How Chemical Pollution Becomes a Social Problem. Risk Communication and Assessment through Regional Newspapers During the Management of PCB Pollutions of the Rhône River (France)

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ABSTRACT

The case study of the polychlorinated biphenyl (PCB) pollutions of the Rhône River (France) offers the possibility of studying criteria for the construction of social problems that result from chemical pollution (2005-2010). We investigated the dynamics of competition that create and define pollution as a social problem and entail its decline. News outlets are crucial for determining how an environmental issue emerges locally or nationally; this study used newspapers to highlight the potential of new outlets as a data source to analyze discourse variability, science-policy-media connections and the hydrosphere. Media coverage was based on a content analysis and textual data analysis of 75 articles. Analytical frameworks such as the Downs Model and the Public Arena Model (Hilgartner and Bosk, 1988) that consider time and stakeholders were tested to determine how human alteration of the hydrosphere can become a social problem and to analyze different communication strategies held by stakeholders. In terms of management, we described the temporal dynamics of the social problem based on the case study and considered an explanation of the selections. We considered the organization of particular stakeholders who define the social problem from its beginning to end by focusing on their discourses, relationships, decision-making and political choices, and scientific studies. Despite some biases, newspapers are useful for retrospectively evaluating the emergence of a social problem in the public arena by describing it through discourse and then understanding the temporal patterns of information. Despite uncertainties and information flow, decisions are made and science is translated to the public.

KEYWORDS

Communication; Environmental policy; PCB pollutions; risk assessment; social problems; temporal patterns.

1. INTRODUCTION

As explained by Smith and Joffe (2009), three information sources contribute to the public knowledge of environmental issues: experience, social links, and media. The majority of the public depends on media information because they cannot experience the whole of reality (Lacey and Longman, 1997). The influence of one media source on the public cannot be determined because of the complexity and number of daily messages received (Wahlberg and Sjoberg, 2000). Among media sources, newspapers can be an interesting source of information in the retrospective analysis of socio-environmental contexts. Because newspapers are part of the daily lives of their readers, they are an element that can mold the relationship between people and their environment (Waitt, 1995), construct public discourse, and shape the public perception of risk (Ferreira, 2004).

Disasters and catastrophes are typical environmental issues of interest to newspapers (Allan et al., 2000; Committee on Disasters and the Mass Media, 1980; Hansen, 2010; Lester, 2010; Pantti et al., 2012; Sandman et al., 1987), and media events consider unusual, unexpected, and emotional threats towards human life and property (Salomone et al., 1990) or add personalization, dramatization, and novelty (Boykoff and Boykoff, 2007). Wakefield and Elliott (2003) studied risk through newspaper reports and stated that scientific interest is doubled if (a) newspapers can teach researchers how to communicate issues regarding risks, and (b) highlight the characterization of the public perception of risk. Through local exploration, the media provides information concerning risks to inform citizens and to influence the acceptability of risk (Bakir, 2010). Newspaper discourse on disaster may provide a basis for assessing a number of research assumptions that consider the media framing of disaster news and the role of newspapers in risk communication and hazard perception (Rashid, 2011).

Nevertheless, as McComas and Shanahan (1999) indicated, media attention and public attention cycles are linked, even though this contribution is not centered on public reception of media messages. If newspapers cannot tell readers what to think specifically (Rogers et al., 1993), they can tell readers what to think about generally. Following this idea, we may ask how an environmental issue emerges in public debate. For Downs (1972), these issues are illustrated by the ups and downs in attention cycles that result from the following three features: (a) problems that influence a few players who are suffering, whereas the majority do not face these difficulties; (b) problems that are generated by social arrangements that provide significant benefits to a majority and a powerful minority of the population; and (c) problems that do not have intrinsic qualities, regardless of whether they cease to exist. From a constructionist approach, certain socio-cultural factors may explain the establishment of ups and downs in the media coverage of environmental issues because of their use of narratives (McComas and Shanahan, 1999). Moreover, Hilgartner and Bosk (1988) wanted to move beyond this type of "natural history model" (p. 54), which considers idealized descriptions that result from the absence of complex temporal patterns and interactions among problems. Social problems must compete for social attention at two levels: to win against other problems and to be characterized among all given definitions of this problem. A social problem is "a putative condition or situation that is labeled a problem in the arenas of public discourse and action" (Hilgartner and Bosk, 1988, p. 55). Figure 1 shows how we apply this theoretical framework to our analyses. A newspaper may be viewed as an efficient public arena as the social problem evolves over time and provides different possibilities of feedback (problem-amplifying or damping). Certain topics are placed in the foreground by newspapers and may assist in the understanding of the science–policy–media connection and media concerns. McCombs and Shaw (1972) considered that media focused on crucial issues during political campaigns and consequently "set the agenda for each political campaign, influencing the salience of attitudes toward political issues" (p. 177). If media coverage does not directly include policy decision making, it may shape the possibility for political engagement (Boykoff, 2011).

Following Leiss (2004), an effective risk communication effort concerning major public controversies such as chemical pollution requires a) a "science translation" (p. 399) that will be given in clear and comprehensible language, b) a qualitative and quantitative description of uncertainties, and c) an interface between science and policy. To explore how information is discussed and how science interacts with media and policy when a pollution problem is emerging, we selected a critical event: the polychlorinated biphenyl (PCB) pollutions of the Rhône River from 2005 to 2010, which was considered a disaster by a large set of stakeholders with a regional extent and entailed a national management scheme. We aim to explore the temporal patterns of discourses and stakeholder involvements with a regional newspaper, *Le Progrès* (considered a public arena), when there are concerns for pollution that is considered a social problem. The following questions are addressed: i) When should stakeholders communicate based on the public's needs; ii) Despite scientific uncertainties, what type of information is spread and what types of decisions are made; and iii) How has scientific research been translated to the public, while comparing different public arenas?

2. SPATIAL AND TEMPORAL CONTEXT

The Rhône River drains a catchment area of 98,000 km² in southeastern France. It has a 512 kilometer main stem downstream of Lake Geneva and flows to the Mediterranean Sea (Figure 2). Its valley is occupied by large urbanized areas: Lyon, Valence, Montélimar, Orange, Avignon and Arles. From 1948 to 1986, nineteen dams were constructed to produce hydroelectricity, to aid in navigation and to irrigate land areas. Four nuclear power plants use water from the Rhône River to cool reactors. This valley is one of the major French axes for transport (highways and high-speed railroads).

