INTRODUCTION

Los pastos marinos son considerados de gran importancia a nivel mundial por la gran cantidad de servicios ecosistémicos que proporcionan, valorados globalmente alrededor de 2 trillones de dólares al año (Costanza *et al.* 1997), entre los cuales: son importantes productores primarios; representan una fuente de alimento para macro-herbívoros como dugongos, manatíes y tortugas, y funcionan como criaderos de fauna asociada de importancia comercial (Orth *et al.* 2006; Santamaría-Gallegos *et al.* 2007; López-Calderón & Riosmena-Rodríguez 2010); son estabilizadores del sedimento, actuando como trampas y reduciendo el movimiento del agua; fungen como especies fundadoras proporcionando microhábitats; como fitorremediadores y finalmente se encuentran entre los más importantes almacenes de carbono orgánico (Siqueiros-Beltrones *et al.* 1985, Ibarra-Obando & Ríos 1993; Hemminga & Duarte 2000; Green & Short 2003).

En los últimos años, diversos autores han reportado una disminución en la extensión de las praderas de pastos marinos, como consecuencia del aumento en la temperatura superficial del mar, la intensificación de eventos climatológicos, las pesquerías y las actividades antropogénicas, entre las que destacan  el cambio de uso de suelo o las descargas de aguas residuales (Short *et a*l 2007; López-Calderón *et a*l 2016).

En el Golfo de California, se distribuyen cuatro especies de pastos: *Zostera marina* L. *1753, Halodule wrightii* Ascherson 1868*, Halophila decipiens* Ostenfeld 1902 *y Ruppia maritima* L. 1753(McMillan & Phillips 1979; Aguilar-Rosas & López-Ruelas 1985; Ibarra-Obando & Ríos 1993; Santamaría-Gallegos *et al.* 2006), cada una de ellas con importantes particularidades en su distribución, rangos de temperatura, fauna asociada y aprovechamiento de recursos. De acuerdo a los registros históricos, las praderas de mayor extensión se encuentran distribuidas cerca de las costas de Sonora y Sinaloa, mientras que en las costas de Baja California Sur, las extensiones son menores, principalmente en las zonas de Isla Ángel de la Guarda, Isla Espíritu Santo, San Gabriel y en la Bahía de La Paz (Ramírez-García & Lot 1994; López-Calderón *et al* 2016).

En el Golfo de California, no existe una línea base que brinde un panorama claro del estado de estos ecosistemas, por lo que el presente trabajo pretende asentar un marco de referencia para contribuir a la conservación de los ecosistemas de pastos marinos, resaltando su importancia ecológica, misma que radica principalmente en tres aspectos: i) su papel como ecosistemas costeros clave para la contribución al resguardo de la fauna y la conexión que mantienen con ecosistemas aledaños, ii) su alta productividad y iii) su importancia como sumideros de carbono (Orth *et al* 2006; López Calderón *et al* 2016).

MATERIAL & METHODS

STUDY SITE

El Golfo de California es un mar parcialmente cerrado ubicado entre la península de Baja California y la región noroeste de México. Tiene una extensión aproximada de 1600 km de longitud y 283,000 km2,en la que se encuentran alrededor de 900 islas e islotes. Es posible distinguir cuatro regiones oceanográficas: El Alto Golfo, El Golfo Norte, Región Central y El Golfo Sur (SEMARNAP 2000)

[…]

SYSTEMATIC REVIEW PROTOCOL

Three information sources were used for the database: specific literature, indirect literature and both national and international herbariums.

For this review, the keywords “Seagrasses”, “Gulf of California”, “*Zostera marina*”, “*Ruppia maritima*”, “*Halodule wrightii*” y “*Halophila decipiens*” were searched into Scholar (accessed 07/2019-01/2021). The selected information is made up of: scientific articles, bachelor, master's and doctorate theses; floristic inventories, book chapters and technical reports from academic and governmental institutions, which address the issue of seagrass in the Gulf of California from different perspectives. Also, despite not discussing seagrasses as central theme, some texts that could provide us some reference about distribution and / or extensión were chosen.

Finally, the online collections of seven herbaria were reviewed: Herbarium of the University of Arizona (ARIZ), Herbarium of the Arizona State University (ASU), Herbarium of the Autonomous University of Baja California (BCMEX), Herbarium Nacional de Mexico (MEXU), Smithsonian National Museum of Natural History (SI NMNH), Herbarium Jesús González Ortega of the Autonomous University of Sinaloa (UAS), Herbarium of the University of Sonora (UNISON-USON).

From all information collected, four essential elements for the database were extracted: species, date, location and coordinates. With these data, maps of historical distribution of seagrass in the Gulf of California were made. Finally, the periods in which there was an increase in seagrass studies were identified and these were classified based on the topic they address.

Evaluation Criteria

For the evaluation criteria, the risk assessment model of the Red List of Ecosystems proposed by the IUCN (2016) was followed, which includes the following categories: two non-threat: Least Concern (LC) and Near Threatened (NT), three threat categories: Critically Endangered (CR), Endangered (EN) and Vulnerable (V); and a collapsed ecosystem category (CO). In addition to a category that reflects the lack of information: Insufficient data (DD) and another for ecosystems that have not been even minimally evaluated: Not evaluated (NE).

