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The fate of human remains in a maritime context and feasibility for forensic humanitarian action to assist in their recovery and identification

Sarah Theresa Dorothea Ellingham[a,*], Pierre Perich[b], Morris Tidball-Binz[a]

[a] International Committee of the Red Cross, Protection Division, Forensic Unit, 19 Avenue de la Paix, 1202 Geneva, Switzerland
[b] APHM, CHU Timone, Service de Médicine Légale et droit de la Santé, 13385 Cedex 5, Marseille, France

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ABSTRACT

The number of annual maritime fatalities reported in the Mediterranean has more than doubled in the last two years, a phenomenon closely linked to the increase of migrants attempting to reach Europe via the Mediterranean. The majority of victims reportedly never gets recovered, which in part relates to the fact that the mechanisms and interaction of factors affecting marine taphonomy are still largely not understood. These factors include intrinsic factors such as whether the individual was alive or dead at the time of submergence, the individual's stature and clothing, as well as extrinsic factors such including ambient temperature, currents, water depth, salinity and oxygen levels. This paper provides a compilation of the current literature on factors influencing marine taphonomy, recovery and identification procedures for submerged remains, and discusses the implications for the retrieval and identification of maritime mass fatalities as part of the humanitarian response, specifically humanitarian forensic action, to the consequences of the current migration phenomenon.

1. Introduction

Recent years have seen an unprecedented humanitarian tragedy due to a loss of human life at sea in the Mediterranean. This is particularly linked to the upsurge of migration, including through maritime routes such as those crossing the Mediterranean; whilst the sea route to the EU is not a new one, the number of individuals commencing on this journey is exponentially growing, as is the death toll attending this increase, as the vessels utilized in the crossings are frequently of low quality and filled way above their capacity [1]. Between 1988 and 2013 a reported 14,309 people died in an attempt to cross the Mediterranean [2], in 2014 and 2015 combined, 7191 people were reported to have lost their lives; the actual number is likely even higher. 2016 alone has seen 4913 casualties [3]. Many victims never get recovered or identified. However in an unprecedented operation, in June 2016 the Italian Navy recovered a sunken fishing boat believed to have held more than 800 migrants when it capsized in April 2015, and identification efforts are underway at the time of writing.

Whilst the majority of maritime fatalities are related to migration, other recent prominent incidents resulting in a large number of individuals finding death in marine bodies of water include the crash of Yemenia flight 626 in 2009, the sinking of the *MS Spice Islander I* off the coast of Zanzibar killing up to 1500 people in 2011, the crash of Air France flight 447 in 2009 with 228 fatalities, the 2014 sinking of the *Sewol* ferry in South Korea, causing the death of 304 individuals, Egypt Air flight 804 killing 66 when crashing into the Mediterranean in early 2016 as well as most likely Malaysian Airlines flight 370 which vanished off the radars over the Indian Ocean with 239 people on board in 2014. The increasing number of mass fatalities in the maritime context poses particular challenges for the recovery and identification of the dead.

Every human being has the right not to lose his or her identity after death [4], and the necessity to retrieve and identify the deceased for humanitarian, judicial and administrative reasons, is not only universally recognized, but also perpetuated in domestic and international law, such as the 1949 Geneva Conventions [5], and their 1977 Additional Protocols [6]. Under International Humanitarian Law (IHL), the dead from armed conflict are a distinct category of victim with the right to having their dignity protected; though the matter of management of the dead is not yet specifically addressed in the evolving body of International Disaster Response Law (IDRL), with the exception of situations

* Corresponding author.
E-mail address: ellingham.sarah@gmail.com (S.T.D. Ellingham).

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in which death was caused by negligence of a State, the adequate management and identification of disaster victims is equally important [7,8]. Nonetheless, for many individuals who lose their life at sea, this does not materialize for a variety of reasons [1].

Despite their relevance in the recovery and identification efforts of human remains from the sea, the mechanisms and factors affecting marine taphonomy are still largely not understood, as research in this area to date has been scarce. There are multiple factors affecting the fate of human remains in the marine context, including intrinsic factors such as whether the individual was alive or deceased at the time of submergence, stature and clothing, as well as extrinsic factors including ambient temperature, currents, water depth, salinity and oxygen levels. Much of the current body of knowledge concerning marine taphonomy is derived from case observations and some experimentally conducted research off the coast of British Columbia.