Our study addresses the period from 2005 to 2010; pollution was discovered in the mid-eighties but appeared to be neglected for over twenty years. During the mid-eighties, researchers were helped through a regional environmental NGO (*Fédération Rhône-Alpes de Protection de la Nature* – FRAPNA – for Rhône-Alpes Federation for nature protection), which revealed and studied this pollution. After two European Frameworks in 1976 and 1985, the use of PCBs was prohibited in 1987 in France (Figure 3). In 1996, the Council of the European Union planned PCB decontamination in different countries. France reacted too late and was condemned in 2002 because its action was too weak. In 2006, a European Commission Recommendation updated the Regulation N°466/2001 and the Recommendation 2002/201/EC, and issued reductions of the presence of dioxins, furans and PCBs in feedingstuffs and foodstuffs to limit human exposure to these chemicals (EC, 2006). In

France, this recommendation entailed the nationwide monitoring of freshwater fish contaminated by PCB congeners (Babut et al., 2012).

After a peak in scientific interest (for example Monod et al., 1988) and public attention at the end of the eighties, the PCB pollutions of the Rhône River drew no attention until 2005. In 2004 in the Grand Large, many dead birds were found and fishing was forbidden. The analyses showed that the death of birds was a result of avian botulism, and fishing was no longer prohibited. However, a fisherman had to reassure his main customers regarding the quality of fish, and in March 2005, he requested more complete analyses (Figure 2). Until September 2005, water authorities did not divulge evidence of pollution, particularly to the media, whereas scientific research was led by the DDASS (Departmental Services about Health and Social Affairs). The Rhône was the first river in France affected by the discovery of PCB pollutions. After the Rhône pollution was detected, other cases were discovered, such as in the Seine or Loire rivers.

On the 14th of September, 2005, the Préfecture (departmental administration) prohibited the consumption and marketing of fish from the Canal of Jonage (Figure 2). From February to August 2007, this interdiction spread from Sault-Brénaz to the Mediterranean Sea. However, in May 2008, the Drôme, Adèche, Gard, and Vaucluse departments reduced the prohibitions (Système d'Information sur l'Eau du bassin Rhône-Méditerranée, 2013), and they were only concerned with benthic species (*Anguilla anguilla, Abramis brama, Blicca bjoerkna, Barbus barbus, Silurus glanis, Cyprinus carpi*o, etc.) and migratory fish (*Alosa fallax rhodanensis, Lampetra fluviatilis, Lampetra planeri, Petromyzon marinu*s, etc.). These departments were followed by the Bouches-du-Rhône department in May 2009 and by the Isère, Ain and Rhône departments in June 2009. In 2013, only a ten-kilometer reach was affected by a complete fish-consumption interdiction in the Ain department, from Loyettes to Saint-Vulbas (the commune of Tredi where treats PCB waste). These interdictions were summarized by the association “Robin des Bois,” which published the first edition of an atlas of PCB contaminated locations (Figure 3) in May 2008 and investigated different potential sources of pollutions (Robin des Bois, 2013). The three characteristics established by Downs in the introduction can easily be found in the 2005-2010 period: (a) less than twenty fishermen needed to find a new job, whereas the functions linked to leisure activities were saved, despite recreational anglers having to stop consuming their fish; (b) many jobs (in agriculture, dams, nuclear power plants, boating or tourism) depended on the Rhône but were not impacted by this environmental degradation, and local politicians used this event to launch political careers at a national scale; and (c) the health question does not benefit from thorough scientific research.

Thanks to a national scheme, new scientific programs were implemented (Figure 3) that focused on the concentrations of PCBs, the transfer of PCBs from sediment to fish (Lopes et al., 2012), and the necessity of determining a sediment quality guideline (Babut et al., 2011). The collection of freshwater fish was performed by professional fishermen (including the fishermen who need to find a new job because of interdictions) and technicians from fish management authorities (Babut et al., 2009). Different institutions (including DDASS, Afssa, and Anses) tried to understand the PCB pollutions and the fish contaminations, considering more and more individuals from two fish in 2005 to 643 in 2009 (Afssa, 2009), and more and more species (Afssa, 2007; 2008). Two classes of PCBs could be distinguished because of their toxicological properties: the dioxin-like PCBs (DL-PCBs) which show analogous toxicity as dioxin compounds and the non-dioxin-like PCBs (non-DL-PCBs) (Blanchet-Letrouvé et al., 2014). The Rhône analyses dealt with PCBs (e.g. DL-PCBs as well as non-DL-PCBs), and PCDDs (Afssa, 2006). A national database on fish contamination by polychlorodibenzo-dioxins (PCDDs) and related compounds (Babut et al., 2012) was created, thanks to the investigations of three hundred and thirteen sites. As the PCDDs are lower than

European thresholds, the researches focused on risk assessment of PCB concentrations (Table 1). Understanding the factors affecting fish contamination appears to be necessary to assess health risks to upper-trophic level consumers (including human beings) (Lopes et al., 2011). The levels of PCBs become a topical issue with a high scientific interest : if Oliveira Ribeiro et al. (2005) dealt with organochlorine pesticides, polycyclic aromatic hydrocarbons, and heavy metals in the eel (*Anguilla anguilla*) in the Rhône Delta, at the Camargue Nature Reserve, their fish collection (thirty eels) of October 2003 was used a few years later to study bioaccumulation of polychlorinated biphenyls in the eels (Oliveira Ribeiro et al., 2008). In France like in many European countries PCB levels in eel are at levels of concern: PCB levels are often higher than in other species (Geeraerts and Belpaire, 2010).

Although Santiago et al. (1994) showed that the occurrence of pollutants increased dramatically downstream from Lyon, new analyses were performed by using sedimentary archives: PCB concentrations were linked to an upstream-downstream pattern because of different drivers (floods, flushing events, tributary contaminations, populations, and the small amounts released by PCB treatment facilities) (Mourier et al., 2014). Desmet et al. (2012) noted that PCB concentrations decreased in the mid-nineties but remained relatively stable afterwards. No additional hot spots of contaminations were found, but studies highlighted the diffuse, significant, and often unknown sources of pollutions that corresponded to 307 kilograms of PCBs released to the Mediterranean Sea from 2008 to 2011 (Pradelle et al., 2013) (Table 2).

