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## Temporal displacement of environmental crime: Evidence from marine oil pollution<sup>☆</sup>



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### ABSTRACT

We provide evidence for temporal displacement of illegal discharges of oil from shipping, a major source of ocean pollution, in response to a monitoring technology that features variation in the probability of conviction by time of day. During the nighttime, evidence collected by Coast Guard aircraft using radar becomes contestable in court because the nature of an identified spot cannot be verified visually by an observer on board of the aircraft. Seasonal variation in time of sunset is used to distinguish evasive behavior from daily routines on board. Using data from surveillance flights above the Dutch part of the North Sea during 1992–2011, we provide evidence for a sudden increase in illegal discharges after sunset across the year. Our results show that even a tiny chance of getting caught and a mild punishment can have a major impact on behavior.

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### Introduction

Rather than comply with the law, businesses may choose to hide their illegal activities from the authorities. Evasion of law enforcement may be particularly challenging in the context of environmental law. Activities that are in contravention of environmental law are often jointly produced with legitimate business activities, providing continuous pressure to engage in criminal behavior. For instance, as in the case discussed in this paper, an environmentally harmful substance may be generated as a by-product of a legal production process. With one way of illegal disposal of the substance closed off, the need to dispose of it is not diminished. If the legal alternative is sufficiently costly, then the potential offender may simply look for other ways of illegal disposal. Gaps in enforcement due to imperfect monitoring may provide just such opportunities. This phenomenon has been documented in several contexts, including midnight dumping of used oil in the US (Sigman, 1998) and the widespread illegal burning of toxic waste during the night in Italy (Mazza et al., 2015). Within the context of environmental crime there may be more of a ‘lump of criminal activity’ that seeks a way out than in other types of crime, even though the elasticity of the overall level of environmental crime with respect to law enforcement activity has repeatedly found to be negative rather than zero (Gray and Shimshack, 2011).

Temporal displacement of illegal behavior in response to law enforcement is thought to be a common evasive strategy – since it requires less from the potential offender compared to other strategies such as a change in tactics – but it is also one

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of the least studied (Guerette and Bowers, 2009). In this paper, we study temporal displacement of illegal discharges of oily waste from shipping. Worldwide, the shipping industry is subject to regulation of the disposal of environmentally harmful substances, including oil and oily mixtures. Radar-guided surveillance by aircraft is a broadly used monitoring technology to identify cases of illegal discharges, next to port state control. Actual detection of oil discharges still relies on visual inspection, since radar also picks up other anomalies on the water surface. In the jurisdiction under study, the Netherlands, the courts dismiss cases that are based on observation by radar only. The standards of evidence require that the illegal nature of the substance is confirmed by an aerial observer who is trained to detect the particular rainbow sheen of oil on the water surface. As a consequence, the probability of conviction is negligible during low-visibility conditions, most importantly the nighttime. Since disposal of oily substances can easily be postponed for a number of hours, the shipping industry has long been suspected of shifting illegal oil discharges from the daytime to the nighttime (Meetskundige Dienst, 1981; Crist, 2003; Carpenter, 2007: 162; HELCOM, 2011). Temporal displacement of illegal discharges in response to this variation in the probability of being convicted has never been studied however, primarily because in most countries surveillance effort during the nighttime is at too low a level to collect meaningful data. This is known to be the case for Belgium, Canada, Finland, France, Poland, Russia and Sweden, but could apply to other countries as well.

The Netherlands is unique in conducting relatively intensive nightly surveillance activities, allowing us to analyze temporal displacement.<sup>1</sup> The Dutch part of the North Sea provides a good area of study because it is one of the busiest navigated seas in the world and also one of the most polluted seas (Camphuysen and Vollaard, 2015). The data collection is unaffected by visibility conditions because it relies on radar. We develop a test for the presence of temporal displacement. For nightly discharges to be strategic in nature, a necessary condition is that the timing is robust to seasonal variation in the time of sunset and sunrise. In December, the time window for discharges under the cover of darkness starts at 4.30 p.m.; in June only at 10 p.m. Variation in the timing of illegal oil discharges similar to variation in the time of darkness provides evidence of evasive behavior.

