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Shipwrecking Probability in Mediterranean Territorial Waters

A Cultural Approach to Archaeological Predictive Modelling

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SUMMARY

This thesis presents a formal approach and a GIS-based methodology for the assessment of the shipwrecking probability in Mediterranean territorial waters, thus addressing the underdevelopment of archaeological predictive models in the maritime domain, particularly in the Mediterranean region. As archaeological predictive models are often criticized for oversimplifying complex historical phenomena to produce quantifiable outcomes, this study focuses on two different scales of analysis to meet the need for both a general tool applicable to spatial planning and a more detailed one providing insights for historical and archaeological research. First, a regional-scale model is developed, which focuses on navigation dynamics in the area between Cap Bon (present Tunisia) and Alexandria (present Egypt) in Roman times. Then, this model is extended to all Mediterranean territorial waters in a simplified version and without chronological limitations. At both scales, the criteria for selecting the input factors are formalized.

In order to identify areas with higher shipwrecking probability than others, two sub-questions are addressed that correspond to separate model components: 1. Where would ships be more likely to transit? 2. Where would ships have a higher risk of sinking? Grounding the theory-building on a systematic screening of accounts by primary sources, the first model component derives transit probabilities by considering multiple, oftentimes competing, criteria that trigger and affect mariners' movements, including in particular the effects of risk perception - thus rejecting the idea that sailors would necessarily choose the optimal or most efficient route. The second model component includes environmental hazards objectively increasing the risk of sinking.

Given the many elements of uncertainty and subjective reasoning behind the model building - a problem often unheeded in archaeological computational modelling - an entire chapter is devoted to a sensitivity analysis of the model and the exploration of diverse model scenarios. The overall methodology attempts to overcome some of the main pitfalls of current modelling approaches to seafaring and to shipwreck locations, namely, the inductive use of shipwreck data without a formal exploration of data biases, and the predominant reliance on environmental and economic input variables to the detriment of cultural and cognitive factors.

This study suggests that by explicitly differentiating between actual and perceived risks, and accounting for the effects this difference produces in terms of variations from the optimal navigation corridors, the predictive ability of the model increases. While constituting a valuable tool for optimizing maritime spatial planning and archaeological investigations, this model also offers insights into the biases in current shipwreck data. The model furthermore provides an adaptable toolkit applicable to other geographical contexts and chronological periods, and a suitable basis for expansion with a future component by modelling post-depositional dynamics that affect the preservation and detectability of wrecks at local scales.

SAMENVATTING

In dit proefschrift wordt een formele benaderingswijze en GIS-methodologie gepresenteerd waarmee de waarschijnlijkheid vastgesteld kan worden dat schepen schipbreuk lijden in territoriale wateren in de Middellandse zee. Hiermee wordt een lacune gedicht in de ontwikkeling van archeologische verwachtingsmodellen in maritieme context, specifiek voor het Mediterrane gebied. Omdat archeologische verwachtingsmodellen vaak worden bekritiseerd vanwege hun neiging om complexe historische fenomenen te over-vereenvoudigen om tot toetsbare resultaten te kunnen komen, wordt de analyse op twee schaalniveaus uitgevoerd. Daarmee wordt zowel voorzien in de behoefte aan een globaal en algemeen toepasbaar model voor ruimtelijke ordening, als in die aan een meer gedetailleerd model voor historisch en archeologisch onderzoek. Dit laatste wordt als eerste gepresenteerd aan de hand van een regionale *case study* die zich richt op de navigatiedynamiek in het gebied tussen Cap Bon (huidig Tunesië) en Alexandrië (huidig Egypte) in de Romeinse tijd. Vervolgens wordt dit model, in een vereenvoudigde vorm en zonder chronologische beperkingen, geëxtrapoleerd naar alle territoriale wateren in de Middellandse zee. Op beide schaalniveaus zijn de criteria voor het selecteren van de inputfactoren geformaliseerd.

Om te kunnen vaststellen welke gebieden een hogere kans op schipbreuk hebben in vergelijking met andere zijn twee deelvragen gesteld die overeenkomen met de twee hoofdcomponenten van ieder model: waar is het het meest waarschijnlijk dat de schepen gevaren hebben? En: waar hadden schepen een grotere kans om schipbreuk te lijden? Het hier ontwikkelde eerste modelcomponent is gebaseerd op een systematische analyse van primaire bronnen die informatie bieden over de vele, vaak tegenstrijdige, criteria die aan de navigatiebeslissingen van zeelieden ten grondslag kunnen liggen. Hierbij is specifiek rekening gehouden met het effect van de perceptie van gevaar, waarmee het idee verworpen wordt dat zeelieden in het verleden één enkele optimale route kozen, uitsluitend gebaseerd op het minimaliseren van de objectieve risico's. De tweede component van het model draait om de vraag of en hoe gevaren als gevolg van omgevingsfactoren de kans op schipbreuk objectief gezien vergroten.

