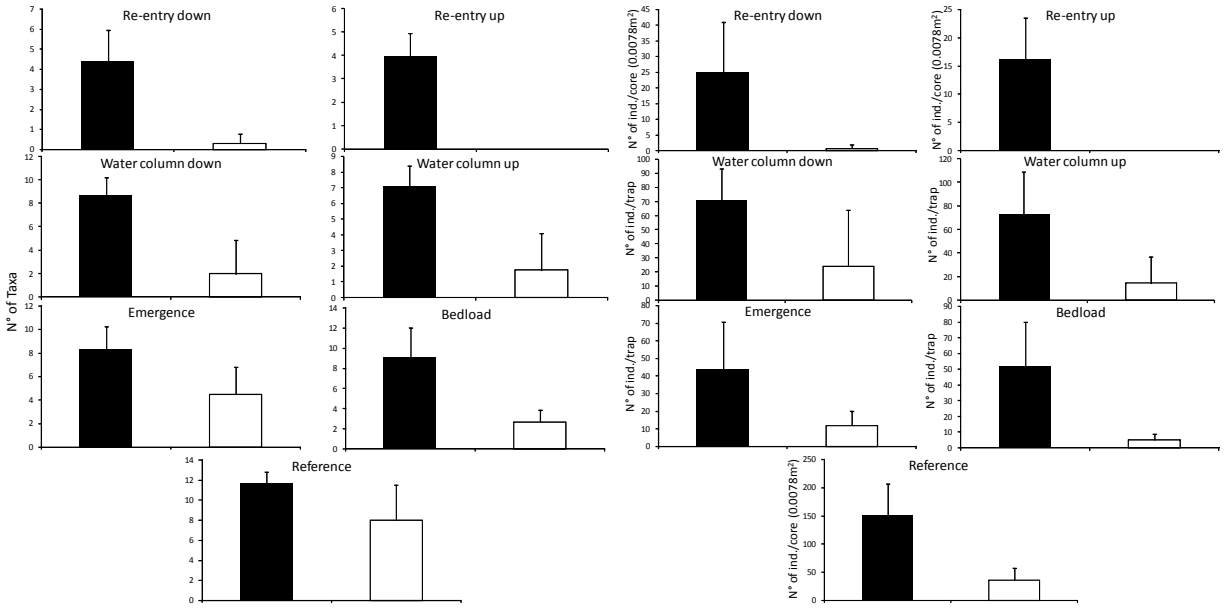

Figure 4. Mean and standard deviation of number of taxa (left) and abundance (right) collected in the different traps and reference samples. Bars represent Bolsico (black) and Colorado (white).

The results of this experiment shows that in Bolsico, the protected site, all types of traps collected abundant and rich macrobenthos suggesting that all mechanism of dispersion were important in this site including bedload transport a dispersive strategy that we initially predicted would be of minor importance. In Colorado with strong current flow, emergence and water column traps collected the most abundant macrobenthos while contrary to our prediction bedload transport appeared of minor role. This suggest that different responses to hydrodynamics conditions, while some species may tolerated strong current and thus may be passively dispersed, other may be buried deeper in the sediment avoiding the flow. This may explain why few organisms were collected in bedload traps. Regarding our prediction of species-specific mechanisms of dispersal, multiple correspondence analyses showed that this was also true at both study sites (figure 5).