3. METHODS

3.1 Collecting a Corpus of Regional Articles

Le Progrès, which is edited, published and printed by a company in Lyon, was the daily newspaper chosen for this study. It is the fifth-largest regional newspaper in France based on sales and is the first newspaper upstream of the Rhône with approximately 250,000 papers sold per day. Its main reader base (more than 700,000 readers) is shown in Figure 3. This newspaper was the first local edition (Lyon metropolitan area with more than 50,000 sold items per day) to discuss the problem of PCBs in the Rhône. The first sick fish found was in its coverage area (approximately ten kilometers from the head office). A majority of the main stakeholders (including elected officials, professional and recreational fishermen, NGO members, and scientists) lived in its diffusion area, and this newspaper acts as a regional forum.

The archives of Sciences Po Lyon (Institute of Political Studies), located in Lyon (Rhône-Alpes), receive and archive this newspaper daily. One researcher thoroughly read all daily papers from January 1, 2003 to December 31, 2010 to select articles related to water issues in the Rhône River. Each article was photographed and catalogued as numerical data, and a database was compiled. Each article in the corpus was considered an individual piece for statistics and characterized by the following variables: publication date, author, page and mentioned actors.

The comparative analysis of different newspapers helped to strengthen the data, to evaluate the variability of opinions and debates, and to evaluate the biases of these sources. To discuss the results, we compared these newspaper articles with other regional newspapers from the downstream stretch and with one of the most powerful and widespread national newspapers, *Le Monde*. At a regional scale, we selected two different newspapers whose coverage areas were located in the middle and lower Rhône (Figure 2): *Le Dauphiné Libéré*, which is a regional newspaper that is the 4th-most sold in France with a coverage area in Drôme and

Ardèche, and *La Provence*, which covers an area of the downstream stretch (Avignon and Arles metropolitan areas). We wanted to study the spreading of this social problem in various areas fed by interactions between different public arenas through social networks and patterned institutions.

The raw material consisted of 674 articles focusing on the Rhône River, and pollution was the third-most mentioned question after leisure and waterfront redevelopment (Figure 4). Seventy-five items were published on the Rhône pollution by PCBs, with 75 percent of the articles in the regional section (shared by all editions of *Le Progrès*), 21 percent in the national sections and only 4 percent in the local sections (in the Lyon metropolitan area). Twenty-three percent of articles were on the front page, which illustrated the importance of PCB pollutions, and 9 percent were interviews revealing the role played by certain actors. A fifth of the articles were written by the same journalist who has great knowledge regarding all local stakeholders and the evolution of this type of pollution. Because these articles are not redundant, we used different analyses to aggregate their messages.

3.2 A Mixed Approach Combining Quantitative and Qualitative Analyses

Considering discourses as a social act, Fairclough (2010) adopted a three-scale approach: a micro-approach similar to linguistics; a meso-approach based on production, circulation and reception; and a macro-approach based on the social construction of discourse (production and reproduction in the society). We focus on the first aspect and also address the second issue. Peters and Hosgood (1985) suggested the creation of a quantitative analysis of issue salience. Our quantification entailed two different methods: a content analysis and textual data analysis.

Berelson (1952, p. 18) defined content analysis as “a research technique for the objective, systematic, and quantitative description of the manifest content of communication.” This descriptive method summarizes “the message set rather than reporting it in all of its detail” (Boykoff and Boykoff, 2007, p. 1194). After reading each article, some categories were created to summarize all of the information for each item (Boholm, 2009). Text is considered as a network of meaningful objects that must be coded in a table (Vasterman et al., 2008). This standard method (Moodie, 1971) allowed comparisons between different texts (McKay and Finlayson, 1982), despite the studied articles showing variability. Nevertheless, the categorization and codes were qualitative phases, although codes could be treated through statistics (Boholm, 2009). To study the 75 articles, we focused on specific explanatory facts regarding the nature of the pollution, consequences such as the location of the pollution and its impact on health and acts that regulate the crisis (Table 3). One person filled in a table with all qualitative variables for each article to limit the interpretation by the coder and to reduce inter-coder variability (Maher, 1997). Two modalities may occur at the same time so that we can study co-occurrences (Boholm, 2009). Codes were assigned after reading each article (Brossard et al., 2004; Wakefield and Elliott, 2003), and statistical analyses were performed with the R software (Ihaka and Gentleman, 1996). This study does not consider how messages are constructed or received but is rather focused on their content.

A discourse analysis was used to determine the role of words and discourse in constituting social practices and individuals from a post-structuralist perspective (Phillips, 2000). To avoid the formation of categories used in the content analysis and bias through hasty interpretations by researchers, textual data analyses considered only written or pronounced words (Lebart et al., 1998). Textual data analyses created in the 1970s were based on inductions and interpretations of statistical results of texts (Benzécri and Benzécri, 1980). This technique has been improved through different statistical analyses (Lebart et al., 1998) and is called textometry, which combines factorial correspondence analyses with full-text search techniques. We used an open-source platform called TXM to perform our textual data analyses (Heiden, 2010). For the “results” section, we combined these quantitative analyses with a qualitative approach through different quotations.

4. RESULTS

4.1 Temporal Signature of Pollution within Media Discourses: Dynamics of Direct Competition Considering Different Issues

The main issue associated with leisure and waterfront developments throughout almost the entire period, whereas pollution coverage underwent a specific bell-shape trend compared to other topics that were more constant in frequency through time or that had many ups and downs (e.g., nuclear power plants, dams, floods, etc.) (Figure 4). When considering the bell-shaped trend of pollution topics, we found that the PCB issue was introduced abruptly. In 2003 and 2004, pollution was an infrequent issue for newspapers that dealt with the presence of heavy metals, which was a recurrent problem without any immediate solution; however, there was no mention of PCBs. Nevertheless, PCB pollutions became a topical issue after 2005 and reached a maximum in 2007.

Content analysis showed that the pollution problem progressively propagated along the Rhône corridor with the availability of additional information: 18 percent was focused on specific sites, particularly the first contaminated site discovered (Grand Large and Canal of Jonage at the beginning of the study period, *Le Progrès*, 09/15/2005) and the site of an unofficial medical study and official research project in the Lower Rhône (*Le Progrès*, 03/05/2008).