Omdat er noodzakelijkerwijs vele onzekerheden en subjectieve afwegingen aan de basis liggen van het model – een probleem dat vaak genegeerd wordt in archeologische voorspellingsmodellen – wordt een heel hoofdstuk gewijd aan *sensitivity analysis*: het toetsen van hoe het model reageert op veranderingen in de berekening en weging van de inputfactoren. Hiermee wordt geprobeerd te ontsnappen aan de twee grootste nadelen van de huidige wijze van modelleren van historische navigatieroutes en van archeologische risicoanalyse; namelijk dat gegevens over scheepswrakken inductief worden gebruikt zonder dat een formele verkenning heeft plaatsgevonden naar de mate van vertekening van deze gegevens, en het overheersende gebruik van omgevingsfactoren en economische factoren ten koste van culturele en cognitieve factoren.

Op basis van de uitkomsten van dit onderzoek blijkt dat het voorspellend vermogen van het model toeneemt wanneer er expliciet gedifferentieerd wordt tussen de werkelijke en de gepercipieerde risico's én als de gevolgen van dit onderscheid, namelijk keuzes die afwijken van de optimale navigatiecorridors, in acht worden genomen. Hiermee levert het model niet alleen een bruikbaar gereedschap voor de ruimtelijke ordening van de maritieme omgeving en voor maritiem archeologisch onderzoek, maar het verschaft ook inzicht in de bestaande vertekeningen in scheepswrakgegevens. Het model biedt bovendien een flexibele GIS-*toolkit* die toegepast kan worden op andere geografische contexten en periodes, en kan in de toekomst uitgebreid worden met een component die ook de post-depositionele processen modelleert die op lokale schaal de bewaringstoestand en detecteerbaarheid van scheepswrakken mede bepalen.

SOMMARIO

In questa tesi viene presentato un modello predittivo, sviluppato utilizzando sistemi informativi geografici (GIS), il cui scopo è di stimare la probabilità di naufragio nelle acque territoriali del Mediterraneo. L'obiettivo è quello di compensare lo scarso sviluppo ed utilizzo di modelli predittivi in ambito archeologico subacqueo -soprattutto nel bacino Mediterraneo- il cui uso ottimizzerebbe invece le indagini archeologiche marine. Dal momento che i modelli predittivi vengono spesso criticati poiché per produrre risultati quantificabili tendono a semplificare e generalizzare fenomeni storici complessi, questo studio si focalizza su due distinte scale di analisi. Una più generale per venire incontro alla necessità di fornire un modello complessivo, applicabile nelle pratiche di archeologia preventiva, e una di dettaglio per supportare studi e analisi storico-archeologiche. Un primo modello viene quindi sviluppato su scala regionale, focalizzandosi sulle dinamiche di navigazione in età romana nell'area compresa tra Cap Bon (attuale Tunisia) e Alessandria (attuale Egitto). Successivamente tale modello viene esteso alle acque territoriali del Mar Mediterraneo, in forma semplificata e senza limitazioni cronologiche. Propedeutica allo sviluppo di entrambi i modelli è la formalizzazione dei criteri seguiti per la selezione dei fattori di input.

Per poter stabilire quali aree presentino una maggiore probabilità di incidenza di naufragi, vengono poste e affrontate due domande di ricerca che sottendono lo sviluppo di due distinte componenti del modello: dove è maggiormente probabile che le imbarcazioni transitassero, e dove è più probabile che naufragassero. Per quanto attiene alle probabilità di transito, queste sono state desunte attraverso un sistematico scrutinio delle fonti storiche, considerando molteplici fattori che possono aver determinato la scelta di destinazioni e rotte, inclusa la percezione del rischio. In tal modo si è anche rifiutata l'ipotesi che le imbarcazioni seguissero necessariamente rotte ottimali, solitamente alla base delle simulazioni di navigazione antica. Per quanto attiene alle probabilità di naufragio, si sono considerati quei parametri, ambientali, oceanografici e meteorologici, che oggettivamente costituiscono un rischio per le imbarcazioni. Visti i molteplici fattori di incertezza nel modello -un problema spesso non formalmente affrontato negli approcci computazionali in ambito archeologico- un intero capitolo è dedicato all'analisi di sensitività e all'esplorazione dei diversi scenari prodotti alterando il modello. L'intero approccio metodologico mira a superare alcune delle maggiori limitazioni degli attuali modelli sviluppati per simulare le antiche rotte di navigazione o predire la localizzazione di relitti. Tali limiti riguardano da un lato l'inferenza induttiva basata sull'osservazione dei siti noti, effettuata senza una adeguata valutazione e compensazione delle distorsioni che pregiudicano l'attendibilità e rappresentatività del campione di dati usati; dall'altro l'utilizzo predominante di fattori ambientali e socio-economici a scapito di quelli culturali e cognitivi.

Le evidenze prodotte da questa ricerca suggeriscono invece che, distinguendo formalmente il rischio reale da quello percepito e identificando così rotte di navigazione non necessariamente ottimali, la prestazione del modello migliora. Le aree indicate come a maggiore probabilità di incidenza di naufragi corrispondono infatti a quelle dove si rileva effettivamente un maggior numero di siti noti. Tale modello, a oggi unico nel suo genere, oltre a fornire un valido strumento per ottimizzare la pianificazione delle indagini archeologiche in mare, costituisce un *toolkit* adattabile e applicabile su diverse scale spazio-temporali e può essere utilizzato come base di partenza per implementare e valutare l'impatto delle dinamiche post-deposizionali per la preservazione dei siti subacquei.

“No book can ever be finished. While working on it we learn just enough to find it immature the moment we turn away from it”

Karl Popper

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