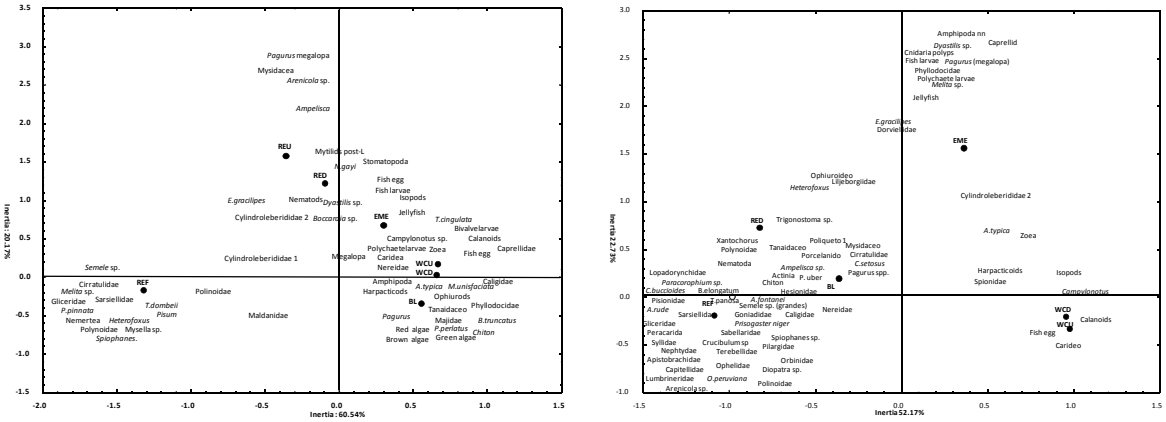

Figure 5. Ordination plots obtained from the correspondence analysis using the average of abundance of taxa collected per trap. Left plot; Bolsico, right plot; Colorado; re-entry up (REU), re-entry down (RED), emergence (EME), water column up (WCU), water column down (WCD), bedload (BL) and reference (REF). The complete list of taxa and abundance obtained throughout the study is presented attached to the report.

Objective 3: The effects of predators creating patch mosaic communities in soft sediments

As stated in the initial proposal, our previous work in the region suggested that large crab species of *Cancer* spp. are the more important sources of small patches of disturbed sediment as they rework the bottom during feeding and burrowing activities. In disturbed patches colonization and succession occurs so these patches are predicted to differ in terms of macrobenthic communities'

structure depending on these predator activities. Predators such as crabs may influence the structure of their community habitat by consuming a selected prey or a wide spectrum of them. Also, indirect effects are generate are triggering escape responses of prey and other predator appealing species but also provoking immigration into the disturbed patch by opportunistic species. Therefore, we conducted a directed sampling and a field exclusion/inclusion experiment aiming to detect the effects of two most abundant predators *Cancer setosus* and *C. coronatus* in the habitat community structure. We predicted that community structure in patches disturbed by crab predator will differ with those non disturbed by large crabs. The field work, including sampling and manipulative inclusion/exclusion experiments were conducted from the 21 July ending up the 5 of September.

Results of the directed sampling: We choose the subtidal area of Bolsico for this study as many hours of diving observation suggested that these species were the most abundant and occurred in large sizes enough to create disturbed patches (no other bottom predators such as flat fish or rays were observed in large quantities to be considered important). Ten crab pits and ten reference areas without crabs were sampled using the standard core as in the colonization and dispersion experiment. To sample pits we searched for large sized crabs (~15 cm width carapace) once detected the crab (either burrowing or feeding) it was carefully lifted from the sediment taken it by the posterior ventral part. The pit was sampled introducing the core as previously described in the colonization experiment. Non-pit areas were sampled in the same way but avoiding patches with signals of crab disturbance. The collected sediment was fixed in a 10% formalin-methanol solution stained with Rose Bengal and processed in the laboratory as previous described. The collected crabs were killed introducing the formalin solution into the stomach for further analysis of predator diet. A summary of the results of this study are presented in figure 6.