It is the aim of this paper to provide a compilation of the current body of knowledge relating to the fate of human remains in a maritime context. This includes processes of marine taphonomy, recovery and identification procedures for submerged remains, and the implications for the retrieval and identification of maritime related mass fatalities, in particular in light of the current migration phenomenon and humanitarian efforts, particularly forensic humanitarian action, to properly manage and identify the dead from these events.

The following sections will discourse upon the factors playing a role in the successful retrieval and identification of human remains, such as water drift, the intrinsic and extrinsic factors influencing the decomposition rate and pattern, as well as technical approaches to the detection and recovery of human remains from a maritime environment. Finally, identification methods will be discussed.

2. Drift

There is a number of factors influencing a body's horizontal and vertical displacement in water after drowning [9]. Vertical movement is dependent on the body's gravity and the relationship of its density to the density of the water; the average density of males and females is 0.98 and 0.97 g/cm^3 respectively, the density of salt water is 1.024 g/cm^3 [10]. This results in the fact that less dense human bodies have a tendency to float, however even small variations have a severe influence on buoyancy [11,12]. This, in turn has a direct impact on horizontal displacement. Particularly in cases of drowning an increase in body specific gravity and subsequent decrease in buoyancy due to increased lung weight through water inhalation or increased stomach weight through water ingestion, leads to a sinking of the body [11]. Once sinking commences, the hydrostatic pressure, which increases by 1 atm. for every 10 m depth, compresses gas containing cavities in the body, causing it to sink to the bottom. The settling of remains on the bottom of a body of water is dependent on factors such as the water currents and the type of substrate [10]. The increased frictional forces at the bottom of maritime environments in combination with the decreased velocity of the water current at greater depths result in the drag forces frequently not being able to overcome gravitational forces and less horizontal body displacement to occur [11]. Significant horizontal displacement therefore only occurs after the body resurfaces if it is not immediately recovered. In cases in which the individual entered the water already dead, died of reasons other than drowning or was wearing a flotation device, it is possible for it to not sink at all [13] and drift of up to 380 km in 60 h [14].

Sunken bodies resurface once they enter the bloating stage of decomposition, the putrefactive gases decreasing the body specific gravity and increasing buoyancy. The exception to this are bodies which are trapped in a structure at the bottom or if they have sunk to depths greater than about 60 m [13,15]. The main factor affecting the rate of decomposition is the ambient temperature, the process thus slowing down in lower water temperatures. Another factor influencing decomposition rate is hydrostatic pressure, with low hydrostatic pressure being more conducive to decomposition. It is therefore not uncommon for sunken bodies to resurface in coastal regions during low tide, as the decrease in water column lowers the hydrostatic pressure on the body [11].

Oceanic currents and particularly drift currents, which are dependent on atmospheric changes, can be highly variable, however there are several numerical oceanographic forecast models which can be accessed, such as the Mediterranean Forecast System Pilot Project (MFSPP), the Princeton Ocean Model (POM) [16] or the US Navy's Naval Oceanographic Office (NAVO) which runs the Shallow Water Analysis and Forecast System (SWAFS), operational models for marginal seas around the world [17–20].

Predicting body displacement in marine environments is highly complex and the collaboration of forensic and operational oceanographic expertise, such as accumulated by the agencies mentioned above, is paramount for such investigations.

3. Decomposition and taphonomy

The process of decomposition in water generally progresses slower than on land, which is due to the cooler temperatures as well as the absence of necrophagous insects. When comparing the differing aqueous environments, salt water decomposition proceeds at an even further decelerated rate than that in fresh water. This can be attributed to the fact that in the latter water is absorbed into the circulatory system, causing organs to swell and rupture, whereas in the former, fluids are drawn out of the blood and thehigh salinity slow bacterial activity [10]. The decomposition of remains in the marine context also heavily depends on many other factors, including whether the remains sink or float. In floating remains disarticulation of the appendages through current and wave action weakening the soft tissue connection of the joints is a common factor [21]. The generally observed sequence of disarticulation occurs at major joints, from distal to proximal; on the upper limbs the first to disarticulate are the wrist joints, the elbow and the shoulder joints. On the lower limbs loss of the feet at the ankle joint is followed by the knee joint. The mandible disarticulates around the same time as the hands, and the cranium is lost parallel to disarticulation of the forearms [21]. This pattern, however can be altered through the presence of clothing, which may preserve the soft tissue and inhibit disarticulation (Figs. 1 and 2).

Fig. 1. Differential decomposition after 70 days of submersion, due to the body being protected by clothing; note disarticulation of the mandible.