Twenty-seven percent of items only considered pollution from a regional approach from October 20, 2005, to May 26, 2007. Fifty-five percent of articles considered the whole Rhône corridor as polluted, and they were published from July 24, 2007, to the end of the period. The number of published items indicated that this pollution was characterized by a specific temporal trajectory in media coverage (Figure 5). Since 2005, the role played by pollution showed a significant increase, which was confirmed in 2007 (Figure 5A and 5B) and based on 9 articles in 2005 and 2006 and 28 in 2007. After the peak in 2007, the number of articles decreased regularly (Figure 5A). In 2010, several articles were published, but the dynamics of the 2005-2007 period appeared to fade. Figure 5B focuses on the monthly scale and shows that the trajectory was not as smooth as shown in the annual focus with specific events provoking increased media attention. Until 2009, these events appeared to be less numerous. Figure 6 shows a factorial component analysis (FCA) performed on all of the words in the corpus with TXM. The first axis is organized according to a temporal approach, and the positive coordinates of the first axis are linked to the beginning of the discovery in 2005 and 2006, whereas the negative coordinates focus on the regulation of the pollution in 2007, 2008, 2009 and 2010. The positive coordinates of the second axis correspond to an equilibrium before the emergence of the problem in 2005 or after the resilience until 2008. The negative coordinates of this second axis are linked to the discovery of major problems.

4.2 Discourse Framework Characterizing an Environmental Pollution

The multiple correspondence analysis performed on the content analysis information at the scale of each article provided a similar synthetic temporal trajectory of the event as that explored by textometry (Figure 6), but it was also related to the topics of concern, pattern of discourse and rationale (Figure 7).

The first two axes represented 51.5 percent of the total inertia (Figure 7). The first factorial map was organized by the problem of diffusion through space and time and evolution of the concerned stakeholders. The negative coordinates on the first axis were structured at a local scale for the first two years of the period, whereas the positive coordinates were structured at the national scale for the last years of the period. The problem peak was shown in the negative coordinates on the second axis, which loaded 20.5 percent of the inertia and highlighted items characterizing this peak that were mainly linked to a negation of the pollution problem (negative coordinates) in 2007.

On the negative side of axis F1, the temporal period was from 2005 to 2006 and evoked the beginning of the pollution during the 2000s at the Lyon urban-area scale. The quoted stakeholders were journalists, professional and recreational fishermen, and water management institutions. The fault appeared to result from illegal contamination, unknown waste and *Electricité de France* (EDF, a national company that produces and distributes electricity): “no analysis was conducted after flushing-out operations” (09/16/2005). The uncertainty was high because of weak scientific studies. No geographic comparison was included, and the study area was either local or regional. The politicians either did not act at all or only acted at a local scale. The pollution may have had consequences on the water supply, irrigation, fish, trophic chain, and human health (for example, the risk of cancer).

On the neutral coordinates, an intermediate situation can be observed before the increased prohibition in the year 2007, and certain stakeholders (scientists, ecologists and companies) and impacts on angler activity were mentioned: “The Rhône River goes downstream […] but we buried our head in the sand” (02/24/2007).

On the positive side of the first axis between 2008 and 2010, the pollution was perceived at a national scale. Responsibilities were attributed to old uses that possibly dated back to the nineteen-thirties. The quoted stakeholders were politicians and members of the court. The entire fluvial corridor was polluted along with other rivers in France. The political actions were both regional and national, the health consequences were numerous and unknown, and additional impacts to leisure activities were induced. Concerning scientific research, there were contrasts between its absence, prominence, and equilibrium. Uncertainty associated with the pollution was weak or normal, and concrete projects were mentioned, such as the extraction of polluted sediments.

On the negative side of the F2 axis, we observed frequent pronounced discourses in 2007 that were organized around the absence of themes (such as production, recreation, environmental scale of pollution, health consequences, and scientific research), role of claims, court, and particular stakeholders, such as the members of the court and companies. The evoked historical period was the seventies. It is still not known exactly who the guilty party may have been. On the positive side of the F2 axis, we found a mixed discourse focused on who was responsible for the pollution, which included companies such Tredi, EDF, which managed the sediments, and illegal users. Certain stakeholders were quoted, such as scientists, water management institutions, and journalists. In the foreground, the weak uncertainty was explained by local contamination; impact of fishermen, anglers and leisure activities, no judiciary consequences; politician mobilization at a local or a regional scale; number of contaminated fish and hydrosystems; great number of health consequences; and scientific research in 2005, 2008, 2009, and 2010.

Considering the causes analyzed through the content analysis, newspapers painted a progressive evolution of attitudes. Forty-two percent of the articles mentioned history to explain the current situation and evoked periods from the 1930s to 2000s, with a peak during the 1980s (21 percent of items): “Twenty years after the first contamination, two fish have the same symptoms” (09/16/2005). The company Tredi was most often quoted; it re-treated PCB waste and was accused of being a polluter. Nevertheless, no single guilty party could be found because the contamination occurred over such a long period and there was such a diversity of polluters. The quantification provided additional information regarding the stakeholders who were explicitly quoted; in 2005 and 2006, professional and recreational fishermen were first, followed by scientists and water managers. In 2007 and in 2008, politicians played a significant role during the peak of the media coverage and environmentalists, whereas scientists and professional and recreational fishermen played a secondary role. Since 2009, there has been a new equilibrium with politicians and courts.

We only focused on people whose names were the most quoted in the corpus (Figure 8): the State (70 occurrences), Prefects (64 occurrences), FRAPNA (59 occurrences), Tredi (the decontamination company was evoked 59 times), French food safety agency (AFSSA for *Agence française de sécurité sanitaire des aliments*), Ministry of Ecology (and its Minister Nathalie Kosciusko-Morizet) and EDF. Before 2007, the main stakeholders were the Prefects and FRAPNA. If EDF was central in 2005, it became an infrequently quoted stakeholder afterwards because it was found innocent. At the end of 2007, the role of the State became prominent and certain national institutions played a greater role, especially the AFSSA and Ministry of Ecology.

5. DISCUSSION

5.1 When Does Pollution Become a Topical Issue?

The understanding of temporal patterns of information enables us to propose strategies to different stakeholders to help them better respond to public interest at the right time, such as when concern over pollution increases.

