Satellite Observation of Heavily Lit Fishing Boat Activity in the Coral Triangle Region

Christopher D. Elvidge
Earth Observation Group
NOAA National Geophysical Data Center
E-mail: chris.elvidge@noaa.gov

Kimberly Baugh, Benjamin Tuttle, Daniel Ziskin, Tilottoma Ghosh
Cooperative Institute for Research in Environmental Sciences
University of Colorado

Christoph Aubrecht
Austrian Institute of Technology

Edward H. Erwin
NOAA National Geophysical Data Center

KEY WORDS: Fisheries, Coral Triangle, Nighttime Lights

ABSTRACT: The Coral Triangle Initiative (CTI) is a new international effort to preserve and restore the magnificent marine ecosystems in the Southeast Asia region spanning the Philippines, Malaysia, Indonesia, Papua New Guinea. The CTI workplan calls for the use of multiple data sources in the conduct of a “rapid seascape assessment” leading to the designation of additional “priority seascapes” for preservation and sustainable management of the regions marine ecosystems. Human activities such as fishing, urban pollution, and sedimentation from poor land use practices are rated as key factors contributing to the degradation of seascapes. As a contribution to the data sources for use in the rapid seascape assessment NGDC has produced a time series of heavily lit fishing boat detections derived from low light imaging data collected by the Operational Linescan System (OLS) flown by the Defense Meteorological Satellite Program (DMSP). Most of the DMSP observed lights are on land (cities and towns). But in some cases lighting is observed offshore where fishermen are using bright lights to attract their catch. The DMSP archive extends from 1992 to the present. Annual cloud-free composites were produced at approximately one kilometer resolution and are accessible from NGDC’s web site. We report on the spatial and temporal variation in the detected fishing boat activity in the coral triangle region.

1. INTRODUCTION

In 2008 the countries of Indonesia, Malaysia, Philippines, Papua New Guinea, Timor Leste and the Solomon Islands established the Coral Triangle Initiative (CTI) with the aim to protect the reefs and marine ecosystems of Southeast Asia. A regional plan of action was adapted (CTI, 2008) calling for a rapid seascape assessment to identify priority areas for marine parks and reserves. The regional plan of action also called for improved monitoring and enforcement to reduce illegal fishing. Figure 1 shows a map of the Coral Triangle region.

As a contribution to the CTI, in 2009 the U.S. National Oceanic and Atmospheric and Atmospheric Administration (NOAA) provided funds to several projects to provide environmental data products relevant to the CTI objectives. One of the projects funded was at the NOAA National Geophysical Data Center (NGDC), a center of excellence in the low light imaging data collected by the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). NGDC proposed to provide open access to near real time geolocated mosaics of nighttime OLS data over the CTI region. This service is available at: http://www.ngdc.noaa.gov/eog/maps/cgi-bin/public/ns/cti/dl. In addition, NGDC proposed to analyze the spatial and temporal patterns of heavily lit fishing boat activity in the CTI region. In this paper we report our findings from the analysis of the fishing boat activity.
2. METHODS

NGDC processed a time series of annual nighttime lights cloud-free composites as one kilometer square equal area grids (Mollweide projection), spanning 1992 through 2008. For the analysis of lights from fishing boats we use the average digital number of lights multiplied by the percent frequency of light detection (avg_lights_x_pct). This product normalized for differences in cloud cover and accounts for the persistence of lights (Elvidge et al., 2009). A total of 30 annual composites were produced, spanning the 18 year period. In most years two satellites had collected OLS data, allowing for two composites to be produced. To identify the locations where heavily lit fishing boats were detected we constructed a summary composite of the maximum nighttime visible band value encountered across the 30 annual composites (“super-max” – shown in Figure 2). The super-max images contains lights from fires, cities, gas flares, fishing boats, plus lights streaks produced by lightning. To identify the offshore areas and the map out the waters for the individual countries a land-sea mask was applied to make it easier to identify the offshore clusters of lights from fishing boats (Figure 3). After the exclusive economic zone vectors were displayed, a set of fifteen vectors were drawn for fishing boats areas: Solomon Islands (Georgia Sound), Papua New Guinea, Indonesia (East Arafura Sea, Irian Jaya, Kepulauan Island, Java Sea, South China Sea, northern part of the South Chine Sea, and Sumatra), Malaysia (Peninsular Malaysia and Sarawak-Sabah), and Philippines (Palawan, Zamboanga, Visayas, and Luzon). The fishing boat vectors (Figure 4) were used to extract the sum-of-lights from each of the 30 annual composites. To eliminate noise, digital values of one were excluded from the tallies. An intercalibration was applied to the digital values as part of the extraction process, as described by Elvidge et al., 2009.

Figure 2. The “super-max” image records the maximum nighttime visible band digital number encountered in the cloud-free inputs into the 30 annual composites.
Figure 3. Super-max image with land areas masked. This makes it easier to find the boats.

Figure 4. Super-max image with land areas masked, EEZ’s shown in cyan, and vectors drawn for clusters of lights from fishing boats.
3. RESULTS

We found substantial variation in the temporal distribution of heavily lit fishing boat activity as shown in Figure 5. For Indonesia lit fishing boat activity increased dramatically in the past 2-3 years in fishing boat clusters identified in the East Arafura Sea, Java Sea and South China Sea. Fishing boat activity on the south coast of Irian Jaya was detected from 1992 through 1997 and there has been very little activity over the past ten years. Lit fishing boat activity in the waters surrounding Sumatra peaked in 1997 and has been declining since that time. Lit fishing boat activity south of Kepulauan Island generally increased from 1993 through 2007 and dipped in 2008. Lit fishing boat activity in the Solomon Islands was only detected in Georgia Sound and had peaks in the early 1990's and has increased again over the past 5 years. Lit fishing boat activity offshore from Papua New Guinea (PNG) has been sporadic. Lit fishing boat activity in the Philippines peaked in 1995-96-97. Lit fishing boat activity surrounding Luzon and Palawan Islands and through the Visayas declined from the mid-1990’s to the early 2000’s and has been largely stable in recent years. Lit fishing boat activity offshore from Zamboanga has only decline slightly since the peak in 1997. Lit fishing boat activity in waters near Peninsular Malaysia peaked in 1994 and declined until 2001, with several ups and downs from 2001 to 2008. Lit fishing boat activity in waters offshore from Sarawak and Sabah generally increased over time, with the exception of a dramatic dip from 2000 to 2003.

4. CONCLUSION

We have defined the locations and temporal patterns of heavily lit fishing boat activity in the Coral Triangle region. The image files and spreadsheet have been posted at http://www.ngdc.noaa.gov/dmsp/download.html. By overlaying these products with other geospatial data (marine protected areas, coral reef locations, etc.) we believe the data could be useful in the rapid seascape assessment planned by the Coral Triangle Initiative.

ACKNOWLEDGMENT

This project was funded by the U.S. National Oceanic and Atmospheric Administration Coral Reef Watch (CRW) Program.

5. REFERENCES


Figure 5. Sum-of-lights index values of the fifteen fishing areas from 1992 through 2008.