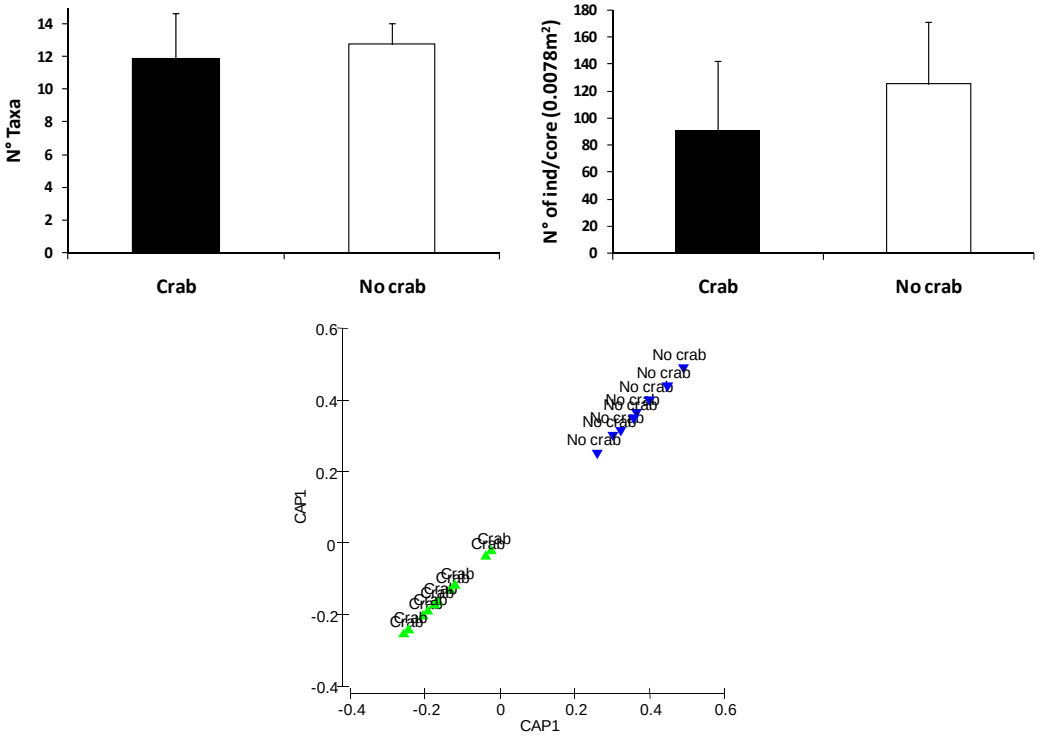

Figure 6. Upper plots: mean±SD of number of taxa (left) and mean±SD of abundance of taxa (right) recorded during the directed sampling of crab pits (black bars) and no crab areas (white bars). Canonical ordination plot (below) calculated from Bray-Curtis dissimilarity/similarity measures with square root transformed data of the average (centroids) of communities from pit and no pit samples.

While no differences were detected in number of taxa, abundance of macrobenthos was significant higher in areas without crabs (one-way ANOVA, $P<0.05$). However, in terms of community structure the canonical ordination plot clearly shows dissimilarities between pit and no crabs communities (fig. 6). One-way PERMANOVA detected significant differences between those communities ($P<0.005$). Data of abundance and number of taxa are attached to the report.

Results of the exclusion/inclusion experiment: Figure 7 shows the experimental design. The idea was to isolate the disturbing effect of *Cancer setosus* and *C. coronatus* in $1m^2$ sediment areas. We deployed cages covered with mesh (0.5 cm aperture) that excluded crab predators and cages

with a crab inside. In the inclusion treatment two *C. setosus* and one *C. coronatus* large sized males (~15 cm width caparace) were used. Since both species do not differ in cheliped size and in the way they disturb the bottom, the data from the inclusion treatment was pooled for both species. Also, control cages and surrounding sediments were sampled. Sampling strategy consisted in leaving the experimental set-up during four days and then collecting a sediment sample from the center of the experimental plot using the standard core. In addition, the experimental crab was collected for stomach content analysis. Three replicate per treatment were used and the whole experimental set-up was repeated three consecutive times.