For Anderson (1997), an environmental issue became newsworthy when the coverage focused on an event, visual components and story that occurred less than 24 hours before. This framework does not completely correspond to the description of PCB pollution: (a) although there was no real event, the announcement of fish contamination and prohibitions on consuming fish can be considered major events; (b) when the pollution was not visually recorded, the newspaper communication was based on “toxic images” or “visual representations that are found in print or digital media of people, places, or toxins, which are used to make claims of human-produced contamination causing the degradation of the natural” (Peeples, 2013, p. 193); but (c) the diffusion of PCB pollutions dates back several decades and may still last a long time. These traditional characteristics of media interest have evolved because of the emergence of slow and long-term environmental processes such as global change (Hansen, 1993).

The temporal pattern of media coverage may be divided into different steps. The Downs’ Model (1972) might correspond to media coverage of PCB pollutions: (a) the pre-problem stage represents the beginning of media interest resulting from scientists and fishermen; (b) alarming discovery and euphoric enthusiasm are symbolized by the extension of the perimeter of consumption prohibitions that combine the confidence of players and seriousness of the problem; (c) cost of significant progress and consideration that the problem cannot prevent riverside inhabitants and users from engaging in the same activities as usual; (d) gradual decline of intense public interest out of boredom, worry and competition from new topical issues after 2008; and (e) post-problem stage when no solution is found and the media interest decreases. The temporal structure looks like a flood hydrograph, and steps A and B behave like a rising limb during a lag time before reaching a peak during step C. Steps D and E may correspond to a falling limb; however, this decline does not reveal the end of the problem, which may reappear through different forms at different times (Cram, 2001) and may form the risk perception. Nevertheless, the Downs Model is a very simple representation of temporal patterns and may not help us understand reality at a finer time scale. The year scale is perhaps too broad to show how a social problem is formed (Newig, 2004). Disaster and risk are characterized by a succession of sporadic levels of media attention and scenes in newspapers that are reanimated as new elements are introduced into the debate. Media coverage is not entirely absent after the peak, and new alarming news can reactivate it. Some new issues including leisure and waterfront developments that appear more topical: The competition is central to understanding the selection of social problems.

5.2 Despite Uncertainties, What Type of Information and Decisions Are Expected by the Public?

We consider the importance of competition and selection in the context of the Hilgartner and Bosk Public Arena Model (1988). Figure 9 offers a systemic and synthetic vision of principles of selection in the studied newspapers. Different feedback was analyzed to understand two temporal dynamics: the problem-amplifying from 2005 to 2008 and the problem-damping. The decrease appears to be linked to the feeling that certain national policies may regulate this pollution and that while the problem may be widespread, it is not such a threat after all. PCB pollutions no longer concentrates this fear of the unknown (Hansen, 1993) because of the partial possibility of answering the five Ws and one H: Who performed the polluting? What happened? When did it take place? Where did it take place? Why did it happen? and How did it happen? Therefore, the debate became somewhat dull. Because the problem might now come to an end as a result of political measures, the questions might arouse fewer emergencies.

There appears to be common points in the temporal patterns between media coverage of PCB pollutions and policies to fight the pollution. Politicians are citizens and consume information from the media; therefore, they may be shaped by it, which may influence their decision-making processes (de Loë, 1999). Figure 8 shows that the most-quoted stakeholders are the actors of the top-down policy. Thus, politicians must be part of the primary definers, and they are followed by fishermen, environmentalists and scientists who may all have a discourse oriented towards preservation or protection of rivers. In our case study, journalists asked for more information and they appeared to appreciate the fight carried by fishermen, environmental NGOs and scientists: "two scientists [A. Devaux and M. Babut, both quoted in four different articles] and an NGO evoke the limits of the first investigation. […] We shouldn't forget the other pollutions" (02/03/2009). From 2006 to 2007, many local and departmental stakeholders (professional and recreational fishermen, mayors, NGOs, etc.) decided to organize large demonstrations and to go to court to explanations for the diffusion of forbidden PCBs; this emphasized the media coverage. When the first research results showed that certain fish may be less contaminated than others because of different exposure to sediments from contaminated sites, the weight of the fish or its age (Babut and Miège, 2007), the area of partial prohibition increased. This decrease of precautionary principles may be another explanation of the decline in media coverage. When the coverage reached an apogee at the end of 2007, a national action began that implicated a new stakeholder: the Minister for Ecology. Thus, on October 10, 2007, Nathalie Koscisuko-Morizet appeared at the Rhône River to announce a national policy (commission and research program) against the pollution of French rivers by PCBs. As soon as this policy was initiated, we noticed a downturn in media interest on the question of PCB pollutants.

If we cannot explain the nature of all of the links between science, media coverage and political regulations, we argue that (a) some players used newspapers to stay in the forefront at a national scale, such as the Minister of Ecology, and at a local scale, such as certain mayors or NGO members, and amplify the social problem through interviews; (b) the chronologies of media coverage and political decisions succeeded each other, with media coverage reaching a maximum when political choices were absent or weak and politicians were in the spotlight, whereas political measures were frequent and researchers exposed their results when media coverage declined; and (c) the importance of media coverage appears to influence the creation of new scientific programs and governmental structures and the visibility and legibility of acts. The media do not only focus on disasters that expose difficulties; however, they show the answers given by society and in particular by politicians: "The professional and recreational fishermen are keeping calm. They are not choosing revolution right away. But we must blow the whistle. The State has to discover the source […]. We must find the polluter to prevent the pollution from continuing" (09/26/2006, a recreational fisherman).

5.3 How Has Science Been Translated to the Public?

Following Leiss (2004), whose aim was to reduce the knowledge gap between experts and lay people over time, we assumed that an efficient risk communication was based on some quantitative expression of pollution understanding that was framed in qualitative terms. The quantitative risk information produced key metrics but tried to translate them in terms that are comprehensible for non-expert audience. The journalist may use international cut-offs to help the understanding: "All of the studied fish have between 9 and 47 picograms of PCBs per gram of flesh and display the European thresholds of 8 picograms" (08/18/2006). We can notice a reference into a non-expert language to the 2006 European recommendation which set a threshold of 8 pg.g^{-1} wet weight for the toxic equivalent concentration in all fish species, except eels. In our case study, three types of research were mentioned: academic research with scientists who published the quoted papers and technical reports (Figure 3), environmentally committed research linked to worldwide or regional NGOs (WWF, Robins des Bois, or FRAPNA), and institutional research (DDASS, Afssa or Anses) that justifies the prohibition area. They both use e-media and their own internet websites to show their current results and future objectives. In June 2008, certain doctors (members of an environmentalist NGO called *Association Santé Environnement Provence* - ASEP) published the conclusions of an unofficial study on 52 people from the Lower Rhône: everyone was a PCB carrier, even people who never ate fish from the Rhône River. The presentation of the results was filmed and published by WWF on Dailymotion (WWF and Asep, 2008). In January 2009, 150 riverside inhabitants of the Rhône River took part in a national study that analyzed the contamination of the population by PCB pollutions, but the results were only published in November 2011 (Anses, 2011). This example about health is emblematic: People no longer had access to information, but may have been contaminated. The residents along the Rhône River may have all been victims, but no responsible party was declared guilty and no pragmatic solutions were found. Concerning decontamination, even though some scientific programs were initiated to handle address sediments, no solution appeared because it is expensive to remove all contaminated sediments and there is uncertainty concerning potential results.

