INTRODUCTION

Globally, seagrasses are one of the most important coastal ecosystems, due to the high value of their ecosystem services, such as primary production, food supply, nutrient cycling, habitat formation, coastal protection, and carbon sequestration (Costanza *et al.* 1997; Ondiviela et al., 2014; Unsworth et al., 2019; UNEP, 2020). Despite their importance, seagrasses were until recently considered the perfect example of an ecosystem that is largely undocumented and understudied (Waycott, et al. 2009).

Recently, several authors have reported the global decline in seagrass meadows at unprecedented rates, due to global climate change, overfishing, even anthropogenic activities, mostly coastal modification, and water pollution (Orth et al., 2006; Duarte et al., 2009). The Gulf of California is one of the regions where this problem occurs (López-Calderón et al., 2010, Riosmena-Rodríguez et al., 2013; López-Calderón et al., 2016).

Nowadays, we know the Gulf of California is home to four species of seagrass: *Zostera marina* L. 1753, *Halodule wrightii* Ascherson 1868, *Halophila decipiens* Ostenfeld 1902 and *Ruppia maritima* L. 1753. According to the historical distribution, the seagrasses are mainly found in the Canal del Infiernillo in Sonora and the coastal lagoons in Sinaloa, while in the Baja California Peninsula, the most representative site is Bahía Concepción (Den-Hartog, 1970; Felger & Moser, 1973; McMillan, 1983; Aguilar-Rosas & López-Ruelas, 1985; Ortega et al., 1986; Ramírez-García & Lot, 1994; Riosmena-Rodríguez & Sánchez-Lizaso, 1996, Meling-López and Ibarra-Obando, 1999; Múñiz-Salazar et al., 2005; Orduña-Rojas & Riosmena-Rodríguez, 2008; Santamaría-Gallegos *et al.* 2006; López-Calderón et al., 2010).

This review focuses on the current state of knowledge of seagrasses in the Gulf of California. Based on the collected information, we made the first full assessment of the distribution, coverage and conservation status of the ecosystem, creating a threat index and provided a baseline to contribute to the study and conservation strategies of seagrass meadows.

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 extension 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

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