According to the Practical Guide for the Application of the IUCN Red List of Ecosystems Criteria (Rodríguez et al. 2015), to determine the risk of collapse, which is the most critical category, five criteria will be evaluated based on one or more proxies. It is important that the evaluation is made with existing data, otherwise, the ecosystem will be classified as DD (Data Defficient). The evaluation criteria includes:

* 1. Currently declining distribution
  2. Restricted distribution
  3. Degradation of the abiotic environment
  4. Altered biotic interactions
  5. Quantitative estimates of risk of ecosystem collapse

Once all the criteria have been evaluated, a final category, which summarizes all the results from the evaluation, is assigned. Based on the results and following the precautionary principle (Precautionary Principle Project 2005), the highest category obtained for any of the criteria will be considered as the general status of the ecosystem.

**Assessment variables**

To assess threat categories, we obtained the following variables:

* Pollution, by ….
* Coastal modification, by …
* Mining, by
* Protection index, by
* Marine Heatwaves, we retrieved Reynolds optimally interpolated sea surface temperature (OISST) data to calculate marine heatwaves events. Marine heatwaves are recognized threats to marine life with the potential to cause significant damage to natural communities (Beas‐Luna et al., 2020; Benedetti-Cecchi, 2021; Brown et al., 2020; Filbee-Dexter et al., 2020; Laufkötter et al., 2020; Suryan et al., 2021), are related to human induced climate change (Laufkötter et al., 2020), and can exacerbate other climate change effects (Cheung and Frölicher, 2020). We used the R package heatwaveR to identify heatwaves and calculate temporal trends from OISST data. The download and extraction process, as well as the analysis is fully reproducible using the R code provided at: GITUHUB LINK. The code was written in the R studio IDE (v.1.4.1103) working on R v.4.0.3.

RESULTS

* DISTRIBUTION MAP: PRESENCE/ABSENCE. (1)
* SUMMARY (TABLE: CURRENT DISTRIBUTION: SITE/DATE/SPECIE/LAT/LONG(3).
* RESEARCH PER DECADE (PLOT) (2)

Chart

Description automatically generated

DISCUSSION

* HISTORICAL DISTRIBUTION VS CURRENT DISTRIBUTION SITE (1)
* WHAT WE KNOW TODAY?(2&3)BY
* TAXONOMY DISCREPANCY
* WHY SEAGRASSES ARE IN THE CURRENT SITES?(1&3)
* BIOTIC & ABIOTIC FACTORS(1&3)
* INVASIVE?/TROPICALIZATION (1&3)
* CONSERVATION STATUS (4)

\*\*\* FUTURE CHALLENGE

* NECESSARY ACTIONS AND PROPOSALS

References

Beas‐Luna, R., Micheli, F., Woodson, C.B., Carr, M., Malone, D., Torre, J., Boch, C., Caselle, J.E., Edwards, M., Freiwald, J., Hamilton, S.L., Hernandez, A., Konar, B., Kroeker, K.J., Lorda, J., Montaño‐Moctezuma, G., Torres‐Moye, G., 2020. Geographic variation in responses of kelp forest communities of the California Current to recent climatic changes. Global Change Biol 26, 6457–6473. https://doi.org/10.1111/gcb.15273

Benedetti-Cecchi, L., 2021. Complex networks of marine heatwaves reveal abrupt transitions in the global ocean. Sci Rep-uk 11, 1739. https://doi.org/10.1038/s41598-021-81369-3

Brown, C.J., Mellin, C., Edgar, G.J., Campbell, M.D., Stuart‐Smith, R.D., 2020. Direct and indirect effects of heatwaves on a coral reef fishery. Global Change Biol. https://doi.org/10.1111/gcb.15472

Cheung, W.W.L., Frölicher, T.L., 2020. Marine heatwaves exacerbate climate change impacts for fisheries in the northeast Pacific. Sci Rep-uk 10, 6678. https://doi.org/10.1038/s41598-020-63650-z

Filbee-Dexter, K., Wernberg, T., Grace, S.P., Thormar, J., Fredriksen, S., Narvaez, C.N., Feehan, C.J., Norderhaug, K.M., 2020. Marine heatwaves and the collapse of marginal North Atlantic kelp forests. Sci Rep-uk 10, 13388. https://doi.org/10.1038/s41598-020-70273-x

Laufkötter, C., Zscheischler, J., Frölicher, T.L., 2020. High-impact marine heatwaves attributable to human-induced global warming. Sci New York N Y 369, 1621–1625. https://doi.org/10.1126/science.aba0690

Suryan, R.M., Arimitsu, M.L., Coletti, H.A., Hopcroft, R.R., Lindeberg, M.R., Barbeaux, S.J., Batten, S.D., Burt, W.J., Bishop, M.A., Bodkin, J.L., Brenner, R., Campbell, R.W., Cushing, D.A., Danielson, S.L., Dorn, M.W., Drummond, B., Esler, D., Gelatt, T., Hanselman, D.H., Hatch, S.A., Haught, S., Holderied, K., Iken, K., Irons, D.B., Kettle, A.B., Kimmel, D.G., Konar, B., Kuletz, K.J., Laurel, B.J., Maniscalco, J.M., Matkin, C., McKinstry, C.A.E., Monson, D.H., Moran, J.R., Olsen, D., Palsson, W.A., Pegau, W.S., Piatt, J.F., Rogers, L.A., Rojek, N.A., Schaefer, A., Spies, I.B., Straley, J.M., Strom, S.L., Sweeney, K.L., Szymkowiak, M., Weitzman, B.P., Yasumiishi, E.M., Zador, S.G., 2021. Ecosystem response persists after a prolonged marine heatwave. Sci Rep-uk 11, 6235. https://doi.org/10.1038/s41598-021-83818-5