The translation from technical and scientific terminology to a public-friendly language is based on a plot with emblematic stakeholders that resembles what can be found in narrative analyses (Clandinin and Connelly, 2000). We studied the stories as told by different stakeholders, such as the fisherman who is considered a main whistleblower and spoke to journalists about his experiences and the major turning point in the contamination discovery in a very dramatic way: “Two breams […] were enough to wake up muddy devils of the

Grand Large reach” (09/16/2005). Over a period of five years, this fisherman produced a great number of interviews and decided to tell it as a story: “I’m waiting. I must now recover from this strain. Evidently, they don’t finish sediment analyses. Anyway, I have no choice” (10/20/2005). Sixteen percent of articles related to PCB pollutions explained his life story and current situation because of this disruption. Following Kwan and Ding (2008), we distinguished two types of history from retrospective and mediated perspectives: an oral history (consisting of personal thought to explain the causes and consequences of the pollution) and a life history (a biographic process to portray his entire life) in discourse. The newspaper focused on this fisherman’s situation, although other fishermen were impacted. He symbolized one type of population that is directly affected: 18 percent of all published photographs depicting a human being present this fisherman in the foreground. Readers may be able to recognize him and consequently know that this article may explain to them the continuation of his story, such as in a serial. The construction of his narrative looks like a plot with an initial situation (everything seemed to be all right), disruption (the discovery of pollution), following events (the consumption prohibition, seriousness of pollution and insistence upon negative consequences), and potential resolution (through political choices, planned research and subventions in 2010). Since 2008, this fisherman has demanded the status of a sentry, which is a status defined in 2007 during the national *Grenelle de l’Environment* that tackled climatic and ecological crises in France and considered sustainable development as a national priority. This status exists but has never been applied. This fisherman wants to provoke national awareness concerning jobs, leisure activities or uses that make people realize environmental problems earlier than usual and must be recognized as a national utility: “Emergency subventions before kicking the bucket! […] I’m furious with the political exploitation of PCB pollutions during the last municipal election campaign” (03/16/2008). Because the focus of narrative analysis is not only on people’s experiences but also the social, cultural, and institutional contexts of the construction of the problem, the media approach appears to use story-telling mechanisms and frames to communicate scientific information.

Finally, to understand public interest, spatial proximity with environmental issues may be a key, and geographic logic may be a result of the spatial diffusion of this pollution: Pollution is everywhere. The locations with high media coverage are scattered along the Rhône corridor and other polluted rivers. If the chosen newspapers put the upstream stretch in the foreground, the downstream stretch is not forgotten. The threatened Mediterranean Sea is often quoted and produces a broader perspective of the pollution case: “Perhaps the Rhône River pollutes the Mediterranean Sea” (08/18/2007). Because using just one newspaper may be biased and does not correspond to the high number of messages received each day, we compared our results with three others dailies. *Le Monde* did not publish any articles regarding this issue in the 1994-2006 period, and the first article was published on the 3rd of March, 2007. At a regional scale, *Le Dauphiné Libéré* in the middle Rhône published its first article on the 4th of March, 2007, and *La Provence* published their first article in the lower Rhône on the 21st of April, 2007. The spatial diffusion of the prohibition from a specific site to the entire Rhône corridor, and finally to the national river network scale can also explain the media’s growing interest towards PCBs. The spatial amplitude of phenomena in the Rhône catchment expanded with the discovery of many polluted river basins (including the Seine, Somme, Loire or Moselle Rivers). Because the situation appeared to be shared and serious, we noticed an amplifying problem; however, this propagation lasted two years. The same photographs (a panel with prohibition signs in Lyon, graphical abstract) have been used by different newspapers. The systematic differences in principles of selection may explain the two-year spreading of this issue as a social problem.

6. CONCLUSION

Although the media is representative of only one perspective regarding the environment, which might appear biased, inaccurate and exaggerated (Pasquarè and Pozzetti, 2007), simplistic and guilty of polarizing arguments (Vasterman et al., 2008), the present research highlights the temporal pattern of critical pollution and its spatial expansion related to a succession of discourses, issues and stakeholders. In terms of management, we showed that the life expectation of such a social problem is difficult to predict. Nevertheless, certain frameworks are useful for understanding the diffusion rationale and interactions between the media, science, and policy. An analysis focused on competition and selection principles appears to be able to explain the structure and organization of the newspaper data and therefore certain trajectories of the information, and the stakeholders and their relationships may entail media coverage. Following Boykoff (2011), we argue that "the media community serves a vital role in the communication process between science, policy and the public" (p. 28). When the social problem became prominent, new stakeholders, such as politicians, appeared and became crucial. More important media coverage inspires the rapid adoption of political regulations that may be undertaken at regional or national scales. Comparing different public arenas, we assumed that the same pollution entails a high variability of discourses in space and time because of problem-amplifying and problem-damping. These different public arenas can be delimited, but these limits seem blurred and in constant interactions; information spreads from one arena to another. It may explain why and how newspapers convert a seemingly long-term environmental problem into an imminent disaster.

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9. LIST OF TABLES

Table 1. An overview of analyses led by the institutional research.