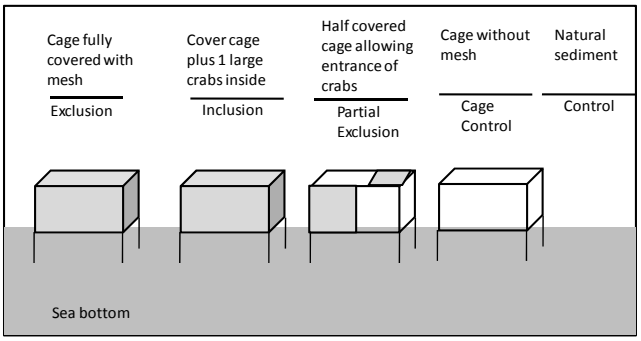

Figure 7. Experimental design for the inclusion/exclusion crab experiment.

As samples of the second and third repetition are still under processing, herein we present preliminary results based on the first sampling. Similarly to the results in the directed sampling, number of taxa did not differ significantly among treatments (figure 8) but significant lower abundances were detected among treatments (figure 8).

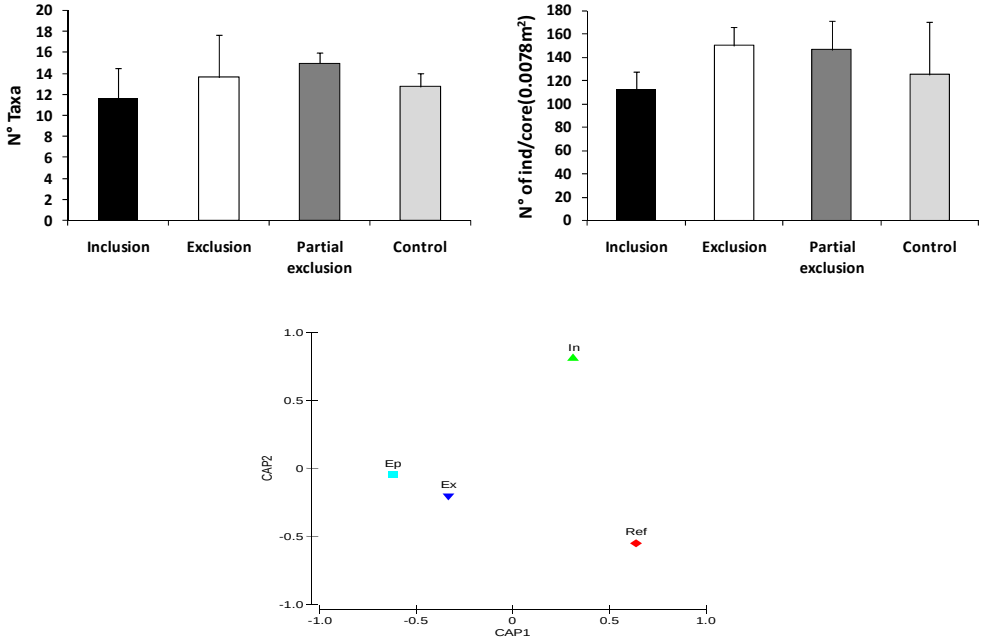

Figure 8. Upper plots: mean±SD of number of taxa (left) and mean±SD of abundance of taxa (right) recorded from the experimental treatments. Canonical ordination plot (below) calculated from Bray-Curtis dissimilarity/similarity measures with square root transformed data of the average (centroids) of the experimental treatments; inclusion (In), exclusion (Ex), partial exclusion (Ep) and reference (Ref) samples.

In terms of community structure, canonical ordination analysis shows high dissimilar communities between the inclusion treatment and total and partial exclusion. The dissimilarity is even higher with the reference community. One-way PERMANOVA detected significant differences between communities ($P<0.05$) and pair-wise comparisons showed significant differences between communities in the inclusion treatment and communities from the rest of the treatments. Information on number of taxa and abundances is presented in tables attached to the report. In addition, preliminary analysis of stomach content shows that crabs species preyed on the bivalve *Tagelus dombeii* and other small crustaceans preferably. Overall, these results suggest that disturbance produced by large *Cancer setosus* and *C. coronatus* influence the distribution of

macrobenthic communities by diminishing the abundances of epifaunal and infaunal organisms and thus modifying community structure. Solely consuming prey items appear not as important as the sediment modification during burrowing.