We use detailed data on radar-identified spots on the water surface and on the flight path of all Coast Guard surveillance flights for the Dutch part of the North Sea for the period 1992–2011. We combine these geographical data with meteorological data on wind speed, water temperature and air temperature. The focus on seasonal variation in the diurnal pattern of radar-identified spots eliminates estimation bias resulting from measurement error. Occasionally, the radar also picks up other substances that are not oil, including subsurface sand banks and algae blooms. All known sources of false positives do not vary with the time of day, let alone with the seasonal variation in the time of sunset. False negatives do not bias our results either, since radar works equally well in day and night.

We find clear evidence for temporal displacement. The hour-by-hour upswings in the probability of observing a spot – a sign of a surge in illegal oil discharges – only start after sunset, so not at some fixed time that may fit the schedule of the crew. The timing of illegal discharges, primarily during the watch of the chief engineer, is shown to vary with the seasons, in line with the variation in the time of sunset. This confirms the earlier suspicions of displacement to the nighttime. In absolute terms, the impact of temporal displacement is declining, together with the overall rate of oil discharges. We do not find that the tendency for temporal displacement has diminished in more recent years, however.

The context of oil pollution from shipping is particularly relevant because ocean pollution is a major source of environmental degradation. The legal discharge of oil and oily wastes is a standard part of operations of a large sea-going vessel, and these discharges are internationally regulated. Some vessel operators opt to discharge oily wastes illegally, and these discharges cumulatively are an important and chronic contributor to ocean pollution. The ecological impact attributable to the chronic levels of oil pollution has been shown to be greater than the impact of large, incidental oil spills that tend to attract major attention in the media (National Research Council, 2003). Oil spills can present a hazard by causing damage and death to birds and marine mammals and by exerting a toxic stress on subsurface organisms. Oil dissolved in the water can be taken up by organisms and affect their physiology, behavior, reproductive potential and survival. Oil may also be transferred to the sediment, where it might persist for many years, and impact on organisms on and in the sea bed. Marine oil pollution remains a great environmental concern globally (National Research Council, 2003; Gullo, 2011), even though the incidence of illegal oil discharges has been reported to have declined in some areas including the North Sea (Camphuysen, 2010; Lagring et al., 2012), the Baltic Sea (HELCOM, 2011) and the Pacific Ocean off the Canadian coast (Serra-Sogas et al., 2008). The policy relevance of the findings of this study extends beyond the confines of the Dutch part of the North Sea: many coastal countries in the western world use deterrence technology that is similar to the Netherlands, including the UK, the US, Germany, Belgium, Canada and France.

This paper contributes to the literature on deterrence. Deterrence is inherently dynamic in nature. Gaps in law enforcement due to imperfect monitoring may be discovered and exploited by offenders. In turn, law enforcement may take measures to counter evasive behavior. The study of this chain of action and reaction should improve our understanding of how deterrence works. Empirical evidence on the interaction between law enforcement and potential offenders is scant, however, which also applies to evidence on temporal displacement of crime in response to law enforcement activity (McCrary, 2010).<sup>2</sup> In a review of empirical evaluations of crime prevention initiatives, Guerette and Bowers (2009) found

<sup>1</sup> Apart from collecting statistics on illegal discharges for all hours of the day, nightly surveillance is mainly conducted to secure a rapid response in case of an emergency at sea and to enforce traffic regulations in shipping lanes around the clock.

<sup>2</sup> An exception is Jacob et al. (2007). They find evidence for temporal displacement of crime in response to weather shocks, which they explain by the presence of income effects for property crime and by decreasing marginal utility from violent crime in the amount of violent crime committed previously.

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