Main institutional publications	Objectives of fish analyses	Fish collection characterization: species and numbers	Fish collection: where and when?	Levels of measured PCBs	Identified concerns and consequences
DDASS, 2005	After an avian botulism, a professional fisherman wanted to reassure his customers	2 breams	Canal of Jonage	7 iPCBs (congeners: 28, 52, 101, 118, 138, 153 and 180): 1365 and 1612 $\mu g.kg^{-1}$ of wet weight (ww) for ∑iPCBs	Risk of chemical pollution : the fish-consumption interdiction in the Canal of Jonage A need of scientific research on iPCBs, but also on DL-PCBs and PCDD/Fs. The necessity of comparing different species.
Afssa, 2006	More detailed analyses of previous results, a study of the variability of fish contamination considering species and different parts of the Rhône River.	39 fish: 8 breams, 5 barbels, 5 pikes, 11 catfish, 5 carps, 2 perches, 2pike-perches, and 1 nase. Two categories are crated: 30 benthic species and 9 pelagic species.	Three areas of the Canal of Jonage	The average toxic equivalent concentration (TEQ) values [min.-max.]: DL-PCBs: 14,09 $pg.g^{-1}$ ww [1,5-71] iPCBs: 220,41 [29-868] PCDD/Fs: 1,16 [0,08-7,5] ∑iPCB are between 29 et 868 $pg.g^{-1}$ and show a correlation with with the quantity of DL-PCBs. Concerning the two categories, the benthic species have on average 206 $pg.g^{-1}$ of ∑iPCB [59-268], whereas the other species have 87 $pg.g^{-1}$ [29-153]	Interpretations linked with the European commission recommendation (n°199/2006): the sum of PCDD/F and DL-PCBs should be lower than 8 $pg.g^{-1}$ ww for the toxic equivalent concentration (TEQ) in all fish species, except eels (12 $pg.g^{-1}$ ww). 23 fish have higher TEQ that 8 $pg.g^{-1}$. Only 4 fish have higher TEQ of PCDD/Fs than 4 $pg.g^{-1}$. The useful decision of the Préfet to forbid the fish-consumption in the Canal of Jonage: all fish seem to be contaminated. The necessity to analyse other parts of the Rhône River and to understand the nature of pollutions. A need of a better knowledge of sediment data contaminations, as the benthic species seem to be more contaminated.
Afssa, 2007	To determine which results are in compliance with European regulatory thresholds, considering fish species. To study if some species may be consumed, according to thresholds. To understand potential transfer of PCBs from bottom sediment to fish.	260 fish: 21 Eels, 49 barbels, 29 breams, 16 pikes, 21 carps, 24 chubs, 13 roaches, 16 nases, 6 mullet, 12 perches, 14 pike-perches, 24 catfish, 5 daces. Different variables, including weight and size, habitat and habitat and alimentation (prone to accumulate PCBs, at the bottom and/or feed on benthos versus pelagic or diverse diet)	Sites (Figure 2): P1 n=33 (upstream Sault-Brénaz), P2 n=67 (Sault-Brénaz), P3 n=61 (Confluence Saône-Rhône), P4 n=79 (Confluence Isère-Rhône) and P5 n=20 (Confluence Rhône-Durance). From 2005 to 2007	The average toxic equivalent concentration (TEQ) values [min.-max.]: Eels: 20 $pg.g^{-1}$ ww [1.2-53.3] Barbels: 14.5 [2.4-46.7] Breams: 20.8 [0.6-18.5] Pikes: 3.6 [0.2-21.2] Carps: 13.2 [1.4-49.9] Chubs:6.7 [0.2-48.7] Roaches: 0.8 [0.2-1.7] Nases: 5 [0.2-13.6] Mullet: 2 [0.2-6.6] Perches: 2.3 [0.1-12.1] Pike-perches: 2.1 [0.9-5.4] Catfish: 13.3 [1.3-59.3] Daces: 2.9 [1.8-5.4] The main observed non-conformities are linked with DL-PCBs and not with PCDD/F: for example eels 19 $pg.g^{-1}$ of DL-PCBs, barbels 14 $pg.g^{-1}$ of DL-PCBs, breams 18 $pg.g^{-1}$ of DL-PCBs…	Interdictions in the Rhône, Isère, Loire, Drôme, Ardèche, Vaucluse, Bouches-du-Rhône and Gard departments Eels (52%, in particular in P4 area), barbels (63% often in P2 and P3 areas), breams (72% particularly in P2 and P3 areas), carps (67% in particular in P2 and P3 areas), and catfish (75%, in particular in P2 and P3 areas) have more than 50% of their fish collection whose TEQ are higher than European thresholds. It is a step to the emergence of partial interdictions: the prominence of species, habitats, fishing area, and weight to understand PCB levels. The Rhône River is polluted by ∑iPCB and DL-PCBs, but not by PCDD/Fs.

				The weight can be an explanation: for example catfish less than 2 kg in P5 area cannot be considered as contaminated.	
Afssa, 2008	To analyse the species which exceed the European thresholds. To develop complementary analyses on non-DL PCBs. To study a potential correlation between sediment pollutions by PCBs and fish contaminations.	386 fish :26 eels, 45 breams, 18 pikes, 7 crucian carps, 22 carps, 66 chubs, 15 roaches, 28 nases, 7 mullet, 23 perches, 18 pike-perches, 28 catfish, 6 trout and 10 daces.	Sites (Figure 2): P1 n=99, P2 n=67, P3 n=65, P4 n=134 and P5 n=21 . From 2005 to 2008	The average toxic equivalent concentration (TEQ) values: (approximate data read from a barplot): Eels≏19 pg.g^{-1} ww Barbels≏12 Breams≏19.5 Pikes≏3.5 Carps≏12] Chubs≏4.5 Roaches≏1 Nases≏3.5 Mullet≏2 Perches≏1.75 Pike-perches≏2 Catfish≏13 Daces≏3 New species (crucian carps≏2 and trouts≏1.5) are added, but they are lower than 8 pg.g^{-1}. New levels of non-DL-PCBs (approximate data read from a barplot): Eels≏675 ng.g^{-1} ww Barbels≏310 ng.g^{-1} ww Breams≏395 ng.g^{-1} ww Pikes≏100 ng.g^{-1} ww Crucial carps≏40 ng.g^{-1} ww Carps≏205 ng.g^{-1} ww Chubs≏100 ng.g^{-1} ww Roaches≏30 ng.g^{-1} ww Nases≏80 ng.g^{-1} ww Mullet≏40 ng.g^{-1} ww Perches≏30 ng.g^{-1} ww Pike-perches≏35ng.g^{-1} ww Catfish≏260 ng.g^{-1} ww Trout≏15 ng.g^{-1} ww Daces≏35 ng.g^{-1} ww New sediment data.	Only DL-PCBs are distinguished in European thresholds. The non-DL-PCBs do not correspond to any thresholds. A reference to European Food Safety Authority which recommends the study of six non-DL PCBs (PCB-28, 52, 101, 138, 153 et 180), which correspond to the ∑iPCB. There is a strong correlation between the TEQ (sum of PCDD/F and DL-PCBs) and non-DL PCBs. The sediments are one sources of fish contaminations. The benthic species show higher levels than the pelagic species.
Afssa, 2009	The context: a national plan to study DL-PCBs and non-DL-PCB. A sanitary approach: to define levels of DL-PCBs, PCDD/Fs and mercury in the Rhône fish, according to European	643 fish in three categories: a/ Eels (n=45), a different threshold, a high bioaccumulation of PCBs b/ Species with a high bioaccumulation of PCBs such breams, barbels, and carps (n=180), and	Sites: P1 n=138 (upstream Sault-Brénaz), P2 n=137 (Sault-Brénaz), P3 n=130 (Confluence Saône-Rhône), P4 n=152 (Confluence Isère-Rhône), and P5 n=140 (Confluence Rhône-	The TEQ of eels are higher than European thresholds. The TEQ of species with high bioaccumulation are higher than European thresholds. The TEQ of species with low bioaccumulation are lower than European thresholds, except in the area between Loyettes	The affirmation of partial interdictions: In P1 area, every species can be eaten and sold, from P2 area to P5 area, Afssa advises the Rhône inhabitants not to eat or sell eels and species with a high bioaccumulation of PCBs. The specificity of a reach between Loyettes and Saint-Vulbas. Daces and crucian carps needs more analyses with a more consistent fish collection and perhaps are not part of species with low bioaccumulation of