Conclusions

The main conclusions that are revealed from the project results are:

- Post- larvae and adult water column dispersion and diel vertical migration are important mechanisms of colonization of disturbed patches of sediment in subtidal sedimentary habitats.
- Post- larvae and adult dispersion of macrobenthic organisms are driven by assemblage's specific mechanisms of dispersion through bottom and water column.
- Relationships between bottom hydrodynamics and post-larvae dispersion are complex in subtidal systems: while in weak current conditions bedload could be important in high energy bottoms this mechanisms may dump dispersion of some taxa.
- Large predators such as *Cancer setosus* and *C. coronatus* disturb soft-sediment creating small patches changing community structure and thus creating the patch mosaic of habitats.
- This study reveals for the first time in subtidal sedimentary habitats of northern off Chile how post-larval and adult dispersion, colonization and predation shape the pattern of biodiversity of the sea floor biota.

OTHER ACHIEVEMENTS OF THE PROJECT:

- Research visit(s) to other institution(s).
- Outreach activities related to the project's main topic.
- Any other contribution, not addressed elsewhere, that you consider important.

The maximum length for this section is 1 page. (Arial or Verdana, font size 10).

During the working time of the project 3100085 I participated in several academic activities including; sponsoring of undergraduate thesis work, training of PhD students, teaching pre- and post- degree courses, reviewing manuscripts for international journals and participation in other publications in join collaboration with colleagues and students within the Instituto de Investigaciones Oceanologicas, Universidad de Antofagasta.

Thesis sponsoring: I'm supervising the thesis entitle "Macrobenthic species-specific responses during the colonization of subtidal sediments: effects of patch size and isolation above the substratum" by Cecilia Valdés and Ayleen Valenzuela, undergraduate Marine Ecology students. This work is in progress although the students have been facing some troubles finishing their work, due to the difficult conditions in the University because the current students strike. However, at the moment the thesis is in an advanced stage and the results will be present in the next "VI Congreso Latinoamericano de Estudiantes de Ciencias Biologicas" to be held in October 18-22 at the Universidad de Antofagasta (see products section).

PhD students training: As part of their PhD studies I supervised the work of two PhD candidates in the frame of their research topics I and II. Roberto Uribe worked along with me during both "dispersion" and "predator" experiments. He participated in the design and installation of the experiments, sampling, samples processing and data analysis. We discussed the research idea and the results obtained. Leonardo Campos worked in the "predator" experiment conducting stomach content analysis. He is further processing data of the colonization experiment as part of his research developing ecosystem indicators.

Teaching: I teach ecological succession in benthic habitats and zonation in rocky shores for the Benthic Ecology undergraduate course. I was part of the Aquatic Systems Ecology course of the Master in Ecology of Aquatic Systems program. I was invited to teach in the Facultad de Ciencias de la Salud for their Master in Biology program. I teach part of the course Current trends on Ecology. Finally I was part of the evaluation committee of research proposals of the PhD and Masters students at the Instituto de Investigaciones Oceanologicas. Because the current students strike I could not further participate in teaching activities.

Manuscript review: I participated as a reviewer of manuscripts for the following journals; Journal of the Marine Biological Association of the United Kingdom, Anales del Instituto de la Patagonia, Ecologia Aplicada, Journal of Experimental Marine Biology and Ecology, Revista de Biologia Marina y Oceanografia, Helgoland Marine Research and Revista de Biologia Tropical.

Parallel publications: I participated in the following publications/submitted manuscripts:

Uribe, R.A. & A.S. Pacheco. First record of *Spurilla neapolitana* Delle Chiaje, 1823 (Mollusca: Nudibranchia: Aeolidiidae) in the central coast of Peru (Humboldt Current Upwelling Ecosystem). Submitted to Marine Biodiversity Records.