	thresholds, to study the spatial variability of contamination and the role of species.	catfish (n=29) c/ Species with low bioaccumulation of PCBs including roaches, perches, daces, and pike perches (n=196), and pikes, chubs, nases, mullet, and crucian carps (n=193)	Durance), 697 fish but 54 were excluded. From 2005 to 2008	and Saint-Vulbas.	PCBs.

Table 2. The (unknown) contemporary sources of PCB pollutions (after Pradelle et al., 2013) at the Arles station from 2008 to 2011. The sum corresponds to the seven indicator congeners (∑iPCB).

Known or suspected sources of PCB contaminations in the Rhône basin	Estimation and trends of PCB_I discharge in the Rhône River and tributaries per year
Atmospheric depositions	Between 6.1 and 8.2 kg
Discharge of wastewater treatment plants	Between 0.4 and 4.3 kg
Human excreta	Between 30 and 110 g
Two PCB treatment facilities	0.4 kg
Industrial waste	0.2 kg
Unknown industrial waste	?
Potential for leaching upon road and building disposal	?
Landfills and polluted soils	?
Accidents or vandalism	?
Swiss discharges	?
Total	From 21 to 153 kg from year to year - 2008: 153 kg of PCBs - 2009: 57 kg of PCBs - 2010: 76 kg of PCBs - 2011: 21 kg of PCBs

Table 3. The grid for the content analysis of texts.

Themes	Variables	Values
Causes	No / Yes	0 / 1
	History: the quotation of decades	0 (no reference), 1930, 1970, 1980, 1990, 2000
	Responsibilities	0 (no reference), Tredi (1), EDF (2), illegal waste (3), blurred and ancient uses (4), unknown (5)
Facts	Data source	0 (no source), scientists (1), journalists (2), politicians (3), professional and recreational fishermen (4), institutions (5), environmentalists (6), companies (7), court (8)
	No / Yes	0 / 1
	Uncertainty	0 (no reference) / 1 (low)/ 2 (middle) / 3 (high)
	Scientific studies	0 (no reference) / 1 (low)/ 2 (middle) / 3 (high)
	Polluted locations	0 (no reference), site (1), reach (2), corridor (3)
	Comparison	0 (no reference), 1 (other French rivers)
Consequences	No / Yes	0 / 1
	Production	0 (no reference), fishing (1), farming (2), water supply (3)

	Recreation	0 (no reference), fish consumption (1), leisure (canoe, boating) and tourism (2)
	Investigation and court	0 (no reference), complaint and investigating process (1)
	Political engagement	0 (no reference), local (1), regional (2), national (3)
	Polluted environment	0 (no reference), fish (1), trophic chain (2), hydrosystem (3)
	Health	0 (no reference), blurred (1), cancer (2), a high number of impacts (3)
Acts	No / Yes	0 / 1
	Types of actions	0 (no reference), no act only the natural processes (1), punctual acts (2), heavy acts (3), scientific studies (4)

10. FIGURE CAPTIONS

Figure 1. Conceptual model of the public arena after Hilgartner and Bosk (1988). The success, size and scope of a social problem are linked with the amount of attention deployed by these arenas. The competition between potential problems is entailed by the carrying capacity of a public arena, which limits the number of social problems.

Figure 2. The location of PCB pollutions of the Rhône River and the study media coverage.

Figure 3. The PCB pollutions, associated actors and main management decisions: a) main political measures in Europe and France and b) chronology of the main steps of the social problem and main scientific results.

Figure 4. Frequencies of nine main environmental issues considering the Rhône River in the *Progrès* from 2003 to 2010 (n=674). It is part of the entire content analysis, which conveys 17 themes, with the 9 main themes chosen. The bold curve corresponds to pollution.

Figure 5. The number of published items related to PCB pollutions in a regional newspaper from 2005 to 2010 (n=75). If Figure 5A uses the year scale, Figure 5B focuses on the monthly scale.

Figure 6. Position of years on the first factorial map of the correspondence analysis (F1 X F2) performed on the Rhône PCB articles published in the *Progrès de Lyon* between 2005 and 2010.

Figure 7. Synthetic view of newspaper content considering the PCB pollutions between 2005 and 2010 from *Le Progrès* through the projection of modalities of the variables on the first factorial map of a multiple correspondence analysis (MCA). Each map corresponds to a variable, and each ellipse aggregates 66 percent of the information.

Figure 8. Cumulated frequency curves of the personally evoked stakeholders; their occurrences from 2005 to 2010.

Figure 9. Applying the conceptual model of the public arena (Hilgartner and Bosk, 1988), including principles of selection and competition. Different factors of the media coverage of PCB pollutions of the Rhône River. The normal lines correspond to problem-amplifying, whereas the dotted lines represent problem-damping.