Riascos, J.M., Vergara, M., Fajardo, J., Villegas, V., & A.S. Pacheco. The role of hyperiid parasites as a trophic link between jellyfish and fish. Submitted to Journal of Fish Biology.

Riascos, J.M., Avalos, C.M., Pacheco, A.S. & O. Heilmayer. Testing stress responses of the bivalve *Protothaca thaca* to El Niño-La Niña thermal conditions. Submitted to Marine Biological Research.

Pacheco, A.S., Riascos, J.M., Orellana, F. & M. Oliva. ENSO cyclical modulation of macrobenthic community structure in the Humboldt Current Upwelling Ecosystem. Pending review for Oikos.

Riascos J.M., Cuturrufo, M., Pacheco, A.S. & M. Oliva. 2011. Regulatory factors and structure of a component population of the spionid *Polydora bioccipitalis* infesting the surf clam *Mesodesma donacium*. Journal of Aquatic Animal Health. doi:10.1080/08997659.2011.616845.

Pacheco, A.S., Silva, A. & J.M. Riascos. 2011. The reccurring visit of a southern elephant seal (*Mirounga lenonina* L. 1758) to the coast of Antofagasta, northern Chile. Latin American Journal of Aquatic Mammals. 9(1) In press.

In these publications/manuscripts the support of my research by FONDECYT is acknowledge.

INFORME DE EVALUACION DEL (DE LA) INVESTIGADOR(A) PATROCINANTE

NOMBRE: Marcelo Enrique Oliva Moreno

Como se indicó en el informe parcial y de común acuerdo con el Dr. Pacheco, se modificó el orden con que se enfrentaron los objetivos propuestos. Esta decisión resultó ser la más adecuada ya que efectivamente aseguró un desarrollo eficiente de los objetivos planteados en este proyecto. Los tres objetivos del proyecto se han alcanzado según lo planificado. En relación al objetivo 1 "The effects of patch size and vertical isolation in the mechanisms of colonization of macrobenthic Communities" se envió un MS a MEPS el cual no fue aceptado, sin embargo se consideraron los comentarios de los referee y un nuevo MS fue ya enviado a JEMBE. En relación al objetivo 2 ("The importance of bedload transport in the colonization of a new patch of sediment") se está en etapa final de redacción de un MS y el trabajo de campo del objetivo 3 ("The effects of predators creating patch mosaic communities in soft sediments") está concluido y los análisis preliminares están soportando la hipótesis asociada a este objetivo. Es importante en este punto destacar que el Dr. Pacheco tuvo problemas de salud y debió someterse a dos intervenciones quirúrgicas (cálculos renales). Ya que todo el trabajo de campo requiere actividades de buceo, este problema de salud afectó la programación del proyecto, pero no influyó finalmente en los resultados finales. Se han realizado a la fecha 3 presentaciones en Congresos Científicos de los resultados de este proyecto, y una cuarta será presentada en octubre de este año en un encuentro internacional.

Durante su Post Doc el Dr. Pacheco ha realizado una serie de otras actividades, tales como participar activamente en actividades docentes de Pre y Post Grado, guiar trabajos de titulación (tesis de pregrado), participar en el entrenamiento de estudiantes de doctorado quienes han realizado parte de sus actividades en el marco del Proyecto dirigido por el Dr. Pacheco, ha sido invitado como evaluador científico en revistas ISI y también ha integrado equipos de investigación que han generado una serie de publicaciones (para más detalles ver informe del Dr. Pacheco). Si bien es cierto varias de estas publicaciones no tienen una relación directa con el problema enfrentado, una de ellas (ENSO cyclical modulation of macrobenthic community structure in the Humboldt Current Upwelling Ecosystem) se refiere al problema de modulación de comunidades bentónicas de fondos blandos en una escala temporal amplia.

Finalmente, es de importancia indicar que el Dr. Pacheco se adjudicó recientemente, en un concurso público, una posición como Académico del Instituto de Investigaciones Oceanológicas de la Universidad de Antofagasta, cargo que está en etapa de ratificación por el programa MECESUP II.

En resumen, considero que las actividades del Dr. Pacheco demuestran que es un investigador maduro e independiente, capaz de generar sus propias hipótesis, planificar experimentos adecuados, llevarlos a cabo y publicar sus resultados. Por otro lado, sus capacidades como Docente aseguran que estamos frente a un académico en sentido estricto.

Firma Investigador(a) Patrocinante

Marcelo E. Oliva

Fecha: 28 septiembre 2011

PRODUCTOS

ARTÍCULOS

Para trabajos en Prensa/ Aceptados/Enviados adjunte copia de carta de aceptación o de recepción.

Nº : 1
Autor (a)(es/as) : Pacheco, AS.; Thiel, M.; Oliva, M.; Riascos, JM
Nombre Completo de la Revista : Helgoland Marine Research
Título (Idioma original) : Effects of patch size and position above the substratum during early succession of subtidal soft-bottom communities
Indexación : ISI
ISSN :
Año :
Vol. :
Nº :
Páginas :
Estado de la publicación a la fecha : Aceptada
Otras Fuentes de financiamiento, si las hay :

Envía documento en papel : si
Archivo(s) Asociado(s) al artículo :
HMRE-D-11-00108Pacheco_et_al.pdf
http://sial.fondecyt.cl/index.php/investigador/f4_articulos/descarga/14714690/3100085/2011/15767/1/

OTRAS PUBLICACIONES / PRODUCTOS

Sin información ingresada.

CONGRESOS

Nº : 1
Autor (a)(es/as) : Pacheco, A.
Título (Idioma original) : Efectos de la escala espacial en los procesos de colonización y sucesión del macrobentos en hábitats de fondos blandos: una revisión del estado del arte
Nombre del Congreso : II Congreso de Ciencias del Mar del Peru
País : PERU
Ciudad : Piura
Fecha Inicio : 24/05/2010
Fecha Término : 28/05/2010
Nombre Publicación :
Año :
Vol. :
Nº :
Páginas :

Envía documento en papel : si
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http://sial.fondecyt.cl/index.php/investigador/f4_congresos/descarga/14714690/3100085/2011/21986/2/

Nº : 2
Autor (a)(es/as) : Pacheco, AS.; Chamblas, K.; Montecino, S.; Valdés, C.; Valenzuela, A.; Oliva, M.
Título (Idioma original) : Efectos del tamaño del parche y el grado de aislamiento del sustrato en la sucesión temprana de comunidades del macrobentos submareal
Nombre del Congreso : XXX Congreso de Ciencias del Mar
País : CHILE
Ciudad : Concepción
Fecha Inicio : 19/10/2010
Fecha Término : 22/10/2010
Nombre Publicación :
Año :
Vol. :
Nº :
Páginas :
Envía documento en papel : si
Archivo Asociado :
Pacheco_et_al_congress_Concepcion_Chile.pdf
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http://sial.fondecyt.cl/index.php/investigador/f4_congresos/descarga/14714690/3100085/2011/21987/2/

Nº : 3
Autor (a)(es/as) : Pacheco, AS.; Uribe, R.; Thiel, M.; Oliva, M.
Título (Idioma original) : Dispersión del bentos en hábitats submareales blandos: migración vertical y transporte en el fondo y column de agua
Nombre del Congreso : XXXI Congreso de Ciencias del Mar
País : CHILE
Ciudad : Viña del Mar
Fecha Inicio : 16/08/2011
Fecha Término : 19/08/2011
Nombre Publicación :
Año :
Vol. :
Nº :
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Envía documento en papel : si
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ANEXOS

A continuación se detallan los anexos físicos/papel que no se incluyen en el informe en formato PDF.

Manuscript in an advance stage reporting the results of the disperison experiment (objective 2).